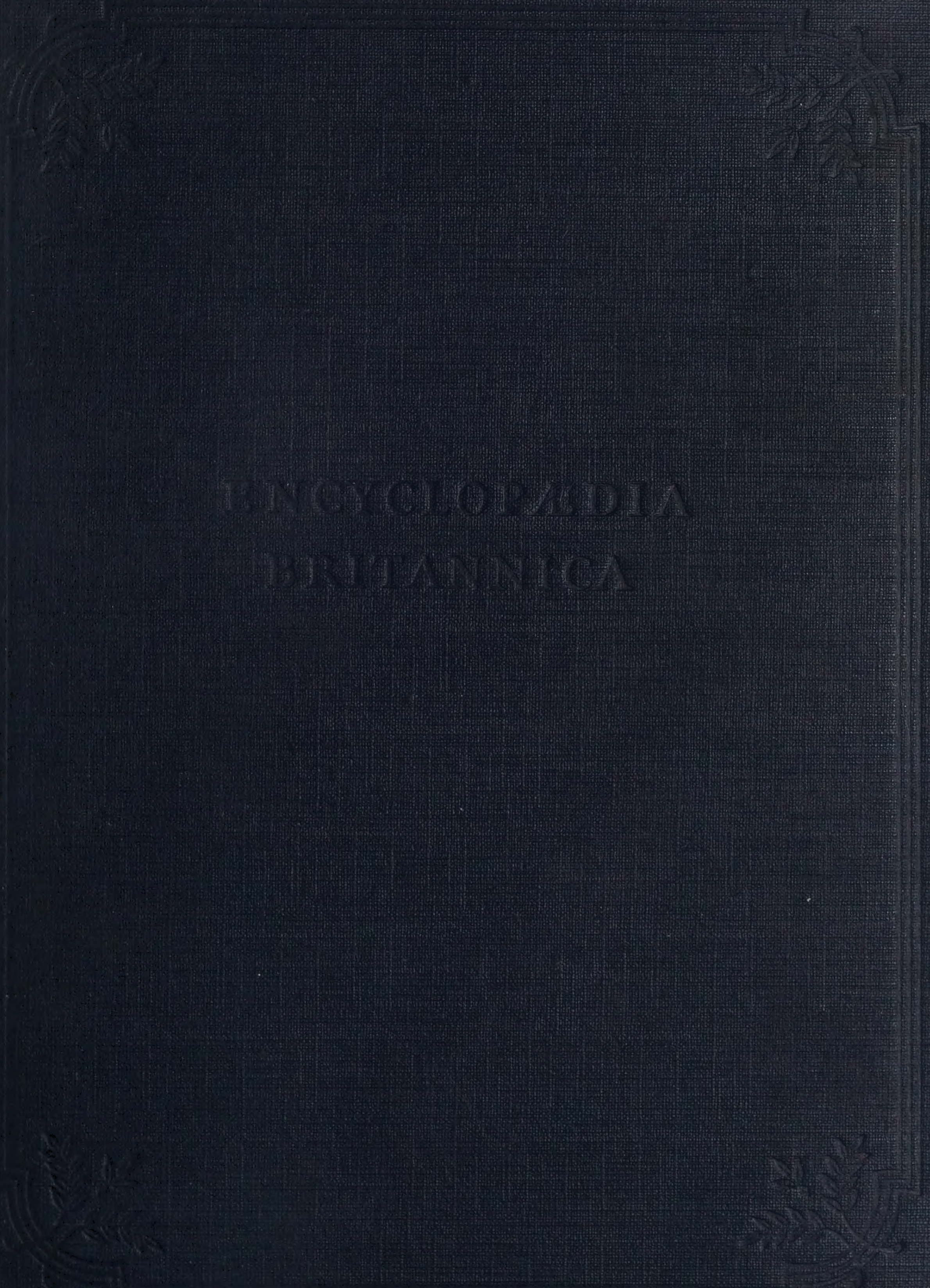

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G. P. B.	G. P. Bidder, D.Sc. President of the Zoology Section of the British Association for the Advancement of Science.	**Sponges.**
G. S.	Grant Showerman, Ph.D. Professor of Latin, University of Wisconsin. Author of *The Great Mother of the Gods.*	**Syncretism.**
G. S. W. E.	George S. W. Epps, C.B.E., B.A., F.I.A. Deputy Actuary, Government Actuary's Department, London.	**Superannuation.**
G. T. M.	Gilbert T. Morgan, O.B.E., D.Sc., F.I.C., F.R.S. Director, Chemical Research Laboratory, Department of Scientific and Industrial Research, London. Author of *Organic Compounds of Arsenic and Antimony.* Editor of the Chemistry section, 14th Edition, *Encyclopædia Britannica.*	**Stilbene;** **Styrene or Styrolene** (*in part*); **Succinic Acid;** **Sulphonic Acids; Tantalum;** **Tartar; Tartaric Acid;** **Tellurium.**
G. W. B. M.	G. W. B. McLeod, C.B.E.	**Taxation, Local** (*in part*).
G. W. Wi.	George Woodward Wickersham, LL.D. Attorney-General of the United States, 1909–13. Of the firm of Cadwalader, Wickersham and Taft.	**Taft, William Howard.**

H. A. B.	H. A. Baylis, D.Sc. Assistant, Department of Zoology, British Museum (Natural History).	**Tapeworms.**
H. A. Wa.	Sir Herbert Ashcombe Walker, K.C.B. General Manager, Southern Railway, London.	**Southern Railway.**
H. B. Wa.	Henry Beauchamp Walters, O.B.E., M.A., F.S.A. Keeper of Greek and Roman Antiquities in the British Museum. Author of *Catalogue of Roman Pottery; Catalogue of Terra-Cottas;* etc.	**Terra-Cotta** (*in part*).
H. C. N.	H. C. Notcutt, Ph.D. Professor of English, University of Stellenbosch, South Africa.	**South African Literature** (*in part*).
H. D.	Herbert Dingle, A.R.C.S., B.Sc., F.R.A.I. Assistant Professor of Astrophysics, Imperial College of Science and Technology, London. Director of the South Kensington Observatory.	**Sun.**
H. E. Da.	H. E. Dalton. Secretary and General Auditor, Studebaker Corporation.	**Studebaker Corporation, The.**
H. E. I.	Herbert E. Ives, B.S., Ph.D. Physicist, Bell Telephone Laboratories, since 1919. Author of *Airplane Photography.*	**Television.**
H. E. S.	Horace Elisha Scudder. Author of *Life of James Russell Lowell; History of the United States;* etc.	**Stowe, Harriet Elizabeth.**
H. G. R.	H. G. Richardson, M.A., B.Sc. Ministry of Agriculture and Fisheries, London.	**Spraying Machinery** (*in part*).
H. Her.	Harold Heron, F.C.S. Analytical and consulting Chemist. Lecturer on Malting and Brewing Chemistry, Sir John Cass Technical Institute, London.	**Starch.**
H. H. S.	Henry Harold Scott, M.D., M.B., M.R.C.S., L.R.C.P., D.P.H., F.R.S.E. Formerly Milner Research Fellow in Comparative Pathology, London School of Hygiene and Tropical Medicine. Lecturer in Tropical Diseases, Westminster Hospital Medical School.	**Sprue.**
H. Hte.	Captain H. Hotine, R.E. Geographical section, General Staff, War Office, London.	**Stereophotogrammetry.**
H. I.	H. Inwards. Formerly President of Luton Chamber. Author of *Straw Hats.*	**Straw and Straw Manufactures.**
H. Je.	Hilary Jenkinson, M.A., F.S.A. Assistant Keeper of the Public Records, London. Maitland Lecturer, University of Cambridge and Reader in Diplomatic and English Archives, University of London.	**Tally.**
H. J. R.	Herbert Jennings Rose, M.A. Professor of Greek, University of St. Andrews, Fife, since 1927. Professor of Latin, University College of Wales, Aberystwyth, 1919–27. Author of *Primitive Culture in Greece; Primitive Culture in Italy; A Handbook of Greek Mythology.*	**Superstition.**
H. L. Mo.	H. L. Morrow. Assistant Editor of *John O'London's Weekly.* Formerly Assistant Literary Editor of *The Daily News*, London.	**Street Cries.**
H. M. C.	Hector Munro Chadwick, M.A., Hon.D.Litt., Hon.LL.D., F.B.A. Elrington and Bosworth Professor of Anglo-Saxon, Cambridge University.	**Teutonic Peoples** (*in part*).
H. N. Br.	Henry Noel Brailsford, M.A. Editor of *The New Leader*, 1922–6. Author of *How the Soviet Works.*	**Soviet System.**
H. N. R.	Henry Norris Russell, Ph.D., D.Sc. Research Professor of Astronomy since 1927, and Director of the Observatory since 1912, Princeton University. Author of *Determination of Stellar Parallax;* etc.	**Stellar Evolution.**
H. P. Hu.	Hilda Phoebe Hudson, O.B.E., M.A., Sc.D. Formerly Lecturer and Fellow of Newnham College, Cambridge. Author of *Ruler and Compasses; Cremona Transformations in Plane and Space.*	**Surface.**
H. Rd.	Herbert Read, D.S.O., M.C. Assistant Keeper, Victoria and Albert Museum, London. Author of *English Stained Glass;* etc.	**Stained Glass** (*in part*).
H. R. H.	Harry Reginald Holland Hall, M.A., D.Litt., F.B.A., F.S.A. Keeper of Egyptian and Assyrian Antiquities in the British Museum.	**Sphinx** (*in part*).
H. Sha.	H. Shapley, A.M., LL.D., Ph.D. Professor of Astronomy, Harvard University, and Director of the Observatory.	**Star Cluster.**
H. S. L.	Herbert Sidney Langfeld, Ph.D. Professor and Director of Psychology Laboratory, Princeton University.	**Stumpf, Carl.**
H. St. J. W.	Brigadier Harold St. John Winterbotham, C.M.G., D.S.O., R.E. Geographical Section, General Staff, War Office, London.	**Surveying** (*in part*).
H. W. B. J.	H. W. B. Joseph, M.A. Lecturer in Philosophy in the University of Oxford.	**Species** (*in part*).
H. W. C. D.	Henry William Carless Davis, M.A. Late Director, *Dictionary of National Biography*, Regius Professor of Modern History, and Fellow and Tutor of Balliol College, Oxford. Fellow of All Souls, 1895–1902.	**Stephen.**
H. W. Sm.	Harry Worcester Smith. Founder of the Masters of Foxhound Association of America. Author of *A Sporting Tour in Ireland; The True American Foxhound; The Cubbing Season.*	**Steeplechasing.**
H. W. W. Wil.	Herbert William W. Wilberforce. Barrister-at-law. Deputy Chairman of the County of London Sessions. Metropolitan Police Magistrate. Formerly Stipendiary Magistrate for Bradford.	**Summary Jurisdiction** (*in part*).
I. A.	Israel Abrahams, M.A. Formerly Reader in Talmudic and Rabbinic Literature, University Cambridge; etc.	**Tam, Jacob Ben Meïr.**
I. F. D. M.	Ian F. D. Morrow, Ph.D. Formerly Senior Moderator of Trinity College, Dublin.	**Straits Question, The.**
I. M.	Sir Ian Malcolm, K.C.M.G., D.L., J.P. British Government Representative on the Suez Canal Board.	**Suez Canal** (*in part*).

J. A. E.	Sir (James) Alfred Ewing, K.C.B., LL.D., D.Sc., M.Inst.C.E., F.R.S. Principal and Vice-Chancellor, Edinburgh University. Director of (British) Naval Education, 1903–16. Author of *The Steam Engine and other Heat Engines;* etc.	**Steam;** **Steam Engine.**
J. A. Ed.	Captain J. A. Edgell, R.N. Assistant Hydrographer to the Navy, Admiralty, London.	**Sounding.**
J. A. S.	John Addington Symonds, LL.D. Author of *Renaissance in Italy; Studies of the Greek Poets;* etc. *See* the biographical article: Symonds, John Addington.	**Tasso, Torquato** (*in part*).
J. A. Th.	John Arthur Thomson, M.A., LL.D. Regius Professor of Natural History in the University of Aberdeen. Author of *The Study of Animal Life; Outlines of Zoology; Heredity; Darwinism and Human Life.*	**Symbiosis.**
J. B. C.	J. B. Crane, B.S. High Pressure Specialist, Combustion Engineering Corporation, New York.	**Steam Generation** (*in part*).
J. Br.	Colonel John Brown, C.B., C.B.E., D.S.O., T.D. Commanded 162nd Infantry Brigade, Territorial Army, 1924–8. Appointed to command 4th Battalion, Northamptonshire Regiment on re-formation Territorial Army.	**Territorial Army.**
J. Bt.	James Bartlett. Late Lecturer on Construction, Architecture, Sanitation, Quantities, etc., King's College, London. Author of *Quantities.*	**Stone.**
J. B. T.	J. B. Trend, M.A. Author of *A Picture of Modern Spain; Alfonso the Sage; Spain from the South; The Madrid Stage in the 17th Century* (in Spanish); etc.	**Spanish Language and Literature** (*in part*).
J. C. Os.	John Clyde Oswald. Managing Director, The New York Employing Printers' Association since 1925.	**Teletypesetter.**
J. C. Sm.	J. C. Smith, C.B.E., Litt.D. H. M. Senior Inspector of Schools in Scotland. Editor of Spenser's *Fairie Queen* and (with Prof. E. de Selincourt) of Spenser's *Poetical Works.*	**Spenser, Edmund.**
J. D. B.	James David Bourchier, M.A., F.R.G.S. Late Correspondent of *The Times* (London) in South Eastern Europe.	**Stambolov, Stefan** (*in part*).
J. F. C. F.	Colonel John Frederick Charles Fuller, C.B.E., D.S.O. Military Assistant to the Chief of the Imperial General Staff. Chief General Staff Officer, Tank Corps, 1917–8. Formerly Chief Instructor, Camberley. Author of *Tanks in the Great War; The Reformation of War; Sir John Moore's System of Training;* etc.	**Strasbourg** (*in part*); **Tactical Formations;** **Tactics; Taginae, Battle of;** **Teutoburger Wald, Battle of.**
J. F.-K.	James Fitzmaurice-Kelly, Litt.D., F.R.Hist.S. Late Gilmour Professor of Spanish Language and Literature, University of Liverpool.	**Spanish Language and Literature** (*in part*).
J. F. M.	James Fullarton Muirhead, LL.D. Editor of many of Baedeker's Guide Books.	**Spitteler, Carl;** **Swiss Literature** (*in part*).
J. F. S.	J. F. Stenning, M.A., C.B., C.B.E. Warden of Wadham College, Oxford, and University Reader in Aramaic.	**Targum.**
J. Gai.	James Gairdner, LL.D., C.B. Late Assistant Keeper of the Public Records. Author of *The Houses of Lancaster and York;* etc. *See* the biographical article: Gairdner, James.	**Talbot (Family)** (*in part*).
J. G. D.	Captain J. G. Dollman. Assistant Keeper, Department of Zoology, Natural History Museum, London.	**Taxidermy.**
J. Gi.	J. Ginsburg, M.A. Associate, Department of Mathematics, Teachers College, Columbia University, New York. Professor of Mathematics, Yeshiva College, New York.	**Stirling Numbers.**
J. Gir.	Jean Giraud. Of the Fondation Emile et Louise Deutsch de la Meurthe, University of Paris.	**Stendhal.**
J. G. R.	John George Robertson, M.A., Ph.D., Litt.D. Professor of German language and literature, University of London. Director of the Department of Scandinavian Studies since 1924.	**Swedish Language and Literature** (*in part*).
J. H.	John Hilton. Director of Statistics, Ministry of Labour, London.	**Strikes and Lock-outs** (*in part*).
J. Har.	Jiro Harada. Of the Imperial Household Museums, Japan. Formerly Professor in the Nagoya College of Technology and in the 8th Higher School.	**Tea Ceremony.**
J. H. B.	Joseph H. Bonneville, A.M. Department of Banking and Science, New York University School of Commerce, Accounts and Finance, New York. Author of *Elements of Business Finance.*	**Stock** (*in part*).
J. H. H.	J. H. Hutton, D.Sc., C.I.E. Director of Ethnology, Assam. Deputy Commissioner, Naga Hills.	**Talaing.**
J. H. Mo.	J. H. Morgan, K.C. Professor of Constitutional Law, University of London. Brigadier-General, late Deputy-Adjutant-General. Reader in Constitutional Law to the Inns of Court. Editor of the Law section, 14th Edition, *Encyclopædia Britannica.*	**State, Act of.**
J. H. R.	John Horace Round, M.A., LL.D. Late Historical Adviser to the Crown.	**Talbot (Family)** (*in part*).
J. H. Ro.	John Holland Rose, M.A., D.Litt. Vere-Harmsworth Professor of Naval History, University of Cambridge. Formerly Reader in Modern History. Author of *Life of Napoleon; Napoleonic Studies;* etc.	**Talleyrand-Périgord, Charles Maurice de.**
J. J. C.	Brigadier-General John J. Collyer, C.B., C.M.G., D.S.O. (retired). Formerly Chief of the General Staff, Union of South Africa.	**South-West Africa, Campaign in.**
J. J. M.	James Joseph Mallon, M.A. Warden of Toynbee Hall, London. Hon. Secretary of Trade Boards Advisory Council. Secretary National Anti-Sweating League, 1906.	**Sweating System** (*in part*).

J. J. S.	J. J. Smith, B.A. Professor in Africaans, University of Stellenbosch, South Africa.	**South African Literature** (*in part*).
J. L. M.	J. Leask Manson, B.Sc., M.I.Struct.E., M.R.San.I. Sometime Technical Officer, Department of Scientific and Industrial Research, London.	**Structural Engineering** (*in part*).
J. Mac.	Sir John Macdonell, C.B., LL.D. Late Master of the Supreme Court. Sometime Quain Professor of Comparative Law, University College, London. Editor of *State Trials; Civil Judicial Statistics;* etc.	**Sovereignty** (*in part*).
J. M. de N.	J. M. de Navarro, M.A. Fellow of Trinity College, Cambridge.	**Teutonic Peoples** (*in part*).
J. M. La.	J. M. Landis, A.B., LL.B., S.J.D. Professor of Legislation, Harvard Law School. Author of *The Business of the Supreme Court of the United States.*	**Statute** (*in part);* **Summary Jurisdiction** (*in part);* **Sunday** (*in part*).
J. M. M.	John Malcolm Mitchell, O.B.E., M.C., M.A., F.S.A. Secretary, Carnegie United Kingdom Trust. Assistant editor in Classics, Archaeology and Ancient History, 11th Edition, *Encyclopædia Britannica.*	**Sphinx** (*in part*).
J. M. Re.	John Morgan Rees, M.A. Lecturer in Economics and Political Science, University College of Wales.	**Syndicalism** (*in part*).
J. P. E.	Jean Paul Hippolyte Emmanuel Adhémar Esmein. Late Professor of Law in the University of Paris, and Membre de l'Institut.	**Taille** (*in part*).
J. Per.	Janet Perry. Lecturer in the Department of Spanish Studies, King's College, University of London. Editor of Juan de Valdes' *Dialogo de las lenguas.*	**Spanish Language and Literature** (*in part*).
J. R. Co.	John R. Commons, A.M., LL.D. Professor of Economics, University of Wisconsin. Author of *Trade Unionism and Labor Problems.* Co-author of *History of Labor in the United States.*	**Strikes and Lock-outs** (*in part*).
J. S.	Sir Josiah Charles Stamp, G.B.E., D.Sc., LL.D., F.B.A. Chairman and President of the Executive, London, Midland and Scottish Railway. Member of the Committee on Taxation and National Debt, 1924. British Representative on the Reparation Commission's Committee on German Currency and Finance, 1924, and Member of the Committee of Experts, Paris, 1929.	**Taxation.**
J. S. F.	Sir John Smith Flett, K.B.E., D.Sc., F.R.S. Director Geological Survey of Great Britain and Museum of Practical Geology.	**Spherulites.**
J. S. R.	James Smith Reid, M.A., Litt.D., LL.D. Formerly Professor of Ancient History in the University of Cambridge and Fellow and Tutor of Gonville and Caius College. Editor of editions of Cicero's *Academia.*	**Statius, Publius Papinius** (*in part*).
J. T. Be.	John Thomas Bealby. Joint author of Stanford's *Europe.* Formerly editor of the *Scottish Geographical Magazine.* Translator of Sven Hedin's *Through Asia, Central Asia and Tibet.*	**Syr-Darya** (*in part*).
J. Van Br.	John Van Brunt. Chief Engineer, Vice-President and Consulting Engineer, Combustion Engineering Corporation, New York.	**Steam Generation** (*in part*).
J. V. B.	James Vernon Bartlet, M.A., D.D. Professor Emeritus of Church History, Mansfield College, Oxford.	**Stephen.**
J. Wil.	James Williams, M.A., D.C.L., LL.D. Late All Souls Reader in Roman Law in the University of Oxford.	**Statute** (*in part*).
K. A.	Karl Åmark, D.Ph. Secretary of the National Economic Society, Stockholm.	**Sweden** (*in part*).
K. Hi.	Karl Hildebrand, D.Phil. President of the Swedish National Debt Board. Editor of the Stockholm *Dagblad,* 1904–13. Member of Swedish Parliament, 1907–18.	**Sweden** (*in part*).
K. P. M.	K. P. Mehta. Managing Director, Tata Sons, Limited.	**Tata Sons, Limited.**
L. C. M.	Sir Leo Chiozza Money, F.R.Stat.S., F.R.G.S., F.Z.S. Author and Journalist. Member of the War Trade Advisory Committee, 1915–8. Parliamentary Secretary to the Ministry of Shipping, 1916–8. Chairman of the Tonnage Priority Committee, 1917–8. Editor of the Economics, Engineering and Industries section, 14th Edition, *Encyclopædia Britannica.*	**South Metropolitan Gas Company;** **Sudan Plantations Syndicate, Ltd.;** **Swan, Hunter and Wigham Richardson, Limited;** **Syndicate** (*in part*).
L. de B. H.	L. de B. Handley. Author of *Swimming and Watermanship; Swimming for Women;* etc.	**Swimming** (*in part*).
L. D. S.	Laurence Dudley Stamp, B.A., D.Sc., F.G.S., M.I.P.T. Sir Ernest Cassel Reader in Economic Geography in the University of London.	**Tertiary.**
L. Fo.	Lauren Foreman, Ph.B. Of the Southern Railway System.	**Southern Railway System.**
L. F. O.	Léon François Ozanne. Chief of the London Office, Compagnie Universelle du Canal Maritime de Suez.	**Suez, Compagnie Universelle du Canal Maritime de.**
L. F. Sw.	L. F. Swift. President, Swift and Company, Chicago.	**Swift and Company.**
L. H.	Lewis Hodous, M.A., D.D. Head of the Chinese Department of the Kennedy School of Missions, Hartford Seminary Foundation. Formerly President of Foochow Theological Seminary.	**Taoism.**
L. J.	Major-General Sir Louis Charles Jackson, K.B.E., C.B., C.M.G., R.E. Instructor in Fortification and Military Engineering, School of Military Engineering, Chatham, 1895–1902. Assistant Director of Fortifications and Works, War Office, 1907–10; reappointed, 1914.	**South African War, 1899–1902** (*in part*).

L. J. S.	L. J. Spencer, M.A., Sc.D., F.G.S., F.C.S., F.R.S. Keeper Mineralogy Department, Natural History Museum, South Kensington. Formerly Scholar of Sidney Sussex College, Cambridge, and Harkness Scholar. Editor of *The Mineralogical Magazine.*	**Stannite; Staurolite; Stibnite; Sylvite; Tetradymite; Tetrahedrite.**
L. of F.	Arthur Hamilton Lee, 1st Viscount Lee of Fareham, P.C., G.C.S.I., G.B.E., K.C.B., F.S.A., F.R.I.B.A. Chairman of the Board of Governors, Sulgrave Manor, Northamptonshire. First Lord of the Admiralty, 1921–2.	**Sulgrave Manor.**
L. R. D.	Lawrence R. Dicksee, M.Com., F.C.A. Head of Sellars, Dicksee and Co. Emeritus Professor of Accountancy and Business Organisation in the University of London.	**Stock-Taking.**
L. Se.	Louis Segal, M.A., Ph.D. Author of *The Soviet Union Year-Book.* Formerly head of Russian Department, Birmingham University.	**Soviet Trade Organizations.**
L. Si.	Lee Simonson, A.B. Director of Theatre Guild, Incorporated, New York. Editor of *Creative Art.*	**Stage Design** (*in part*).
L. Sn.	Ludwick Silberstein, Ph.D. Mathematical Physicist, Research Laboratory, Eastman Kodak Co., Rochester, N. Y.	**Tensor Analysis.**
L. S. R.	L. S. Richardson, B.S. Assistant Chief, Press Service, United States Department of Agriculture, Washington.	**Soya Bean.**
L. St.	Leonard Stein. Political Secretary to the World Zionist Executive. Staff-Captain Palestine Military Administration and subsequently on Political Staff, E. E. F. in Jerusalem.	**Syria** (*in part*).
L. V.	Luigi Villari. Italian Vice-Consul in New Orleans, 1906; Philadelphia, 1907. Acting Consul, Boston, 1907–10. On the Secretariat of the League of Nations, 1920–3. Author of *Italian Life in Town and Country; The Awakening of Italy;* etc.	**Sturzo, Luigi.**
M. Bg.	Wing-Commander Hon. Maurice Baring, O.B.E., F.R.S.L. English Diplomat. Sometime Correspondent for the *Morning Post* (London) in Manchuria, Russia and Constantinople, and for *The Times*, London, in the Balkans. *See* the biographical article: Baring, Maurice.	**Taine, Hippolyte Adolphe** (*in part*).
M. C. S.	Malcolm Charles Salaman. Hon. Fellow, Royal Society of Painter-Etchers, London. Formerly Dramatic and Art Critic of *The Sunday Times* (London). Author of *Old English Colour-Prints.*	**Stipple and Crayon Engraving.**
M. G.	Moses Gaster, Ph.D. Chief Rabbi of the Sephardic Communities of England. Vice-President of the Zionist Congress, 1898, 1899 and 1900. Vice-President, Jewish Historical Society of England. Author of *A New Hebrew Fragment of Ben-Sira; The Samaritans;* etc.	**Sturdza.**
M. M. H.	M. M. House, D.D.S. Research and development S. S. White Dental Manufacturing Company, Philadelphia. Formerly, Extension Course Division, Dental Department, University of Minnesota.	**Teeth, Artificial.**
M. N. T.	Marcus Niebuhr Tod, M.A. Fellow and Tutor of Oriel College, Oxford, and University Reader in Greek Epigraphy. Joint author of *Catalogue of the Sparta Museum.*	**Sparta.**
M. Si.	Max Silberschmidt, Ph.D. Assistant Professor, Cantonal Technical School, Winterthur, Switzerland.	**Switzerland** (*in part*).
M. Sie.	Manne Siegbahn. Professor of Physics, University of Uppsala.	**Spectroscopy** (*in part*).
N. C.	Newcomb Carlton, M.E., A.M. President of the Western Union Telegraph Company.	**Telegraph.**
N. E. C.	Norman E. Crump. Statistical Correspondent to the *Financial Times*, London. Joint author of Clare's *A. B. C. of the Foreign Exchanges.*	**Stock** (*in part*); **Tael.**
N. M'l.	Norman M'Lean, M.A. Master of Christ's College, Cambridge, and University Lecturer in Aramaic.	**Syriac Literature.**
O. G. S.	Orrin G. Sherman. Policyholders Service Bureau, Metropolitan Life Insurance Company, New York.	**Stagger Plan.**
O. H. T. R.	O. H. T. Rishbeth, M.A., F.R.G.S. Professor and Head, Geography Department, University College, Southampton.	**Tasmania** (*in part*).
O. J. L.	Sir Oliver Lodge, D.Sc., LL.D., F.R.S. Principal of the University of Birmingham, 1900–19. President of the Society for Psychical Research, 1901–4. Author of *Ether and Reality; Raymond, or Life and Death;* etc.	**Spiritualism.**
P. A. K.	Prince Peter Alexeivitch Kropotkin. Russian geographer, author and revolutionary. Editor for the Jura Federation of *La Révolte. See* the biographical article: Kropotkin, P. A.	**Syr-Darya** (*in part*).
P. McC	Primrose McConnell, B.Sc., F.G.S. Member of the Royal Agricultural Society. Author of *Diary of a Working Farmer.*	**Sowing.**
P. M. H.	P. M. Heldt, B.E.E. Engineering Editor, *Automotive Industries.* Author of *The Gasoline Automobile: its Design and Construction.*	**Speedometers.**
P. P. Cr.	Paul Phillippe Cret. Professor of Architectural Design, University of Pennsylvania, Philadelphia. Architect of Pan-American Union Building, Washington; Valley Forge Memorial Arch, Philadelphia.	**Stadium** (*in part*).
P. Q.	Philip Quayle, B.S. Chief Physicist, Peters Cartridge Company, King's Mills, Ohio. Author of *Spark Photography Applied to Small Arms; The Importance of Shot Strings;* etc.	**Spark Photography.**

P. Z. C.	Major-General Sir Percy Z. Cox, G.C.M.G., G.C.I.E. Acting British Minister to Persia, 1918–20. High Commissioner in Mesopotamia, 1920–3. Secretary, Foreign Department, Government of India, 1914.	**Tabriz;** **Tehran.**
R. Al.	Rafael Altamira y Crevea. Professor of History of Political and Civil Institutions of America, University of Madrid. Member of the Real Academia de la Historia and the Real Academia de Ciencias Morales y Políticas, Madrid.	**Spain** (*in part*).
R. A. L.	R. A. Langworthy. Vice-President and General Manager of Ruths Accumulator Company, Inc., New York.	**Steam Accumulators.**
R. B. D.	Roland B. Dixon, Ph.D. Professor of Anthropology at Harvard University. Author of *Oceanic Mythology; Racial History of Man; The Building of Culture.*	**South America** (*in part*); **Tapuyan.**
R. C.	Rhys Carpenter, M.A., Ph.D. Director, American School of Classical Studies at Athens. Professor of Classical Archaeology at Bryn Mawr College, Pennsylvania. Hon. Corresponding Member of the Hispanic Society of America. Author of *The Greeks in Spain;* etc.	**Spain** (*in part*).
R. C. C. C.	R. C. C. Clay, M.R.C.S., L.R.C.P., F.S.A., F.R.A.I.	**Stonehenge.**
R. C. Co.	Robert C. Cotton. Major, United States Army. Historical Section, Army War College, Washington.	**Supply and Transport, Military** (*in part*).
R. D. Hi.	Robert Drew Hicks, M.A. Formerly Fellow and Classical Tutor, Trinity College, Cambridge.	**Stoics.**
R. F. N.	Royal F. Nichols, A.M., Ph.D. Professor of History, University of Pennsylvania. Author of *Democratic Machine 1850–1854.*	**Taylor, Zachary.**
R. Fr. v. R.	Rochus Freiherr von Rheinbaben. Author of *Stresemann, der Mensch und der Staatsmann.*	**Stresemann, Gustav.**
R. G.	Richard Garnett, C.B., LL.D. Late Superintendent of the Reading Room, British Museum, and Keeper of the Printed Books. *See* the biographical article; Garnett, Richard.	**Swift, Jonathan** (*in part*).
R. H. B.	Lieutenant-Colonel Roger Hammet Beadon, C.B.E., R.A.S.C. Employed under Colonial Office in 'Iraq, 1925.	**Supply and Transport, Military** (*in part*).
R. H. Ch.	Rev. Robert Henry Charles, M.A., D.D., Litt.D., F.B.A. Archdeacon of Westminster. Late Grinfield Lecturer and Lecturer in Biblical Studies, Oxford. Professor of Biblical Greek at Trinity College, Dublin, 1898–1906.	**Testaments of the Twelve Patriarchs.**
R. I. P.	Reginald Innes Pocock, F.L.S., F.Z.S., F.R.A.I., F.R.S. Natural History Editor of *The Field* and Temporary Assistant in the Zoological Department of the British Museum since 1923.	**Tardigrada.**
R. Lev.	Reuben Levy, M.A. Lecturer in Persian, Cambridge University.	**Susa.**
R. L. F.	R. Louise Fitch, A.B., M.A. Dean of Women, Cornell University, Ithaca, N. Y.	**Sororities.**
R. M. F.	Miss R. M. Fleming. Librarian, The Geographical Association, Aberystwyth. Author of *Ancient Tales from Many Lands; Stories from the Early World.*	**Tajik Republic;** **Tatar Republic.**
R. M. H.	Ray M. Hudson, M.E. Assistant Director for Commercial Standards, United States Department of Commerce.	**Standardization** (*in part*).
R. N. B.	Robert Nisbet Bain. Assistant Librarian, British Museum, 1883–1909. Author of *Scandinavia: The Political History of Denmark, Norway and Sweden, 1513–1900;* etc.	**Svane** (*in part*); **Sweyn I.** (*in part*).
R. N. Ba.	Vice-Admiral Robert Nesham Bax, C.B., R.N. (retired). Director of the Mobilization Department at the Admiralty, 1924–6. Served World War in Channel Squadron, Dardanelles Operations; etc.	**Submarine Campaign.**
R. N. R. B.	R. N. Rudmose Brown, D.Sc. Head of the Department of Geography, University of Sheffield. Member of the Scottish Antarctic Expedition, 1902–4, and of the Scottish Arctic Expeditions to Spitsbergen, 1909, 1914 and 1919. Author of *Spitsbergen; The Polar Regions;* etc.	**Spitsbergen** (*in part*).
R. R. M.	Robert Ranulph Marett, M.A., D.Sc., F.R.A.I. Rector of Exeter College, Oxford, University Reader in Social Anthropology.	**Spell;** **Supernaturalism.**
R. R. P.	Raye R. Platt, A.B. Head of Department of Hispanic American Research, American Geographical Society of New York. Author of numerous articles on South America.	**South America** (*in part*).
R. Rt.	Reinhold Rost, C.I.E., LL.D. Editor of Wilson's *Essays on the Religions of the Hindus;* Hodgson's *Essays on Indian Subjects.*	**Tamils** (*in part*).
R. S. Cl.	R. S. Clay, B.A., D.Sc., F.Inst.P. Principal, Northern Polytechnic, London. President of the Optical Society.	**Spectacles.**
R. U. S.	R. U. Sayce, M.A. Lecturer in Material Culture and Physical Anthropology in the University of Cambridge. Formerly Lecturer in Geology, and Geography, University College, Natal.	**South Africa, Union of** (*in part*); **South-West Africa** (*in part*); **Swaziland** (*in part*).
S. A. C.	Stanley Arthur Cook, Litt.D. University Lecturer in Hebrew and Aramaic; Lecturer in Hebrew and Syriac and Fellow of Gonville and Caius College, Cambridge. Editor for Palestine Exploration Fund. Co-editor, *Cambridge Ancient History.* Author of *Religion of Ancient Palestine.*	**Talmud** (*in part*).

S. Ch.	Stuart Chase, S.B. President and Director, Labor Bureau, Incorporated, New York. Author of *The Tragedy of Waste; Your Money's Worth;* etc.	**Standardization** (*in part*).
S. De J.	S. De Jastrzebski, F.S.S. Member American Academy of Social and Political Science. Formerly Assistant Registrar-General, Great Britain.	**Suicide.**
S. de M.	S. de Madariaga, M.A. King Alfonso XIII. Professor of Spanish Studies, University of Oxford and Fellow of Exeter College. Author of *Shelley and Calderon;* etc.	**Spain** (*in part*); **Spanish Language and Literature** (*in part*).
S. E. C.	S. E. Chandler, D.Sc. Chief Assistant, Imperial Institute, London. Joint author of *Tea, Its Cultivation, Manufacture and Commerce.*	**Tea** (*in part*).
S. F.	Simon Flexner, M.D., LL.D. Director of the Laboratories of the Rockefeller Institute for Medical Research, New York, since 1903.	**Spinal Meningitis.**
S. H.	S. Herbert. M.A. Lecturer in International Politics, University College of South Wales, Aberystwyth.	**Syndicalism** (*in part*).
S. I. F.	S. I. Franz, Ph.D., LL.D. Professor of Psychology, University of California. Author of *Nervous and Mental Re-education.*	**Subnormal and Feeble-minded, Education of.**
S. L.	Stephen Herbert Langdon, M.A., Ph.D. Professor of Assyriology, Oxford, since 1919. Director of the Weld-Blundell and Field Museum Expedition to Mesopotamia since 1922.	**Tammuz.**
S. L. R.	Samuel L. Rothafel. Executive Director, Roxy Theatre, New York.	**Stage Design** (*in part*).
S. R. B.	Sona Rosa Burstein, M.A. Diplomée in Anthropology (Oxon). Research Assistant at the Wellcome Historical Medical Museum. Member of the Folk-Lore Society.	**Tabu.**
S. S. K.	S. S. Katzenellenbaum. Professor of Financial Science at the University of Moscow. Member of the Board of Directors of the State Bank.	**Soviet Banking System.**
S. T. H. W.	Captain S. T. H. Wilton, R. N. (retired). Formerly Assistant Director of Naval Ordnance, Admiralty, London.	**South Africa, Union of** (*in part*).
T. A.	Thomas Ashby, D.Litt., F.B.A., F.S.A., Hon.A.R.I.B.A. Formerly Director of the British School at Rome. Revised and completed for press a *Topographical Dictionary of Ancient Rome* (by the late Professor J. B. Plattner).	**Subiaco;** **Succi; Sutri;** **Syracuse** (*in part*); **Taranto; Terracina.**
T. A. C.	Sir Theodore Andrea Cook. Late Editor-in-Chief of *The Field* (London). Editor of the Sports section, 14th Edition, *Encyclopædia Britannica.*	**Stadium** (*in part*).
T. A. J.	Thomas Athol Joyce, M.A., O.B.E. Deputy-Keeper, Department of Ethnography, British Museum. Author of *South American Archaeology; Maya and Mexican Art;* etc.	**South America** (*in part*).
T. C.	Lieutenant-General Sir Travers Edwards Clarke, G.B.E., K.C.M.G., C.B. Quartermaster-General to the British Armies in France, 1917–9 and to the Forces and Member of the Army Council, 1919–23.	**Supply and Transport, Military** (*in part*).
T. F. H.	Talbot F. Hamlin, B.A., B.Arch. Instructor in the History of Architecture, Columbia University, New York. Author of *The Enjoyment of Architecture; The American Spirit in Architecture.*	**Spire; Stair;** **Staircase; Strap Work;** **Swastika; Temple.**
T. H. P. H.	T. H. P. Heriot, F.I.C. Lecturer on Sugar Manufacturing, Royal Technical College, Glasgow.	**Sugar** (*in part*).
T. J. E.	Major T. J. Edwards. Secretary to the Honours and Distinctions Committee, The War Office. Author of *The Non-Commissioned Officer's Guide to Promotion in the Infantry.*	**Stripe.**
T. N. C.	Thomas Nixon Carver, A.B., Ph.D., LL.D. Professor of Political Economy, Harvard University. Author of *Principles of Rural Sociology; This Economic World;* etc.	**Standards of Living.**
T. P. N.	T. Percy Nunn, M.A., D.Sc. Principal of the London Day Training College. Professor of Education, University of London.	**Teachers, Training of** (*in part*).
T. W. F.	Thomas W. M. Fox. Late Professor of Textiles in the University of Manchester.	**Spinning.**
T. Wi.	Thomas Wilfred. Founder of the Clavilux Laboratory, New York. Inventor of the Clavilux.	**Stage Design** (*in part*).
V. C. C. C.	Miss V. C. C. Collum. Fellow of the Royal Anthropological Institute of Great Britain and Ireland.	**Stone Monuments, Primitive.**
W. A. B. C.	Rev. William Augustus Brevoort Coolidge, M.A., F.R.G.S., Hon.Ph.D. Fellow of Magdalen College, Oxford. Editor of *The Alpine Journal*, 1880–9; etc.	**Switzerland** (*in part*); **Tell, William** (*in part*).
W. A. Be.	W. A. Bettesworth, B.A. Late Sports Editor of *The Field.*	**Stoolball.**
W. A. P.	W. Alison Phillips, M.A. Lecky Professor of Modern History, Dublin University.	**Spain** (*in part*); **Templars** (*in part*).
W. A. St.	W. A. Starrett, B.S.in C.E. President, The Starrett Corporation and Vice-President of Starrett Brothers, Incorporated, New York. Author of *Skyscrapers and the Men Who Build Them.*	**Structural Engineering** (*in part*).

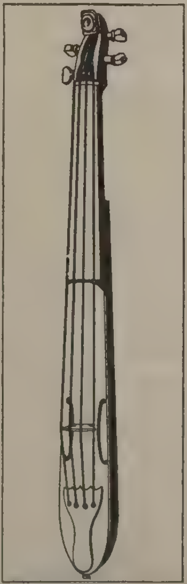
W. B. H.	Walter B. Harris, F.R.G.S., F.S.A. Traveller, Explorer and Author. Correspondent of *The Times* (London) in Morocco. Author of *Morocco that was; France, Spain and the Rif;* etc.	**Tangier** (*in part*).
W. B. P.	William Belmont Parker, A.B. Editor of *South Americans of To-day.*	**Sucre, Antonio José de.**
W. B. R. K.	W. B. R. King, M.A., F.G.S. Sedgwick Museum, Cambridge.	**Springs.**
W. C. B.	William C. Bagley, Ph.D. Professor of Education, Teachers College, Columbia University.	**Teaching, Methods of.**
W. C. B. T.	W. C. B. Tunstall, M.A. Civilian Lecturer, Royal Naval College, Greenwich.	**Spanish Succession, War of** (*in part*).
W. E. Co.	Rt. Rev. William Edward Collins, D.D. Formerly Professor of Ecclesiastical History, King's College, London, and Lecturer, St. John's and Selwyn Colleges, Cambridge.	**Testamentum Domini.**
W. E. Cx.	Warren E. Cox. Art Editor of the 14th Edition, *Encyclopædia Britannica.*	**Technique in Art;** **Terra-Cotta** (*in part*).
W. E. I.	Major-General Sir William Edmund Ironside, K.C.B., C.M.G., D.S.O. G.O.C. Meerut District, India. Commandant, Staff College, Camberley, Surrey, 1922–6. Commander-in-Chief, British Forces in Russia, 1918–9. Author of *Tannenberg: the first thirty days in East Prussia.*	**Tannenberg, Battle of.**
W. E. R.	W. E. Rappard. Rector of the University of Geneva and Professor of Economic History and Public Finance.	**Switzerland** (*in part*).
W. E. S.	Walter E. Spahr, M.A., Ph.D. Professor of Economics, School of Commerce, Accounts and Finance, and Chairman of the Department of Economics, New York University.	**Stockbroker** (*in part*).
W. E. Wh.	W. E. Whitehouse, M.Sc. Assistant Lecturer and Demonstrator in Geography, University College of Wales.	**Sweden** (*in part*); **Switzerland** (*in part*).
W. F. G. S.	W. F. G. Swann, M.A., D.Sc. Director Bartol Research Foundation, The Franklin Institute, Philadelphia.	**Terrestrial Magnetism.**
W. G. B.	Walter George Bell, F.S.A., F.R.A.S. Author of *The Great Fire of London in 1666; The Great Plague in London in 1665.*	**Tewkesbury, Battle of.**
W. H. K.	William H. Kobbé. Consulting Engineer for Texas Gulf Sulphur Company.	**Sulphur, Special Applications of.**
W. H. Mi.	William Hobson Mills, M.A., Sc.D., F.R.S. Lecturer in Organic Chemistry, and Fellow of Jesus College, Cambridge University.	**Stereochemistry.**
W. H. Wi.	Sir William Henry Willcox, K.C.I.E., C.M.G., C.B., M.D., B.Sc., F.R.C.P. Physician and Lecturer on Chemical Pathology and on Forensic Medicine, St. Mary's Hospital, London. Medical Adviser to Home Office, 1919.	**Sulphonal Group, The.**
W. J. B.	Sir William John Berry, K.C.B. Director of Naval Construction, Admiralty. Director of Warship Production, 1917–23. Vice-President of Institution of Naval Architects.	**Submarine** (*in part*).
W. J. Br.	Rev. William Jackson Brodribb, M.A. Formerly Fellow of St. John's College, Cambridge.	**Tacitus, Cornelius** (*in part*).
W. J. Don.	William J. Donovan, A.B., LL.D. Formerly Assistant to Attorney-General of the United States.	**Supreme Court of the United States, The.**
W. L.	Walter Landells. London Stock Exchange.	**Stockbroker** (*in part*).
W. La.	William Latey. Of the Middle Temple, Barrister-at-Law and of the Probate and Divorce Courts.	**Sunday** (*in part*).
W. L. De B.	William L. De Baufre, E.E., M.E., M.S. Technical Adviser, Combustion Engineering Corporation, New York.	**Steam Generation** (*in part*).
W. Ma.	W. Martin. Foreign Editor, *Journal de Genève*, Switzerland.	**Switzerland** (*in part*).
W. McD.	William McDougall, M.A., M.B., F.R.S. Professor of Psychology in Duke University, N. C.	**Suggestion;** **Subliminal Self.**
W. M. M.	W. M. Marston, A.B., LL.B., Ph.D. Lecturer in Psychology, Columbia University.	**Synapse.**
W. S. G.	Walter S. Gifford, A.B., LL.D. President, American Telephone and Telegraph Company, New York.	**Telephone.**
W. S. Hi.	Walter Sanders Hiatt. Newspaper and Magazine Writer. Formerly correspondent for Associated Press, Europe and Asia.	**Syndicate** (*in part*).
W. S. L.	W. S. Lewis, M.Sc., F.R.G.S. Professor of Geography, University College, Exeter.	**Styria;** **Tatra Mountains.**
W. S. L.-B.	Walter Sydney Lazarus-Barlow, B.A., M.D., F.R.C.P. Member of the Cancer Committee, Ministry of Health. Formerly Professor of Experimental Pathology, Middlesex Hospital Medical School, London University.	**Sunlight Treatment.**
W Spr.	W. Sproule. Director and President of the Southern Pacific Company.	**Southern Pacific Company.**
W. T. C.	William Thomas Calman, D.Sc., F.R.S. Keeper of the Department of Zoology, British Museum (Natural History).	**Teredo.**
Y. A.	Yarnall Abbott. Artist, Painter. Fellowship, Pennsylvania Academy of Fine Arts, Philadelphia.	**Tempera.**

THE
ENCYCLOPÆDIA BRITANNICA
FOURTEENTH EDITION

VOLUME 21
SORDELLO TO TEXTILE PRINTING

SORDELLO, a 13th-century Italian troubadour, born at Mantua, who is praised by Dante in the *De vulgari eloquio,* and in the *Purgatorio* is made the type of patriotic pride. He is the hero of a well-known poem by Robert Browning. The real Sordello was the most famous of the Italian troubadours. About 1220 he appeared at Florence in a tavern brawl; and in 1226, while at the court of Richard of Bonifazio at Verona, he abducted his master's wife, Cunizza, at the instigation of her brother, Ezzelino da Romano. The scandal resulted in his flight (1229) to Provence, where he seems to have been for some time. He entered the service of Charles of Anjou, and probably accompanied him (1265) on his Naples expedition; in 1266 he was a prisoner in Naples. The last documentary mention of him is in 1269, and he is supposed to have died in Provence. His didactic poem, *L'Ensenhamen d'onor,* and his love songs and satirical pieces have little in common with Dante's presentation, but the invective against negligent princes which Dante puts into his mouth in the 7th canto of the *Purgatorio* is more adequately paralleled in his *Serventese* (1237) on the death of his patron Blacatz, where he invites all Christian princes to feed on the heart of the hero.

For Sordello's life and works *see* the edition of Cesare de Lollis (Halle, 1896).



BY COURTESY OF MESSRS. HOOPER AND JACKSON

SORDINO. AN OBSOLETE STRING INSTRUMENT

SORDINO, SORDONI, SORDUN, musical terms somewhat promiscuously applied (1) to contrivances for damping or muting wind, string and percussion instruments (*Sordini*); (2) to a family of obsolete wind instruments blown by means of a double reed (*Sordoni* or *Sordun*); (3) to a stringed instrument. To these must also be added the *Surdellina* or *Sordellina,* a kind of musette invented (*see* BAGPIPE) in Naples in the 17th century.

SOREL, AGNES (*c.* 1422–1450), mistress of King Charles VII. of France, was born of a family of the lesser nobility at Fromenteau in Touraine. She was attached to the service of Isabel of Lorraine, queen of Sicily, wife of René of Anjou, the brother-in-law of Charles VII. From 1444 until her death in 1450 she was the acknowledged mistress of the king, the first woman to hold that semi-official position which was to be of such great importance in the subsequent history of the old régime. Her ascendancy dated from the festivals at Nancy in 1444, the first brilliant court of Charles VII. Her sudden death from dysentery, shortly after the birth of her fourth child in 1450, was attributed, apparently without foundation, to poison.

See A. Vallet de Viriville's articles in *Bibliothèque de l'École des chartes* (3rd series, tom. i.); and R. Duquesne, *Vie et aventures galantes de la belle Sorel* (1909).

SOREL, ALBERT (1842–1906), French historian, was born at Honfleur on Aug. 13, 1842. He was of a characteristically Norman type, and remained all his life a lover of his native province and its glories. He studied law in Paris, and after a prolonged stay in Germany entered the foreign office (1866). In 1870 he was chosen as secretary by M. de Chaudordy, who had been sent to Tours as a delegate in charge of the diplomatic side of the problem of national defence; in these affairs he proved himself a most valuable collaborator. After the war of 1870–71, when Boutmy founded the *École libre des sciences politiques,* Sorel was appointed to teach diplomatic history (1872), a post in which he achieved great success. Some of his courses have formed books: *Le Traité de Paris du 20 novembre 1815* (1873); *Histoire diplomatique de la guerre franco-allemande* (1875); also the *Précis du droit des gens* which he published (1877) in collaboration with his colleague Théodore Funck-Brentano. In 1875 Sorel left the foreign office and became general secretary to the newly-created office of the *Présidence du sénat.*

His duties left him sufficient leisure for the great work of his life, *L'Europe et la révolution française* (8 vols., 1885–1904). His object was to do over again the work already done by Sybel, but from a less restricted point of view and with a clearer and more calm understanding of the chess-board of Europe. He spent almost 30 years in the preparation of this history; the analysis of the documents, mostly unpublished, on French diplomacy during the first years of the Revolution, which he published in the *Revue historique* (vol. v.–vii., xi.–xiii.), shows with what scrupulous care he read the innumerable despatches which passed under his notice.

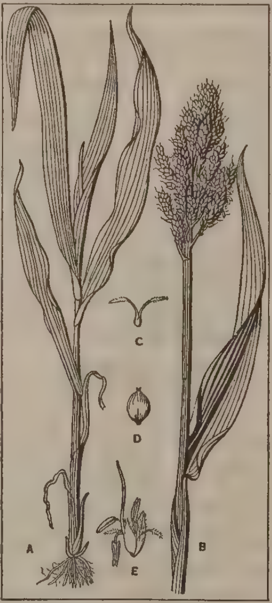
He was also, and above all things, an artist. He drew men from the point of view of a psychologist as much as of a historian. Sorel was elected a member of the Académie des sciences morales et politiques (Dec. 18, 1889) and of the Académie française (1894). He died in Paris on June 29, 1906.

Sorel's other works include: *La Question d'Orient au XVIIIe siècle, les origines de la triple alliance* (1878); *Montesquieu* (1887); and *Mme. de Staël* (1891) in the *Grands écrivains* series; *Bonaparte et Hoche en 1797* (1896); and *Recueil des instructions données aux ambassadeurs* vol. i. only (1884). Most of his essays and articles contributed to various reviews and to the *Temps* have been collected into volumes: *Essais d'histoire et de critique* (1883); *Lectures historiques* (1894); *Nouveaux essais d'histoire et de critique* (1898); *Études de littérature et d'histoire* (1901).

SOREL, CHARLES, Sieur de Souvigny (1597–1674), French novelist, was born in Paris about 1597. In 1635 he was historiographer of France. He tried to supersede the pastoral romance by the novel of adventure, the *Histoire comique de Francion* (1622). He also wrote *Le Berger extravagant* (1627), *Polyandre* (1648) and *La Connaissance des bons livres* (1673). He died on March 8, 1674.

SOREL, a town of Quebec, Canada, at the confluence of the Richelieu and St. Lawrence rivers. Pop. (1921) 8,174. It occupies the site of a fort built in 1665 by A. de Tracy to guard the route by way of the Richelieu to Lake Champlain and the Hudson, and is named after the first commandant.

SORGHUM, a term applied to a number of varieties of a small cereal grown extensively in warm countries, and known botanically as *S. vulgare, Andropogon Sorghum,* or *Holcus Sorghum.* It includes one of the most important tropical grains, great millet, Indian millet, or Guinea corn. In India it is known as *jawari* (Hindustani), *jowari* (Bengali), *cholum* (Tamil), and *jonna* (Telugu) and in the West Indies as Negro or Guinea corn. It is a strong grass, growing to a height of from 4 to 8 or even 16 ft.; the leaves are sheathing, solitary, and about 2 in. broad and 2½ ft. in length; the panicles are contracted and dense, and the grains, which are enclosed in husks and protected by awns, are round, hard, smooth, shining, brownish-red, and somewhat larger than mustard seeds. The plant is cultivated in Asia, in the United States, and in the south of Europe. E. Hackel (in *Die natürlichen Pflanzenfamilien*) says the culture probably had its origin in Africa, where a variety known as durra has become the most important cereal; the natives also chew the stem, which contains sugar. The sweet sorghums are grown in China, north India, Africa and America for the manufacture of syrup and for forage.



Millet or Guinea Corn (Sorghum vulgare)
(A) Shoot, (B) Flowering stem (inflorescence), (C) Pistil, (D) Fruit, (E) Single flower, (C & E) Enlarged

A full account of the cultivation and use of the species in India will be found in Sir G. Watt's *Dictionary of the Economic Products of India* (1893). *See* also W. W. Robbins, *Botany of Crop Plants* (Philadelphia, 1924).

SORIA, a province of Spain, formed in 1833 out of Old Castile. Pop. (1920) 151,595; area, 3,983 sq.m. Soria is a bleak and lofty region, bounded on three sides by mountains. A range of sierras culminating in the peaks of Urbion (7,389 ft.) and Cebollera (7,139 ft.) on the north, and the great Sierra del Moncayo (7,707 ft.) on the east, separate the valley of the Duero from the Ebro. Almost the whole of the province belongs to the region watered by the Duero and its affluents. There are extensive forests of pine, oak and beech and large tracts of pasture land. The climate is cold and dry, and the scenery grand, but austere. Between 1887 and 1900 the population decreased by nearly 7,000; it is now stationary.

SORIA, the capital of the Spanish province of Soria; on the river Duero (Douro). Pop. (1920) 7,619. The churches of Santo Domingo and San Nicolas, the collegiate church of San Pedro, the cloisters of the convent of San Juan, and several other ecclesiastical buildings are fine specimens of Romanesque work of the 12th and 13th centuries. Near the Duero are the ruins of the old citadel, and the 13th century walls may still be seen.

SORITES, in logic, means a series of connected syllogisms, in which the conclusion of one syllogism is used, as a premise in another. *See* Logic, and the bibliography given there.

SORMOVO, a town of Russia, in the Nizhegorod province, on the Volga. It was a village of about 6,000 inhabitants in 1897, but has grown since the provision of electric power to a population (1926) of 40,071. It manufactures machinery and refines crude Baku naphtha brought up the Volga river.

SOROCA, a frontier town of Bessarabia, Rumania, capital of the department of Soroca, situated on the right bank of the Dniester, 81 m. north-north-west of Kishinev. Pop. (1928) 27,000 including many Jews. Corn, wool, fruit, wine and cattle are exported. Soroca was the old Genoese colony of Olchiona, and still has the ruins of a 13th century Genoese castle. The Moldavians erected a fortress in the 15th century. Soroca changed hands many times between Poland, Russia and Turkey.

SOROLLA Y BASTIDA, JOAQUIN (1863–1923), Spanish painter, was born in Valencia, and received his art education first in his native town and under F. Pradilla, and then in Italy and Paris. His first striking success he achieved with "Another Margaret," which was awarded a gold medal in Madrid and was bought for the St. Louis Gallery. He soon became the acknowledged head of the modern Spanish school of painting. His "Fishermen's Return" was acquired for the Luxembourg Museum. His exhibit at the Paris Universal Exposition of 1900 won him a medal of honour and his nomination as Knight of the Legion of Honour. Between 1910 and 1920 he contributed to the Hispanic Society of America, a series of portraits of Spanish writers and a "Panorama of the Forty-nine Provinces of Spain," consisting of 49 compositions with views and costumes. He died at Madrid on Aug. 10, 1923. He is represented at the Berlin National Gallery, at the Venice and Madrid Museums and in Buenos Aires.

See Hispanic Society of America, Eight Essays on *Joaquin Sorolla y Bastida* (1909); A. de Beruete y Moret, *Sorolla y Bastida,* 1920.

SORORATE. This term was introduced by Sir James Frazer to designate all marriages with a wife's sister, whether in the lifetime of the first wife or after her death. In his view it is complementary to the custom of the levirate and both "are offshoots from one common root, a system of group marriage in which all the husbands were brothers and all the wives were sisters to each other, though not to their husbands; and that system in its turn originated in a simple desire to get wives as easily and cheaply as possible." (*Folklore of the Old Testament,* vol. ii., p. 317.)

It is to be noted that in cases where fraternal polyandry is permitted, the wife of the eldest brother is the common wife while the wife of the youngest brother belongs to him alone, and that in societies where a definite relation as the cross-cousin, is prescribed for the eldest son, the youngest son is free to marry whom he will or can, within the more general rules of exogamy, so that the wives of the younger brothers in such cases do not or may not possess the status required for the wife of the eldest brother, while the younger sister of the late wife would possess that status. In the case of the matrilineal Garos, marriage with a prescribed relative, the cross-cousin, the son of the woman's mother's brother, is binding only on the youngest daughter. No rights are conferred by marriage with the elder daughters. It is further to be noted that as with the Ba-Ila (*The Ila speaking peoples,* vol. i., p. 391) a woman though married may be called to leave her husband and her children to become the wife of her late sister's husband under the sororate regulation. In India it is generally the wife's younger sister who is taken as a second wife when the first wife is barren or suffers from an incurable disease. In advanced communities marriage with the deceased wife's sister occurs for practical reasons when there are young children to be brought up. In primitive communities the relationship created by the first marriage between the two families is marked by a series of obligations of an economic, religious and social nature so that there is clearly an advantage in maintaining the existing mode of relationship over the creation of a new series of analogous obligations. Thus in Ashanti "in the case of chiefs when a wife dies, the wife's family are expected to replace the deceased woman by giving her sister in marriage to the chief" (R. S. Rattray, *Ashanti*, p. 34, 1923). In the case of societies organized on the dual basis (*see* DUAL ORGANIZATION), each moiety acts as a reservoir of spouses for the other moiety and is obliged to find mates.

See Frazer, *Folklore of the Old Testament*, vol. ii. (1918); Westermarck, *History of Human Marriage*, vol. iii. (1921).

SORORITIES, organizations of women distinctive to colleges and universities in the United States. Sororities are self-perpetuating, secret in nature chiefly as to initiation ritual, having each a characteristic badge, and various symbolic insignia—colours, flower, tree, flag, patron, motto and pledge pin. The first Greek letter sorority, Kappa Alpha Theta, was founded at De Pauw university in Jan. 1870. In 1928, it contained 1,037 chapters and about 175,000 members.

Government and Activities.—The governments of all are similar—a council of three to nine members to carry out legislation enacted at national or district conventions. Many sororities have accumulated endowment funds. Practically all sororities publish quarterly magazines, song books, catalogues and bulletins of various kinds. Because of inadequate living conditions in many institutions, each sorority has sanctioned the establishment of lodges by its chapters. Fifty per cent of the chapters are so equipped, this property being worth about $5,000,000. A large Panhellenic hotel has been built in New York city. The National Panhellenic Congress was formed in Chicago in 1902. Sororities have made valuable surveys of collegiate conditions as they pertain to women and have done much to improve them. Extraneous philanthropic work has been undertaken, and many sororities assist their members with scholarships, loan funds, vocational and employment bureaux.

See William Raimond Baird, *Manual of Fraternities* (1927); Ida S. Martin, *The Sorority Handbook* (10th ed., 1928). (R. L. F.)

SORREL (*Rumex acetosa*) (family Polygonaceae), a hardy perennial, native to Great Britain and found throughout the north temperate zone. The leaves are used in soups, salads and sauces. Sorrel grows freely in any good garden soil, and is increased by dividing the roots during the early part of spring. They should be planted in rows 15 to 18 in. apart. The leaves, when fully grown, are gathered singly. The common garden sorrel is much superior to the wild plant; French sorrel (*Rumex scutatus*) is a hardy perennial, distributed through Europe but not native in Great Britain.

SORRENTO, a city of Campania, Italy (anc. *Surrentum*, *q.v.*). Pop. (1921), 7,121 (town); 9,783 (commune). It stands on cliffs about 160 ft. high, between the Bay of Naples and the Bay of Salerno. It is a summer and winter resort, its northerly aspect rendering it comparatively cool. At Sorrento Bernardo Tasso wrote his *Amadigi;* and Torquato Tasso, to whom a marble statue has been erected in the Piazza, was born in the town in 1544.

SORSOGON, a municipality (with administration centre and 47 *barrios* or districts), capital and port of the province of Sorsogon, Luzon, Philippine Islands, on the Gulf of Sorsogon, 279 m. from Manila. Pop. (1918), 16,694. It lies in a rich agricultural region, abacá being its chief product; and is a busy commercial place. The language is Bikol.

SOSIGENES, Greek astronomer and mathematician, probably of Alexandria, flourished in the 1st century B.C. According to Pliny (*Nat. Hist.* xviii. 25), he was employed by Julius Caesar in the reform of the Roman calendar (46 B.C.), and wrote three treatises. From another passage of Pliny (ii. 8) it is inferred that Sosigenes maintained the doctrine of the motion of Mercury round the sun, which is referred to by Cicero, and was also held by the Egyptians. He was the tutor of Alexander of Aphrodisias, the most famous of the commentators on Aristotle. He wrote a work on *Revolving Spheres*, from which some important extracts are preserved in Simplicius's commentary on Aristotle's *De caelo*.

SOSITHEUS (*c.* 280 B.C.), Greek tragic poet, of Alexandria Troas, a member of the Alexandrian "pleiad." He must have resided at some time in Athens, since Diogenes Laërtius tells us (vii. 5, 4) that he attacked the Stoic Cleanthes on the stage, and was hissed off by the audience. Suïdas calls him a Syracusan. According to an epigram of Dioscorides in the Greek Anthology (*Anth. Pal.* vii. 707) he restored the satyric drama in its original form. Part of his pastoral play, *Daphnis* or *Lityerses* is extant.

See O. Crusius *s.v.* Lityerses in Roscher's *Lexikon der griechischen und römischen Mythologie*. The fragment in Nauck's *Tragicorum graecorum fragmenta* apparently contains the beginning of the drama.

SOSNOWIEC, a town of Poland, in the province of Kielce. Pop. (1921) 86,700. It owes its rapid rise to its position in the centre of the Dambrowa coalfield, between Bendzin, Dambrowa and Katowice. The towns of this region are almost continuous, extending from Kielce into the provinces of Cracow and Silesia. Sosnowiec is also a great railway junction. Situated on the Warsaw-Vienna railway, it is a junction for the Kielce and Radom, Cracow and Lemberg, and Katowice and Breslau lines. Electric power stations have been established, sending a cable as far as Czenstochowa, while an electric tram system is being extended to the other towns in the basin. Iron foundries and some textile factories, as well as coal mines, employ large numbers of workmen. Sosnowiec is, after Lodz, the largest Polish industrial town.

SOSTENUTO, musical term signifying that the passage so marked is to be played in a "sustained" manner.

SOTADES, Greek satirist, of Maronea in Thrace (or of Crete), chief representative of the writers of coarse satirical poems, called *κίναιδοι*, composed in the Ionic dialect and in a metre named after him "sotadic." He lived in Alexandria during the reign of Ptolemy II. Philadelphus (285–247 B.C.). Sotades was imprisoned for a satire on Ptolemy, escaped to Caunus, was captured, shut up in a leaden chest and thrown into the sea.

Only a few genuine fragments of Sotades have been preserved (*see* J. G. Hermann, *Elementa doctrinae metricae*, 1816).

SOTER, pope from about 167 to 174. He wrote to the Church of Corinth and sent it aid. His letter is mentioned in the reply given by Dionysius, bishop of Corinth, and Harnack thinks it can be identified with the second so-called epistle of Clement.

SOTHERN, EDWARD ASKEW (1826–1881), English actor, was born in Liverpool on April 1, 1826, the son of a merchant. After acting in the English provinces, he went to the United States in 1852. There he made a great success in New York in 1858 as Lord Dundreary in Tom Taylor's *Our American Cousin*. He gradually worked up the humour of this part so that it became the heart of the play. He created the title rôle in T. W. Robertson's *David Garrick* (1864). Sothern also made a hit as Sam Slingsby in Oxenford's *Brother Sam* (1865). Sothern was a born comedian, and off the stage had a passion for practical joking. He died in London Jan. 21, 1881.

SOTHERN, EDWARD HUGH (1859–), American actor, was born at New Orleans on Dec. 6, 1859, the son of Edward Askew Sothern, noted English comedian. His first stage appearance was in a small part with his father's company at the Park theatre in New York city in 1879. He toured England in 1882–83, became leading comedian in McCullough's company in 1883, and under Daniel Frohman was leading man at the Lyceum theatre in New York city. He married Virginia Harned in 1896, and in 1899 formed his own company with her as his leading lady.

In 1900 he appeared in the title rôle of *Hamlet*, in 1901 in that of *Richard Lovelace* and in 1902–03 as Villon in *If I Were King*, three of his greatest rôles. In 1904 he entered into combination with Julia Marlowe, the two first appearing together in *Romeo and Juliet* at Chicago. Except for two years, 1907–09, they played together almost continuously until their retirement from the stage. They were married in 1911. Besides *Romeo and Juliet* they have co-operated in *Much Ado About Nothing*, *Taming* *of the Shrew, Merchant of Venice, Twelfth Night, Macbeth, Jeanne D'Arc, John the Baptist, When Knighthood was in Flower* and *The Sunken Bell.* Although noted chiefly as a Shakespearian actor, Sothern has a repertory of over 125 diverse parts.

See his autobiography, *The Melancholy Tale of Me* (1916); and W. M. Winter, "The Art of E. H. Sothern," *Century Magazine* (May, 1915).

SOTHIC PERIOD, in ancient Egyptian chronology, the period in which the year of 365 days circled in succession through all the seasons. The tropical year, determined as it was in Egypt by the heliacal rising of Sirius (Sothis), was almost exactly the Julian year of precisely 365¼ days (differing from the true solar year, which was 11 minutes less than this). The sothic period was thus 1,461 years. (*See* EGYPT: *Ancient.*)

SOTHO, a powerful nation of Bantu-speaking peoples, numbering some 500,000, which inhabits the Crown colony of Basutoland in South Africa. It is made up of a large number of different tribes, which were welded together early last century by the great chief Moshesh. Culturally they belong to the central division of southern Bantu (*see* SOUTH AFRICA: *Ethnology*).

See E. Casalis, *The Basutos* (1861); E. A. T. Dutton, *The Basuto of Basutoland* (1923).

SOTO, FERDINANDO [Fernando, or Hernando] **DE** (1496?–1542), Spanish captain and explorer, born at Jeréz de los Caballeros, in Estremadura. In 1519 he accompanied d'Avila on his second expedition to Darien. In 1528 he explored the coast of Guatemala and Yucatan, and in 1532 he led 300 volunteers to reinforce Pizarro in Peru. He played a prominent part in the conquest of the Inca kingdom (helping to seize and guard Atahualpa, discovering a pass through the mountains to Cuzco, etc.), and returned to Spain with a fortune of 180,000 ducats, which enabled him to marry the daughter of his old patron d'Avila. Excited by reports as to the wealth of Florida (a term then commonly used in a much wider extension than subsequently), he sold part of his property, gathered a force of 620 foot and 123 horse, armed four ships, and obtained from Charles V. a commission as "adelantado of the Lands of Florida" and governor of Cuba. Sailing from San Lucar in 1538, he first went to Havana, his advanced base of operations; starting thence on May 12, 1539 he landed in the same month in Espiritu Santo bay, on the west coast of the present State of Florida. For nearly four years he searched for gold. He probably passed north into Georgia as far as 35′ N., then south to the neighbourhood of Mobile, and finally north-west towards the Mississippi, which was reached in 1541; the following winter was spent on the Ouachita, in modern Arkansas and Louisiana, west of the Mississippi. As they were returning in 1542 along the Mississippi, De Soto died. De Soto's men, under Luís Moscoso de Alvarado, descended the Mississippi to the sea in 19 days from a point close to the junction of the Arkansas with the great river, and thence coasted along the Gulf of Mexico to Panuco.

Three narratives of this expedition are extant, of seemingly independent origin. (1) *Relacam* . . . (Evora 1557) professing to be the work of a Portuguese of Elvas, who had accompanied the expedition, was published in an English translation by Hakluyt in 1609 (reprinted from the 1611 edition by the Hakluyt Society [London, 1851]). (2) The famous history of Florida by Garcilasso de la Vega; it was completed in 1591, and first appeared at Lisbon in 1605 under the title of *La Florida del Ynca,* and has since passed through many editions in various languages. (3) A report presented to Charles V. of Spain in his Council of the Indies in 1544, by Luis Hernandez de Biedma; it is printed in Ternaux-Compans' "Recueil de pièces sur la Floride" in the *Historical Collections of Louisiana* (Philadelphia, 1850) and in W. B. Rye's reprint for the Hakluyt Society of Hakluyt's translation of the Portuguese narrative (*The Discovery and Conquest of Terra Florida,* London, 1851).

See also Bancroft's *History of the United States,* vol. i.; J. H. M'Culloch, *Researches . . . concerning the aboriginal history of America* (Baltimore, 1829); Albert Gallatin, "Synopsis of the Indian Tribes," in *Archaeologia americana,* vol. ii. (Cambridge, Mass., 1836); E. G. Bourne (ed.), *Narratives of the Career of Hernando de Soto in the Conquest of Florida* (2 v., New York, 1904); J. W. Monette, *History of the Discovery and Settlement of the Valley of the Mississippi* (New York, 1846, 2 vols.).

SOTTO VOCE (It.), lit. "under the voice," that is, an undertone. Term applied both to music and speech.

SOUBISE, BENJAMIN DE ROHAN, DUC DE (?1589–1642), Huguenot leader, younger brother of Henri de Rohan, inherited his title through his mother Catherine de Parthenay. He served his apprenticeship as a soldier under Prince Maurice of Orange-Nassau in the Low Countries. In the religious wars from 1621 onwards his elder brother chiefly commanded on land and in the south, Soubise in the west and along the sea-coast. Soubise's chief exploit was a singularly bold and well-conducted attack (in 1625) on the Royalist fleet in the river Blavet (which included the cutting of a boom in the face of superior numbers) and the occupation of Oléron. He commanded at Rochelle during the famous siege. When surrender became inevitable he fled to England, which he had previously visited in quest of succour. He died in 1642 in London.

SOUBISE, CHARLES DE ROHAN (1715–1787), peer and marshal of France, the grandson of the princesse de Soubise known to history as one of the mistresses of Louis XIV. He accompanied Louis XV. in the campaign of 1744–48. Soon after the beginning of the Seven Years' War, through the influence of Mme. de Pompadour, he was put in command of a corps of 24,000 men, and was defeated at Rossbach (1757). He continued in the service until the peace of 1763. He died in Paris on July 4, 1787.

SOUHAM, JOSEPH, COUNT (1760–1837), French soldier, was born at Lubersac on April 30, 1760, and became a general of division in 1793. He was disgraced with Moreau and Pichegru for alleged participation in the conspiracy of Cadoudal. He regained his rank in 1809, took a notable part in Gouvion St. Cyr's operations in Catalonia, and won the title of count. In 1812 Masséna, in declining the command of Marmont's army recommended Souham for the post. The latter was thus pitted against Wellington, and by his skilful manoeuvres regained the ground lost at Salamanca. At the fall of the First Empire he deserted the emperor, and was well received by Louis XVIII., who gave him high commands. He retired in 1832, and died on April 28, 1837.

SOULT, NICOLAS JEAN DE DIEU, Duke of Dalmatia (1769–1851), marshal of France, was born at Saint-Amans-la-Bastide (now in department of the Tarn) on March 29, 1769, the son of a notary. He was intended for the bar, but on his father's death in 1785 he enlisted as a private in the French infantry, and rose rapidly in the army. He laid the foundations of his military fame by his conduct in Masséna's great Swiss campaign (1799), and especially at the battle of Zürich. He acted as Masséna's principal lieutenant through the protracted siege of Genoa, and after many successful actions he was wounded and taken prisoner at Monte Cretto on April 13, 1800. The victory of Marengo restoring his freedom, he received the command of the southern part of the kingdom of Naples, and in 1802 he was appointed one of the four generals commanding the consular guard. Despising Napoleon, Soult affected devotion, being appointed in 1803 to the command at Boulogne and in 1804 to be one of the first marshals of France. He commanded a corps at Ulm, and at Austerlitz (*q.v.*) he led the decisive attack. After the peace of Tilsit he was created (1808) duke of Dalmatia. In the following year he was given a command in Spain after the battle of Gamonal and he pursued Sir John Moore to Corunna.

For the next four years Soult remained in Spain, and his military history is that of the Peninsular War (*q.v.*). In 1812 he was obliged, after Wellington's victory of Salamanca, to evacuate Andalusia, and was soon after recalled from Spain at the request of Joseph Bonaparte, with whom he had always disagreed. In March 1813 he assumed the command of the IV. corps of the *Grande Armée,* but he was soon sent to the south of France to repair the damage done by the defeat of Vittoria. His campaign there is the finest proof of his genius as a general, although he was repeatedly defeated by Wellington, for his soldiers were raw conscripts, facing Wellington's veterans.

Marshal Soult's political career was less creditable, and it has been said of him that he had character only in front of the enemy. After the first abdication of Napoleon he declared himself a Royalist, received the order of St. Louis, and acted as minister for war (Dec. 3, 1814–March 11, 1815). When Napoleon returned from Elba Soult declared himself a Bonapartist, was made a peer of France and acted as major-general (chief of staff) to the emperor in the Waterloo campaign.

At the Second Restoration he was exiled, but was recalled in 1819 and in 1820 again made a marshal of France and in 1827 a peer. After the revolution of 1830 he made out that he was a partisan of Louis Philippe, who revived for him the title of marshal-general. He was minister for war, 1830–34 and 1840–44, and ambassador extraordinary to London for the coronation of Queen Victoria in 1838. In 1848, when Louis Philippe was overthrown, Soult again declared himself a republican. He died at his castle of Soultberg, near his birthplace, on Nov. 26, 1851. Soult published a memoir justifying his adhesion to Napoleon during the Hundred Days, and his notes and journals were arranged by his son Napoleon Hector (1801–1857), who published the first part (*Mémoires du maréchal-général Soult*) in 1854. Le Noble's *Mémoires sur les opérations des Français en Galicie* are supposed to have been written from Soult papers.

See A. Sallé, *Vie politique du maréchal Soult* (1834); A. de Grozelier, *Le Maréchal Soult* (Castres, 1851); A. Combes, *Histoire anecdotique du maréchal Soult* (Castres, 1869).

SOUND. The definition of the word sound depends upon the point of view adopted. Subjectively it may be regarded as the sense impression of the organ of hearing; objectively, the vibratory motion which produces the sensation. The physiological and psychical aspects of sound are treated in the article on HEARING. In what follows we shall deal mainly with the physical aspects of sound, that is, with the phenomena which occur outside the ear. Just as it is customary to regard "light" as including invisible radiations in the ultra-violet and infra-red, so we shall regard sound as including mechanical vibrations of all frequencies audible or otherwise. It may, in fact, be regarded as a branch of mechanics which deals with alternating or vibratory motion. As we shall see, the study of alternating mechanical motions is closely analogous to that of alternating electrical currents; the mathematical theory of one is often of much assistance in the consideration of the other. Alternating currents provide also a convenient means of exciting the corresponding mechanical vibrations, of whatever frequency. Recent developments in the production of alternating currents of very high frequency have their counterpart in the production of corresponding mechanical vibrations.

Sound Due to Vibratory Motion.—It is common observation that all sounding bodies are in a state of vibration. In the more obvious cases (*e.g.*, a vibrating stretched string) the vibrations can be seen directly as a blurred outline, or optical magnification may be necessary to reveal their existence. The vibrations of a body which is emitting sound can sometimes be felt if the finger touches the surface lightly; any appreciable pressure by the finger is often sufficient to stop the sound and the vibration instantly. The simple experiment with a lightly suspended pithball brought into contact with the surface of the body emitting sound, proves in a convincing manner that the body is in vibration—a resonant glass or metal vessel, or a tuning fork, serve excellently as a source of sound for this experiment.

Medium Necessary for Sound Transmission.—When a body, *e.g.*, a tuning fork, vibrates in an elastic medium such as air, the latter is compressed and rarefied by the "to and fro" motions of the vibrating body. These compressions and rarefactions are passed on from one layer of the medium to the next and in this manner the vibrations of the body are transmitted through the medium to a distant point. The necessity for an elastic medium to transmit the sound from the source is best illustrated by an experiment first performed effectively by Boyle and later by Hawksbee (1705). In this experiment a bell is suspended by a silk thread inside a glass globe connected to a vacuum pump. When the globe is full of air and the bell is excited, the sound can be heard clearly. As the air is withdrawn by the pump, however, the sound weakens and ultimately, when the vacuum is very good, the bell becomes inaudible. The experiment is more effective when an electric bell is set ringing continuously in an atmosphere of hydrogen reduced to an extremely low pressure by an efficient quick-acting vacuum pump. We are naturally inclined to regard the atmosphere as the universal medium for the transmission of sound. Speech, music, and all the familiar noises of every day life are conveyed to the ear through the surrounding air. Solids and liquids are, however, excellent media for sound transmission as may be observed in numerous ways. The water-pipes in the house often carry the "singing" and "hammer" sounds which travel along the pipes from one room to another. The "string-telephone" exemplifies the passage of sound through a long wire tightly stretched. Certain "deaf cases" have been made to hear via the bones of the head, by holding one end of a stiff rod between the teeth, the other end being pressed into contact with the vibrating source, *e.g.*, a clock or a piano. Listening near the hull in a ship's cabin below the water line, the sound of the propeller of a neighbouring ship can be heard clearly—exemplifying the transmission of sound through the sea. If further proof is desired submersion of the observer's head in the water will be even more convincing.

Velocity of Sound.—The sound of thunder is not heard until some time after the lightning flash; the flash of a gun is seen before the report is heard; the puff of "white" steam from the whistle of a distant engine is observed before the sound arrives. These, and many other examples might be quoted as evidence that sound takes time to travel and that its velocity is small compared with the velocity of light (186,000 miles per second). In air, sound takes nearly five seconds to travel a mile, in water about one second, and in iron or steel about a third of a second, *i.e.*, it travels about fifteen times as fast in iron as in air. The experiment is easily tried on a long stretch of iron railing or piping—an observer at one end, listening to the sound of a blow on the other end, hears two blows, the first through the iron, the second through the air.

All kinds of sounds, high and low, loud and weak (with certain limited exceptions) travel with the same velocity in the same medium,—otherwise the music of a distant band would become confused on arrival at the listener's ears. Just as ripples spread outwards in two dimensions from a stone thrown into a pond, so waves of sound spread, in three dimensions, from a simple vibrating body through the surrounding medium. The movement of any particle of the medium, is, however, purely local, each particle making small to and fro excursions in a manner similar to that of the vibrating body itself. The local motion of the particles must be clearly distinguished from the motion of the disturbance which travels forward from layer to layer of the medium with an ever-increasing radius. It is the state of the minute to and fro motion which advances, the medium as a whole, after the disturbance has passed, being practically in its initial position. In this respect the motion is well exemplified by the ripples on a water surface. The sound waves, however, differ from the ripples in one important respect, viz. the vibratory motion takes place in the same line as the direction of advance of the wave, whereas in the case of the ripples the to-and-fro motion is *at right angles* to the direction of propagation of the wave. The former type of motion, as in the sound wave, is termed *longitudinal;* the latter, *transverse.* The general character of longitudinal wave motion may be demonstrated by means of a long helical spring (*e.g.*, 6 ft. long 4 inches dia. of wire ·06 in. thick) supported horizontally at frequent intervals by strong threads. If one end be moved to and fro longitudinally a corresponding motion will travel, like a wave, to the other end. Various effects of reflection, etc., with which we are not immediately concerned may also be demonstrated with this simple apparatus. It is a commonplace observation that any number of sound waves may cross the same airspace at the same time. No confusion arises due to this overlapping of the waves.

Receivers of Sound.—To complete the natural sequence of events a suitable receiver is required to collect the sound energy after transmission through the intervening elastic medium. When the sound travels through the atmosphere the ear forms a natural, though not always the most convenient, receiver. When liquids or solids transmit the sound other forms of receiver are generally to be preferred.

Order of Treatment.—From what has already been said it will appear that the physical basis of the theory of sound involves three fundamental considerations. First a vibrating body is essential to the production of sound; second, an elastic medium in contact with the vibrating body is required to transmit the vibrations to a distant point; and third, some form of receiver is necessary to absorb the energy from the medium and to reconvert it into a form of vibratory motion convenient for observation. We shall follow this order of treatment as far as practicable.

SOURCES OF SOUND

Vibrating Systems.—A fundamental advance in the theory of sound was made in 1843 when Ohm proved that the simplest and most fundamental type of sound sensation is that which corresponds to a simple harmonic motion, *i.e.*, to the simplest mathematical form of periodic function. (*See* HARMONIC MOTION.) Such motions may vary in period and amplitude but in no other manner; they are consequently ideal for the production of "simple" or "pure" tones. Another important feature of this form of motion is the possibility of transmission from one medium to another without change of form. Again, it has been proved by Fourier that the most complex form of periodic motion can be analysed (or synthesised) into a series of simple harmonic motions having frequencies which are multiples of that of the complex motion. The vibrations of a tuning fork may approximate closely to a simple harmonic motion, the resulting sensation being described as a "pure tone."

Simple Harmonic Motion (*see* WAVE MOTION) is typified by the oscillations of a particle attracted towards a fixed point O with a force varying as the distance x from O. If s be the force at unit distance from O, then at x it will be $-sx$, the sign of the force being always opposite to that of the displacement. Thus if m is the mass of the particle

$$m\partial^2x/\partial t^2 = -sx \quad \text{or, writing } n^2 = s/m, \quad \partial^2x/\partial t^2 + n^2x = 0 \qquad (1)$$

of which the solution is

$$x = a\cos(nt+\epsilon) \qquad (2)$$

the constants a and ϵ are arbitrary. The motion is therefore periodic, the values of the displacement x, and the velocity $\partial x/\partial t$ of the particle recurring whenever nt increases by 2π. The *periodic time* of the oscillation is therefore

$$T = 2\pi/n = 2\pi\sqrt{(m/s)} \qquad (3)$$

a quantity independent of a. The type of vibration indicated by equation (2) is of fundamental importance. The equation shows that the particle oscillates between two points at a distance a on opposite sides of O. This distance a is called the *Amplitude* of the vibration. The quantity ϵ represents the initial *Phase* of the vibration when $t=0$. By simple differentiation of equation (2) we obtain the *velocity of the particle* $\partial x/\partial t = -an\sin(nt+\epsilon)$ and *the acceleration* $\partial^2x/\partial t^2 = -n^2x$ as postulated in equation (1). The meaning of equation (2) for S.H.M. is often expressed graphically as the projection on a diameter of the motion of a point moving uniformly, with constant angular velocity n on a circular path of radius a, the periodic time (for one revolution) being $T=2\pi/n$. The reciprocal of the *Period* T, viz., $n/2\pi$, is termed the *Frequency*. The quantity n is sometimes called the *pulsatance*.

Practical demonstration of the relation between a simple harmonic motion and the corresponding circular motion, may be seen in any type of reciprocating engine; the motion of the piston in the cylinder is approximately simple harmonic whilst that of the flywheel is circular with uniform velocity. A simple pendulum, a weight suspended on a spring, a rapidly vibrating wire, tuning fork, or diaphragm all illustrate, approximately, simple harmonic motion; any differences in their motion arising from differences in frequency and amplitude only.

The relationship (3) for the periodic time of vibration is of very wide application in the theory of sound. It indicates the general principle that the period T increases with the "inertia" or mass factor m and decreases with the "stiffness" or "elastic factor" s (s being the force required to produce unit displacement). Thus in the case of a simple pendulum of length l, $s=mg/l$, whence the periodic time of an oscillation is $T=2\pi\sqrt{(l/g)}$. The period of vibration of a mass m on a helical spring of strength s is expressed directly by (3), viz. $T=2\pi\sqrt{(m/s)}$. We also obtain from (2), for the energy of the vibrating particle

$$\begin{aligned} \text{Mean kinetic energy} = \text{Mean potential energy} &= ma^2n^2/4 \\ \text{Maximum energy} &= ma^2n^2/2. \end{aligned} \qquad (4)$$

The energy is a maximum at the mid-point and at the two turning points of the vibration. In the former case it is all kinetic and in the latter all potential energy.

When a single particle is acted on by a number of distinct forces, each of which would cause it to perform S.H.M., the question arises as to the resultant motion. A number of important cases require consideration:—I. *Vibrations of the Same Frequency and in the same straight line.* It may be shown that such a system of vibrations is reduced to a single resultant by means of a vector polygon, the angles representing relative phases, in exactly the same manner as a system of forces acting at a point. II. *Two Vibrations of nearly the same frequency and acting in the same straight line: beats.* This case has very important applications in sound and is of frequent occurrence. If two vibrations of the same amplitude and *nearly* equal frequency act together the resultant amplitude will at first be *double* the single amplitude. As the higher frequency vibration gains on the lower, however, thereby changing the relative phase, a point will be reached when they are in opposition and will neutralize each other (amplitude zero). This cyclic process goes on so long as both vibrations are maintained. If the two frequencies are N and $N+\partial N$, the resultant amplitude will vary between $2a$ and 0, the time interval between two successive maxima being $2\pi/\partial N$, *i.e.*, the *frequency of the beats* will be ∂N, the difference between the two, nearly equal, frequencies. The phenomenon of beats is observed when two notes *nearly* in tune are heard together—a periodic rise and fall of intensity being noticed. As the beats between two notes increase in frequency a sensation of roughness or discord (*dissonance*) sets in, and ultimately two independent notes of the diatonic scale are recognised. The *beat effect* has direct application in the comparison of one sound frequency (*e.g.*, that of a vibrating string) with a standard of frequency such as a tuning fork. The well-known *heterodyne* of radio-telegraphy or telephony is a beat effect between two sets of radio-frequency (*e.g.*, 10^6 cycles per second) oscillations, slightly mistuned. The *beat-note* is adjusted to have any frequency, say 500 periods per second, which falls within the audible range. III. *Vibrations at right-angles.* In this case we are dealing with the motion of a particle on a plane surface. When the imposed vibrations have the same frequency, it is readily shown that the particle traces an elliptical path, which may vary from a straight line, when the phases differ by 180°, to a circle when the phases differ by 90° and the amplitudes are equal. (a). *Frequencies nearly equal.* In this case the particle follows a path which slowly changes through the various forms, straight line, ellipse, circle, etc., due to the slowly changing phase difference. The frequency of performance of a complete cycle of figures will, of course, be ∂N, the difference between the two nearly equal frequencies. (b). *Frequencies Commensurate.* 2:1, 3:1, 4:1, etc. Here again the particle traces out a curve having a certain number of loops—this number being equal to the ratio of frequencies. For *nearly* commensurate frequencies the curve slowly changes as the phase difference varies. Numerous mechanical devices have been designed for drawing automatically the various "harmonic" curves obtained by compounding two or more harmonic vibrations. These generally consist of two compound pendulums controlling a common writing point, and each capable of performing simple harmonic motion in one or possibly two directions simultaneously. Beautiful and fascinating designs may be traced in this way.

An optical method of exhibiting a small difference of frequency between two tuning forks was devised by J. A. Lissajous (1822–

1880). A small mirror is attached to one prong of each fork, one of which vibrates in a vertical plane and the other horizontally. A narrow pencil of light is reflected successively from the two mirrors and falls on a screen. When the forks vibrate together the spot of light on the screen traces out the "resultant" curve of the two vibrations. If the two forks have the same frequency the figure is a stationary ellipse; if they differ slightly in frequency, the ellipse assumes successively the various forms including a straight line and a circle. These figures are known as *Lissajous figures.* The same principle may, of course, be applied to any two systems vibrating at right angles with approximately equal, or commensurate, frequencies. Recently Dye has employed the cathode-ray oscillograph for the harmonic comparison of very high electrical frequencies (of the order 10^6 p.p.s.).

Fourier's Theorem.—*Summation of any number of simple harmonic-vibrations of commensurate frequencies. Synthesis and analysis of complex wave-forms of vibration.* This very important theorem due to J. B. J. Fourier (*Theorie de la Chaleur.* Paris, 1822) asserts that *any single-valued periodic function whatever can be expressed as a summation of simple harmonic terms having frequencies which are multiples of that of the given function.* (*See* HARMONIC ANALYSIS.) The theorem not only deals with the synthesis of a complex form of vibration, but also indicates a method of analysis of such a vibration into its component simple vibrations or harmonics. Thus if x is the resultant displacement at a time t, in a complex vibration of frequency $n/2\pi$,

$$\begin{aligned}x=f(nt)=A_0+A_1\cos nt+A_2\cos 2nt+\ldots+A_r\cos(rnt)\\+B_1\sin nt+B_2\sin 2nt+\ldots+B_r\sin(rnt).\end{aligned}\tag{6}$$

By suitable choice of the amplitude-values A_0, A_1, etc., B_1, B_2, etc., it is possible to analyse or synthesise any form of *single-valued periodic vibration.* Thus the displacement curve represented by fig. 1 (a), may be obtained by adding a sufficient number of odd terms of a sine series. In fig. 1 (b) the first, third and fifth terms are added, in fig. 1 (c) the first fifteen odd sine terms are added. It will be seen that (c) approximates closely to (a), the more terms taken the more nearly does the synthesised curve approach the ideal. The mathematical analysis or synthesis of complex wave-forms may become very laborious. In order to simplify the process various mechanical "*harmonic analysers*" have been constructed (*see* Millar's "Science of Musical Sounds") which perform the necessary mathematical integrations, by a direct mechanical process. Fourier's theorem and harmonic analysis have a wide field of application not only in the study of sound-vibrations, but in astronomy, meteorology, tide prediction, mechanical and electrical engineering.

Loudness, Pitch and Quality. Intensity, Frequency and Wave-form.—Sounds differ from one another in three respects.

(i) *Loudness and Intensity.*—These two terms refer to the subjective and physical aspects respectively. The intensity of a sound refers to a definite physical quantity which determines the rate of supply of vibrational energy (proportional to [amplitude]). Loudness corresponds to the degree of sensation, being dependent both on the intensity of the sound and the sensitiveness of the ear under the particular conditions. Near the limits of audibility *loudness* may be very feeble although the intensity be very great. The sensation of loudness varies over a relatively small range for enormous variations of intensity. An ear which can detect a feeble watch tick remains undamaged by a neighbouring explosion—although the range of intensity involved in these examples may be greater than 10^{12} to 1. The relation between sensation (loudness) and stimulus (intensity or amplitude) is generally expressed by Weber's law—"The increase of stimulus necessary to produce a just perceptible increase of sensation is proportional to the pre-existing stimulus." This law indicates a rapid diminution of sensitiveness of the ear with increase of total intensity of the sound.

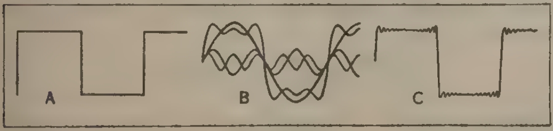


FIG. 1

(ii) *Pitch and Frequency.*—The frequency of a regular or periodic vibration is the number of vibrations performed per second. Musical sounds arrange themselves in a natural order according to *pitch.* The latter depends solely on the *predominant frequency* of the vibrations—the greater this frequency the higher the pitch—and on the number of these vibrations reaching the ear per second. The latter stipulation is made to include sounds received from sources of sound in motion. This relation between pitch and frequency is simply verified by means of a revolving toothed wheel striking the edge of a card which produces a sound whose predominant frequency is proportional to the product of speed (revolutions per second) and the number of teeth on the wheel. For a given note the predominant frequency is the same whatever the source of the note, and the ratio of the frequencies of two notes forming a given musical interval is the same in whatever part of the musical range the two notes are situated. The more important consonant *intervals* with their frequency eatios are Unison 1:1, Major Third 5:4, Fifth 3:2, Major Sixth 8:5, Minor Third 6:5, Fourth 4:3, Minor Sixth 5:3, Octave 2:1. Notes whose frequencies are multiples of that of a given one, the *fundamental*, are called *harmonics*. The frequency ratios defining each note of the *diatonic musical scale* are

C	D	E	F	G	A	B	C
1	9/8	5/4	4/3	3/2	5/3	15/8	2

The same series of ratios applies to any octave which may be chosen.

(iii) *Quality and Wave-Form.*—Sounds of the same pitch and loudness, but produced by different means, are distinguished by their quality. Thus the same note produced by a voice, a piano, or a violin, would have distinct characteristics which are at once recognisable by the ear. Very few sounds can be regarded as "pure," that is, free from overtones. The presence or absence of these overtones decides the *quality* of the sound. A tuning fork emits almost a pure tone whereas a violin note is rich in overtones characteristic of the instrument. Quality depends therefore on wave-form. Fourier's analysis of the wave-form of the sound emitted by a particular instrument tells us which harmonics are present and their relative importance.

Forced Vibrations, Damping, Resonance.—On account of the dissipation of energy by forces of a frictional nature, a vibrating body if left to itself, is gradually brought to rest. Its vibrations may be maintained, however, by the application of a suitable periodic force, which supplies the energy dissipated by friction and sound radiation. It is important to consider the relation between the frequency of such a force and the frequency of the free or natural vibration of the body. It is generally assumed that for small oscillations the frictional forces are proportional to the velocity of the particle. Consequently the equation of forces becomes

$$m\frac{\partial^2 x}{\partial t^2}+r\frac{\partial x}{\partial t}+sx=F\cos pt\tag{7}$$

where $F\cos pt$ represents the external periodic force of maximum value F and frequency $p/2\pi$, r is the resistance per unit velocity and s the restoring force per unit displacement. Writing $s/m=n^2$, $F/m=f$ and $r/2m=k$ it can be shown that the displacement x is given by

$$x=\frac{f\sin\epsilon}{2kp}\cos(pt-\epsilon)\quad\text{where}\quad\tan\epsilon=\frac{2kp}{(n^2-p^2)}\tag{8}$$

representing the *forced vibration* of period $p/2\pi$ and amplitude $f\sin\epsilon/2kp$. In the case where there is no friction, the *damping constant* $k=0$, $\sin\epsilon=\tan\epsilon=0$, $\epsilon=0$ or π, and

$$x=\frac{f}{(n^2-p^2)}\cdot\cos pt\tag{9}$$

Amplitude of Forced Vibrations.—In the steady state of maintained oscillations, equations (8) and (9) represent the resultant *forced* motion. The amplitude A of the motion, is given by

$$A=\frac{f\sin\epsilon}{2kp}=\frac{f}{\{(n^2-p^2)^2+4k^2p^2\}^{\frac{1}{2}}}\left(\text{Since } \sin\epsilon=\frac{2kp}{\{(n^2-p^2)^2+4k^2p^2\}^{\frac{1}{2}}}\right). \qquad (10)$$

This expression is of fundamental importance. The amplitude A is a maximum when the denominator of the expression is a minimum, *i.e.*, when $p^2=n^2-2k^2$ (provided $n^2>2k^2$); the maximum value being then

$$A_{\text{max.}}=f/2kn. \qquad (11)$$

In the case where there is *no damping* ($k=0$), and the free frequency n is the same as the forced frequency p, it will be seen that the amplitude A becomes *infinite*. Such a case of course never occurs in practice, for the damping k is never zero. For *moderate values of damping* ($n^2>2k^2$), the forced amplitude $A_{\text{max.}}$ (equation [11]) is greatest when the forced frequency coincides with that of the free vibration, and may become very large when k is small. This condition is known as *resonance*. When dealing with sources of sound, we shall have occasion to refer frequently to resonant vibrations.

Phase of Forced Vibrations.—The force and the resultant forced vibrations are not necessarily in phase. From equation (8) we see that $\tan\epsilon$ is always positive when p is less than n, that is ϵ lies between 0 and $\pi/2$ when the forced frequency is less than the free frequency, and $\tan\epsilon$ is always negative when p is greater than n, that is, ϵ lies between $\pi/2$ and π when the forced frequency is greater than the free frequency. *At resonance*, when $n=p$, $\tan\epsilon=\infty$ and $\epsilon=\pi/2$, *i.e.*, the force and the displacement are "in quadrature" whilst the force and velocity are "in phase." *Away from resonance, if the damping is small*, the phase difference ϵ will, in general, be nearly equal to 0 or to π, that is, *the displacement will be in phase or out of phase with the force according as the frequency of the force is less or greater than the frequency of the free vibrations.* These phase effects are beautifully demonstrated by means of a frequency meter of the vibrating reed type, viewed intermittently at, or very near, the frequency of excitation. The graduated series of reeds appear as in fig. 2 (a) when viewed in the ordinary way, but as in fig. 2 (b) when viewed intermittently. In accordance with the theory, the reeds on opposite sides of the resonant one are seen to be in opposite phase, with the resonant reed intermediate.

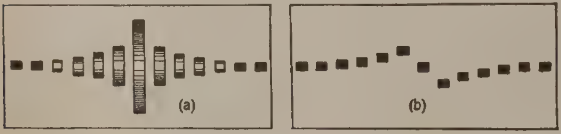


FIG. 2

Power Dissipation.—In order to maintain vibrations against damping forces, a certain rate of energy supply is necessary. This is measured by the product of the force $f\cos pt$ and the particle velocity $\partial x/\partial t$ (obtained by differentiating equation [2] with respect to t). The mean power required to maintain vibrations is thus found to be

$$W=\frac{f^2}{4k}\cdot\sin^2\epsilon \qquad (12)$$

This reduces to zero when $\epsilon=0$ or π *i.e.* when $k=0$ (*see* equation [10]). In the case of *damped vibrations at resonance the power dissipation is a maximum for*

$$\epsilon=\pi/2, \quad \text{whence} \quad W_{\text{max.}}=f^2/4k \qquad (13)$$

Sharpness of Resonance.—The effect of damping becomes relatively more and more important as resonance is approached. At resonance the amplitude and power dissipation reach a maximum. The ratio of power dissipation W under specified conditions to that at resonance is given by

$$\frac{W}{W_{\text{max.}}}=\sin^2\epsilon=\frac{4k^2}{\left(\frac{n^2-p^2}{p}\right)^2+4k^2} \quad \text{[from (4)]} \qquad (14)$$

a relation indicating how the power required to maintain vibrations against frictional and radiation losses varies near resonance. It will be seen from (14) that *the energy dissipated* at a frequency $p/2\pi$, near resonance, *is half the resonance value when*

$$\left(\frac{n^2-p^2}{p}\right)^2=4k^2,$$

that is when

$$(n-p)=\pm k \text{ (approx.)} \quad \text{or} \quad \frac{p}{n}=1\pm\frac{k}{n}, \qquad (15)$$

i.e., when the frequency of the force differs from that of the resonator by the fraction k/n. This ratio k/n therefore constitutes a measure of the *sharpness of resonance*. The reciprocal of the ratio, *i.e.*, n/k is sometimes referred to as the "persistence" of the vibrations. The smaller the damping k and the higher the natural frequency n, the sharper will be the tuning, and the greater the persistence of the vibrations. This principle has many striking and important applications. Thus in frequency standardisation, *e.g.*, of tuning forks or quartz resonators, very great accuracy of tuning is essential, and the damping must be extremely small. In other cases, *e.g.*, the faithful reception or reproduction of sound vibrations over a range of frequencies, resonance is distinctly undesirable, and the system must have a natural frequency ($n/2\pi$) removed as far as convenient from any possible values of the forced frequency ($p/2\pi$), or, alternatively, the system must be heavily damped (k large).

The damping constant k of a vibrating system is determined by direct measurement of the rate of decay of its free oscillations (from $A_2=A_1e^{-k\tau}$, or $\log A_1/A_2=k\tau$ where A_1 and A_2 are successive amplitudes on the same side and τ is the periodic time $-k\tau$ is known as the *logarithmic decrement* of the oscillations). The damping coefficient k may be determined alternatively from observations of the sharpness of resonance.

Electrical Oscillations.—Alternating electrical and magnetic effects provide a very convenient means of exciting the corresponding mechanical vibrations. The advent of the thermionic three-electrode valve, as a simple means of producing electrical oscillations over a wide range of frequency and power, has greatly assisted in the rapid development in the design of electrical sound sources, and in electrical methods of receiving and recording sound waves. There is a close analogy between electrical and mechanical oscillations. If we replace inertia (mass) m in the mechanical system by inductance L in the electrical system, mechanical resistance r by electrical resistance R, spring factor (or stiffness) s by 1/capacity ($1/C$), displacement x by quantity Q, velocity $\partial x/\partial t$ by current $i=\partial Q/\partial t$, acceleration $\partial^2x/\partial t^2$ by rate of change of current $\partial^2Q/\partial t^2$—the electrical equations become identical with the corresponding mechanical equations. Thus the electrical equation for the forced oscillations of a circuit containing inductance L, capacity C, and resistance R, is

$$L\frac{\partial^2Q}{\partial t^2}+R\frac{\partial Q}{\partial t}+\frac{Q}{C}=E\cos pt \qquad (16)$$

which is analogous to equation (7) for a mechanical system. With the substitutions mentioned above (with $k=L/2R$ and $f=E/L$) the solution of this equation is similar to equation (8) and the subsequent remarks relative to resonance and damping apply also to the electrical system. The frequency of free vibration of a mechanical system is $N=\frac{1}{2\pi}\sqrt{(m/s)}$ (*see* equation [3]), and the corresponding frequency of electrical oscillations is $N=\frac{1}{2\pi}\sqrt{LC}$. This is also the frequency at resonance in the case of forced vibrations provided the damping k and resistance

R are not excessive.

For the various methods of generating alternating currents, (*e.g.*, by valve oscillators, interrupters, alternators, etc.) the reader should consult the article on WIRELESS TELEGRAPHY.

Motional Impedance.—On account of the extensive use of electrical forms of sound generators and receivers it is very important in design to have a knowledge of their characteristics. In any form of machine which converts electrical energy into motion the moving mechanism reacts on the electrical circuit. Thus the revolving armature of an ordinary electric motor generates what is called a "back e.m.f." in opposition to the applied voltage. This back e.m.f. may alternatively be regarded as an increased resistance to current flow in the armature, the efficiency of the motor being measured by the ratio of this resistance R relative to the total resistance $(R+r)$ in the circuit; the net power used in the motor being a maximum when $R=r$, in which case the efficiency is 50 per cent. In a similar manner the mechanical vibrating element of an electrical sound generator or receiver reacts on the electrical circuit, the back e.m.f. due to the vibration appearing as a change of impedance of the circuit. The change of impedance due to this cause is termed *motional impedance* and, relative to the total impedance, is a measure of the efficiency of the sound generator.

Transverse Vibrations of Strings.—When any point of a thin flexible wire stretched between two fixed clamps or bridges is displaced transversely and released, the wire commences to vibrate. This vibration results from transverse motions travelling in opposite directions along the string and successive reflections of these motions from the fixed ends. In order to visualise such reflection of a transverse motion it is well to make a few simple experiments on waves travelling along a stretched rope, one end of which is held in the hand whilst the other end is fixed. It will be observed that the movement of each particle of the rope when forming part of the reflected wave is in the opposite direction to its motion in the original wave. The rope assumes the form of a sine wave if the end is moved up and down harmonically. Before we can deduce the modes of vibration of a stretched string it is necessary to know the velocity with which a wave of displacement travels along the string and also the manner in which the direct and reflected waves affect each other to produce what are called stationary waves.

Velocity of a Transverse Wave Along a String.—The following method is due to Tait. The string is supposed to be drawn through an imaginary smooth tube with velocity c. The tube is straight except for an isolated curved portion which represents the wave on the string. If R is the radius of curvature at any point of the tube, the force acting in the direction of the normal to an element δs is $T\delta s/R$ where T is the tension in the string. Now the centrifugal force of the element δs, of mass m per unit length, and velocity c will be $m\delta s\cdot c^2/R$, and this must balance the force $T\delta s/R$ if there is to be no reaction on the tube. Thus if $T\delta s/R=m\delta s\cdot c^2/R$, then $c=\sqrt{(T/m)}$ and there is no reaction on the tube, *i.e.*, the tube may be regarded as absent and *the wave travelling along the string with the velocity* $c=\sqrt{(T/m)}$.

Reflection. Formation of Stationary Waves. (See WAVE MOTION.)—If both ends of the string of length l are fixed, the wave is reflected successively from end to end, and the resultant motion is determined by the superposition of the direct, or *incident wave*, and the *reflected wave*. The resultant displacement y at the instant t of a point distant x from one end will be $y=f(ct-x)-f(ct+x)$ where f indicates "a function of." Since $y=0$ when $x=l$ we have also $f(ct-l)=f(ct+l)$, or $f(z)=f(z+2l)$ where $z=(ct-l)$, which indicates that z is a periodic function repeating at intervals of $2l$. Consequently the displacement at any point of the string is periodic, the period $T=2l/c$ being the time taken for a wave to travel along the full length of the string and back again. The frequency of this form of vibration is consequently $N=c/2l$ where $c=\sqrt{(T/m)}$, *i.e.*,

$$N=\frac{1}{2l}\sqrt{\frac{T}{m}} \qquad (17)$$

If the displacement y varies sinusoidally with a frequency $n/2\pi$, we have $y=a\cos n(t-x/c)-a\cos n(t+x/c)$ which reduces to

$$y=2a\sin nt\cdot\sin(nx/c) \qquad (18)$$

At any point x on the string the amplitude is therefore $2a\sin nt$, varying sinusoidally with time between zero and $2a$. The amplitude of successive particles is also varying with x according to a sine law. The result is a series of loops on the string of amplitude 0 to $2a$. The condition for the formation of loops on a string of finite length l is clearly that in which *l is a whole multiple of the length of a loop*, *i.e.*, provided the number of loops is 1, 2, 3, · · · etc. The *fundamental* frequency n of the string is given by (17), the various possible overtones are simple multiples of n, *i.e.*, they form a harmonic series. The modes of vibration of a string vibrating with 1, 2, 3 loops is shown in fig. 3. The points marked n which are permanently at rest during the vibrations, are called *nodes*, whilst the points marked a where the amplitude is a maximum are called *anti-nodes* or *loops*. It will be evident that the string could be clamped at the nodes n without affecting the motion of the remainder of the string. Denoting the *wave-length* of the vibration by λ we must have $N'\lambda=c=\sqrt{(T/m)}$ whence the frequency

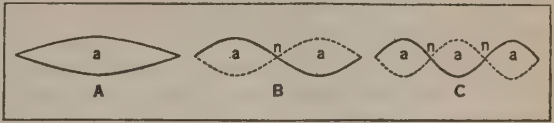


FIG. 3

$$N'=\frac{s}{2l}\sqrt{\frac{T}{m}} \qquad (19)$$

s being the number of loops, *i.e.*, half wave-lengths, into which the string of length l is divided.

The string may vibrate with any of the frequencies given by equation (19) at the same time, *i.e.*, a note may be produced which is made up of the fundamental and a number of harmonics. The laws of a vibrating string indicated by equation (19) may easily be verified by means of a *monochord* or *sonometer*, which consists essentially of a thin metallic wire (*e.g.*, steel piano wire) stretched over two bridges by means of a weight hanging over a pulley, or by a spring tensioning device. A movable bridge provides a convenient means of varying the vibrating length of the wire. The monochord is a very *useful means of comparing frequencies*—the frequency of the string being inversely proportional to the vibrating length. Exact tuning is indicated by the "beats" between the monochord note and the note compared with it. The various overtones of a string may also be very simply demonstrated by means of the monochord, the string being lightly damped at any point corresponding to a node and plucked or bowed at a point corresponding to an antinode of the overtone required to be excited. The positions of the antinodes are easily determined by means of little paper riders.

Stiffness of Strings and Yielding of Supports.—When the thickness of the string becomes appreciable in relation to the length of a loop, the stiffness may have a perceptible effect on the frequency of vibration—this effect becoming more and more important the higher the overtone excited (*i.e.*, the greater the number of loops). Where great accuracy is required a modification of equation (19) is necessary, viz.

$$N=\frac{s}{2l}\sqrt{\frac{T}{m}}\left\{1+\frac{\pi^3 s^2 r^4 E}{8l^2 T}\right\}$$

where r is the radius of the circular section of the wire and E Young's modulus of elasticity for the material. Yielding of the "bridges" supporting the wire may have the effect of increasing or decreasing the frequency according as the supports have (*a*) very large mass M but small spring factor or (*b*) very large spring factor μ and negligible mass. The effects of (*a*) and (*b*) are equivalent to a change of length of the string in the ratios $1:(1-2Tl/Ma^2s^2\pi^2)$ and $1:(1+2T/\mu l)$ respectively.

Methods of Producing Vibration in Strings. Quality.—A stretched string may be set in vibration by numerous methods. Plucking, bowing and striking are the more familiar; exemplified in the harp, the violin, and the piano, respectively. A string may also be set in vibration by forced oscillation of a point of support, *e.g.*, if one end is attached to the prong of a vibrating tuning fork (Melde's experiment). Electromagnetic methods may also be used to excite a metallic string. In one of these methods a light metal wire is attached at right angles to the vibrating wire and arranged to dip in a small cup of mercury at each downward movement. A current passing through this intermittent contact actuates a small electromagnet which maintains the wire in vibration in the same manner as an electric bell is operated. In another method the vibrating wire itself carries an alternating electric current and lies in a permanent magnetic field. When the frequency of the current and position of the magnet are suitably chosen one of the numerous possible overtones of the wire will be readily excited. It will be appreciated that the method of excitation has a very important influence on the form of the wave which travels along the string. The quality of the note is of course dependent on this wave form, *i.e.*, on the relative amplitudes of the various overtones present in the vibration. It is just this addition of overtones to the fundamental which makes it possible for the ear to distinguish between the sounds of a piano, a violin, and a harp, emitting the same fundamental note.

Strings as a Source of Sound; The Sounding Board.—A vibrating wire *rigidly* supported would radiate extremely little sound energy to the surrounding air on account of the local reciprocating flow of air between opposite sides of the vibrating wire. It is necessary in an efficient stringed sound source that the bridges should yield and communicate the vibrations to a surface of large area, *i.e.*, to a sound board, in contact with the medium. This sound board is therefore a vital part of all stringed musical instruments—it is important, however, in a good instrument, that the sounding board should have no predominant resonance frequencies of its own; otherwise these would reinforce disproportionately the corresponding frequencies of the strings.

Transverse Vibrations of Elastic Rods.—The vibrations of a stretched wire are controlled by the tension whilst the stiffness of the wire may generally be disregarded. In the case of a relatively thick wire or rod the stiffness may become all-important and tension may ultimately be disregarded. Even when simplified as far as possible the theory of transverse vibrations of elastic rods is very complex in comparison with the theory of strings. In the case of strings, harmonic waves travel with a velocity independent of wave-length but in the case of rods or bars this is not so. It is shown in textbooks of sound (*see* Bibliography) that the velocity of a transverse elastic wave in a rod is proportional to $t\cdot\sqrt{(E/\rho)}\cdot/\lambda$ where t is the thickness in the direction of displacement, E elasticity, ρ density, and λ the wavelength. The velocity is thus dependent on the wavelength, a fact which makes the theory much more complex. It may be shown that the possible frequencies of transverse vibration of a bar are given by

$$N=C\frac{k}{l^2}\sqrt{\frac{E}{\rho}} \qquad (20)$$

where k is the radius of gyration of the section of the bar about the neutral plane, and l is the length of the bar ($k^2=t^2/12$ for a rectangular bar of thickness t). The value of the constant C depends on the method of supporting or clamping the bar and on the overtone to be excited. *The frequency is therefore proportional to the velocity of longitudinal waves* [$\sqrt{(E/\rho)}$] *in the material of the bar. It also varies as the thickness* (*or radius*) *and inversely as the square of the length of the bar.* As in the case of strings, stationary waves are set up in rods by the combined effects of the direct and reflected waves. The possible forms of these stationary waves depend on the method of supporting the rod. Some of the modes of vibration of a *free-free rod*, *i.e.*, entirely free or supported at two nodes, are shown in fig. 4a; whilst fig. 4b illustrates those for a *clamped-free bar*, *i.e.*, a bar fixed in direction at one end and free at the other.

In the case of the *free-free bar* the constant C in equation (20) for the frequency is equal to $\frac{\pi}{8}(4s\pm1)^2$ where s may be 1, 2, 3, etc. *i.e.*, the possible frequencies are proportional to the squares of the successive odd numbers commencing at 3. *For a clamped-free bar* the constant C in equation (20) is approximately equal to $\frac{\pi}{8}(4s\pm1)^2$ where s may be 0, 1, 2, 3, etc. More accurate values for $(4s\pm1)$ in the case of the fundamental ($s=0$) and the first overtone ($s=1$) are 1·1937 and 2·9884 respectively. The frequencies of the first three tones relative to the fundamental are consequently 1, 6·25 and 17·6 approximately. The relation $N\propto k\cdot\sqrt{(E/\rho)}/l^2$ has been experimentally verified by a number of physicists, both in the case of the free-free and the clamped-free bar.

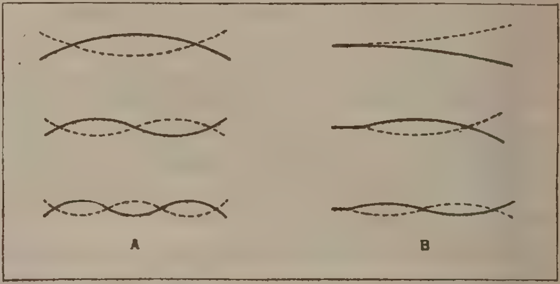


FIG. 4

Applications and Methods of Excitation.—As in the case of strings the transverse vibrations of a bar may be excited by striking, plucking, bowing, or by electromagnetic means, the partials present, and consequently the quality of the note being dependent on the method of excitation. The only method of supporting a bar which yields "harmonic partials" is the free-free method, which has application in a musical instrument known as the "harmonicon" or "dulcimer" in which freely supported bars of graded lengths are struck by a hammer, thus producing an agreeable succession of musical tones. Thin rods or reeds, clamped at one end and excited by plucking, are used in the "musical box" so well known. Used in combination with suitable air cavity resonators, clamped-free reeds are fitted in various musical instruments, notably the clarinet group. The combined action of an air blast and a vibrating reed is illustrated in the concertina and the harmonium, whilst in the reed pipes of an organ the reed is combined with a resonant air column. The reed of the telephone earpiece designed by S. G. Brown is operated electromagnetically. It is used in an almost unstable condition, the pull of a permanent magnet being nearly sufficient to overcome the stiffness of the reed. This results in a large increase of sensitiveness to the superposed alternating magnetic field.

Frequency Meters form a good example of the electro-magnetic or direct mechanical excitation of reeds. The frequency meter consists essentially of a graded series of clamped steel reeds actuated by a common electro-magnet supplied with alternating current of which the frequency is required. Such instruments have been made covering various ranges from 1 or 2 to 1,500 cycles per second. The frequency of a clamped-free bar may be lowered either by loading the free end or by reducing the cross section near the clamped end. The frequency may be raised either by shortening the bar or reducing the cross section near the free end.

Tuning Forks.—On account of its great purity of tone and constancy of frequency the tuning fork is generally regarded as a standard of frequency and pitch. During recent years it has increased enormously in importance as a frequency standard for controlling electrical circuits, in such a manner as to form an electrical standard of great accuracy and of extensive range.

The tuning fork may be regarded either as a development from a free-free bar bent into the form of a U, or as consisting of a pair of symmetrical clamped-free bars attached to a common block of metal. Numerous patterns are in existence approximating to one or other of these two forms. It will be sufficient here to regard each prong as a clamped-free bar. In consequence of the oscillation of the centre of gravity of the two bars as they vibrate there will be communication of vibration to the block to which they are clamped. To reduce the amplitude of this vibration, which is in the direction of the prongs, the block must be firm and massive. The frequency of a fork of this construction with prongs of rectangular section of thickness t will therefore be

$$N=(1\cdot 1937)^2\cdot\frac{\pi}{8}\cdot\frac{t}{\sqrt{12}\cdot l^2}\sqrt{\frac{E}{\rho}} \tag{21}$$

that is, $N=8\cdot 24\times 10^4 t/l^2$ if the prongs are of steel in which $\sqrt{(E/\rho)}=51\times 10^4$ cms./sec. *The frequency of a fork will therefore vary directly as the thickness of the prongs and as the velocity of sound in the material, and inversely as the square of the length of the prongs.* The first and second overtones of a fork will have frequencies $6\cdot 25N$ and $17\cdot 6N$ respectively. These overtones may easily be excited in a large fork by bowing at suitable points.

The fundamental tone of a tuning fork may be selectively reinforced by attaching the stem to a *resonance box* of the same frequency—the overtones of the fork and the air cavity are widely different and do not reinforce each other. Two forks of nearly the same pitch may be compared by the method of beats, which gives in a very simple and direct manner the difference in frequencies. This method is also useful in studying the effect of temperature on the frequency of a fork—the one fork is kept under standard conditions whilst the temperature of another is varied. The temperature coefficient of frequency for a steel fork determined in this way is approximately -10^{-4} per degree C rise of temperature. The temperature coefficient of a fork made of elinvar steel is about one tenth of this.

Electrically Maintained Forks.—The vibrations of a low-frequency fork may readily be maintained by means of electrical contacts controlled by the prongs and an electro-magnet situated between them. The mode of operation is similar to that of an electric bell. Forks of higher frequency (of the order of 1,000 p.p.s.) are maintained by means of electromagnets arranged in a special form of 3-electrode valve circuit devised by Eccles. Electrically maintained forks may be used to drive what are known as *phonic motors* (*see* Rayleigh's Sound, Vol. I., p. 67), the vibratory motion of the fork being thereby converted into a rotary motion of combined accuracy and constant speed. Electrically maintained forks and phonic motors, with their applications in standard frequency determinations, are described in A. B. Wood's *Textbook of Sound.* Forks are now in common use as sub-standards of time. The period of a fork is a very constant quantity and serves as a convenient sub-division of a second when time intervals have to be measured with accuracy. As a consequence of the increased application of the tuning fork for this purpose, methods have been devised for increasing the accuracy and perfection of electrically maintained forks. Low-frequency forks of this character giving an accuracy greater than 1 in 10,000 are in common use. If particular care is taken with the choice of material, design, and control of the fork, an accuracy of 1 in 10^6 or even 1 in a million is possible.

Electrically maintained forks of this nature are used to control electrical "multi-vibrator" circuits which serve as frequency standards for all frequencies which are multiples of that of the fork, *e.g.*, in steps of 1,000 cycles, up to 1·5 million cycles per second. The tuning fork thus functions as a standard of radio-frequencies. It is possible to maintain an electrically driven fork by means of the "seconds" contacts of a standard pendulum clock. Such *clock controlled forks* are not subject to temperature variations, etc., and remain accurately in step with the standard clock over relatively long periods of time.

Longitudinal Vibrations of Rods.—When a rod is set into longitudinal vibration its axis remains undisplaced whilst cross-sections vibrate to and fro in the direction of the axis of the rod. The quantities involved are the density of the material and its elastic properties. Consider a rod of cross section A and an elementary slice of it bounded by two planes at x and $x+\delta x$ at right angles to the axis x of the rod. If the plane at x is displaced at the time t to $x+\xi$ the plane at $x+\delta x$ will be displaced to $x+\delta x+\xi+d\xi/dx\cdot\delta x$, that is, the actual elongation of the slice is $d\xi/dx\cdot\delta x$ and its fractional elongation $d\xi/dx$. This change in thickness of the slice implies a difference in the forces acting on its faces. The total force acting on the face at x will be $EAd\xi/dx$ where E is Young's Modulus of elasticity. Similarly at the opposite face of the slice the force will be in the opposite sense and equal to $EA(d\xi/dx+\delta x\cdot d^2\xi/dx^2)$. Consequently the resultant force acting on the slice will be $EA\cdot\delta x\cdot d^2\xi/dx^2$. Now the mass of the slice is equal to $\rho A\delta x$, where ρ is the density of the material, and the acceleration is $d^2\xi/dt^2$. We have therefore

$$\rho A\delta x\cdot\frac{d^2\xi}{dt^2}=EA\frac{d^2\xi}{dx^2}\cdot\delta x \quad\text{or}\quad \frac{d^2\xi}{dt^2}=\frac{E}{\rho}\cdot\frac{d^2\xi}{dx^2} \tag{22}$$

an equation of the same form as that obtained for the transverse motion of a string, indicating a *wave travelling along the rod with velocity* $c=\sqrt{(E/\rho)}$. The above treatment is approximate only, since it ignores lateral bulging or contracting of the sides of the rod. The result is, however, sufficiently true provided the wave length λ is great compared with the width or thickness of the rod. As in the case of vibrating strings the direct and end-reflected waves in a rod of finite length form stationary waves with nodes and antinodes in accordance with the relation $c=N\lambda=\sqrt{(E/\rho)}$ or $N=\frac{1}{\lambda}\cdot\sqrt{(E/\rho)}$. In the fundamental mode of vibration of a free bar $\lambda=2l$ and the various partials require $s\lambda=2l$. Consequently the expression for the frequencies of the partial tones is

$$N=\frac{s}{2l}\sqrt{\frac{E}{\rho}}, \tag{23}$$

which is similar to equation (19) for strings, the tension T being now replaced by the elasticity E. *When the bar is clamped at the mid point*, an important practical case, *all partials requiring an antinode at that point are suppressed*, consequently only the odd partials are present. It will be seen that *the partials* given by (23), *form a harmonic series*—provided $\lambda/2$ is always large compared with the diameter or thickness of the rod and that lateral bulging and shrinking may be neglected.

The frequency of longitudinal vibrations in bars is usually very high compared with that of the transverse modes, the ratio increasing rapidly as the diameter or thickness diminishes relative to the length. The nodes of a bar vibrating longitudinally are points of maximum stress, whereas the antinodes are points of zero stress. Biot and Tyndall demonstrated this fact to a large audience by means of passing polarised light through the node of a vibrating strip of plate glass. The analyser was set at extinction before the rod was set in vibration so that no light was seen on the screen. On stroking the rod with a resined cloth vigorous vibrations were set up and intermittent light was passed on to the screen. No such effects were observable at the antinodes where there is no stress.

Methods of Excitation.—Rods of metal, wood, or glass, clamped at the midpoint or at one end, are readily set in vibration by the steady frictional drag of a resined cloth drawn, with a moderate pressure, along the rod towards an antinode. Another method, more suitable for relatively short stiff rods, is to strike the end a sharp blow with a hammer. This method usually results in a complex sound due to both transverse and longitudinal vibrations—the one or the other may be rapidly damped out by clamping at a suitable point.

Electrical Methods of Excitation.—Powerful longitudinal vibrations may be set up in bars of magnetic material by acting on them with alternating magnetic fields of the resonating frequency. Using a small alternating current magnet (with iron wire core) mounted close to the end of a steel bar, the fundamental and harmonics can readily be excited as almost pure tones. The resonance is extremely sharp (indicating very small internal damping) and careful tuning is required. Vibrations have been obtained in non-magnetic rods by electrostatic methods (J. H. Vincent, *Nature*. Dec. 31, 1927) the end of the vibrating rod forming one plate of a condenser supplied with high frequency alternating current from a valve oscillator[1]. (*See* THERMIONIC VALVE.)

Longitudinal Vibrations of High Frequency in Piezo-Electric Crystals.—Certain crystals, notably quartz and rochelle salt, have the property of changing their linear dimensions when subjected to electrostatic stress, and conversely they develop electrical charges on their faces when mechanically strained. The phenomenon is known as piezo-electricity (discovered by P. Curie, 1880). The best effects are obtained when slices or rods of the crystal are cut in certain specified directions relative to the optic axis. Voltage applied to the faces at the ends of the electric axis produces a change of thickness and length of the crystal. If alternating voltage is applied, the thickness and length fluctuate accordingly, the maximum effects being produced when the frequency of the electrical alternations coincides with the natural frequency of longitudinal elastic vibration. W. G. Cady (*Phys. Rev.*, *19*, p. 1, 1922) has made use of this property of a quartz crystal in the construction of *standards of high frequency*, with particular application to radio-frequency standardisation. A special electrical circuit which we need not consider here was employed to detect the resonance in the quartz. Thus Cady found that a *quartz resonator* 30x4x1·4 m.ms. vibrating longitudinally in the direction of its length had a fundamental frequency of 89,870 cycles per second. The tuning was so sharp that a change of frequency of 1 cycle per second was measurable. The overtones were also excited and found to approximate to harmonics of the fundamental. G. W. Pierce (*Proc. Amer. Acad.*, Vol. 59, Oct. 1923 and Vol. 60, Oct. 1925) has succeeded in controlling the frequency of an oscillating valve by means of such a crystal. In this manner a *quartz oscillator* may be used as a *frequency stabiliser* for radio purposes.

Quartz plates vibrating longitudinally in the direction of their *thickness* (the electric axis) have been employed by Langevin, Boyle, and others as a *source of super-sonic vibrations*, more particularly for use under water. The same apparatus is used in the converse process of reception, for the alternating pressure of the arriving sound waves produces corresponding electrical effects which, when suitably amplified and heterodyned, can be heard in telephones. Langevin and Boyle have employed this apparatus for the detection by an echo method of submerged objects (wrecks, icebergs, etc.), the sound emitted from a large disc of quartz being sharply directional and therefore suitable for such purposes. (*See* numerous papers by R. W. Boyle in *Proc. Roy. Soc. of Canada* 1922–28.) R. W. Wood and A. L. Loomis, using a piezo-electric quartz crystal vibrating at frequencies of the order 5x10^5 cycles per second have obtained striking effects of a physical and biological nature (*Phil. Mag.*, Sept. 1927). With the crystal vibrating under oil, they estimated the pressure of the sound radiation to be equal to 150 grams weight—the free surface of the oil being raised into a mound 7 cm. high!

The uses of *Rochelle salt* as a sound generator and receiver have been demonstrated by Nicholson (*Amer. Inst. Elect. Eng. Proc.*, Nov. 1919) who in one application used the crystal to replace a gramophone sound-box, the amplified e.m.f.s produced in the crystal being sufficient to operate loud-speakers or telephones. The elasticity of Rochelle salt is very small, $E=3\times10^8$ as compared with 8×10^{11} for quartz and 2×10^{12} for steel. (An excellent bibliography on piezo-electricity and its applications is given by W. G. Cady in the *Proc. Inst. Radio Engineers*, April 1928.)

Torsional Vibrations of Rods.—A solid rod or tube of circular section may be twisted in such a way that each transverse section remains in its own plane. If the section is not circular, a warping is liable to take place and the analysis is very complex. Consider a tube of radius r and thickness δr and let θ be the angular displacement of any section distant x from the origin. The "shear" of the material of the tube is $r\cdot\partial\theta/\partial x$. The opposing elastic force per unit area is $\mu r\partial\theta/\partial x$ where μ is the coefficient of rigidity of the material ($\mu=E/2(\sigma+1)$ in which E is Young's modulus and σ is Poisson's ratio). Since the area of section of the tube is $2\pi r\delta r$ the moment of this force round the axis is $2\mu\cdot\pi r^3\cdot\delta r\cdot\partial\theta/\partial x$ and the restoring force acting on the slice of thickness δx has the moment $2\mu\pi r^3\delta r\cdot\delta x\cdot\partial^2\theta/\partial x^2$. Now the moment of inertia of the slice is $2\pi r\delta r\cdot\delta x\cdot\rho r^2$ (ρ is the density of the material) whence the equation of motion is

$$\rho\frac{\partial^2\theta}{\partial t^2}=\mu\frac{\partial^2\theta}{\partial x^2}\quad\text{or}\quad\frac{\partial^2\theta}{\partial t^2}=c^2\frac{\partial^2\theta}{\partial x^2}\quad\text{where}\quad c=\sqrt{\frac{\mu}{\rho}}\tag{24}$$

which is independent of r, and therefore equally applicable to tubes of all radii and to a solid rod. *The velocity of torsional wave transmission is* $c=\sqrt{(\mu/\rho)}$. The ratio of this velocity to the corresponding longitudinal velocity is $\sqrt{(\mu/E)}=1:\sqrt{[2(\sigma+1)]}$. Taking $\sigma=0\cdot25$ for a steel rod the ratio of velocities becomes 1·58. The possible frequencies of torsional vibration of a rod will be

$$N=\frac{s}{2l}\sqrt{\frac{\mu}{\rho}}\tag{25}$$

analogous to the harmonic series for the longitudinal vibrations. Torsional vibrations are readily set up by applying tangential forces of a frictional character, *e.g.*, by means of a resined cloth, to the free end of a rod clamped at a suitable point.

Vibrations of Membranes.—The transverse vibrations of stretched membranes are related to those of diaphragms and plates in a manner analogous to the transverse vibrations of stretched strings and elastic bars. In the former case the vibrations are conditioned by the applied tension and are independent of elastic forces, whereas in the latter the elastic forces are all-important and tension almost negligible.

By analogy with the case of wave motion in one dimension (a stretched string) it may be shown that the equation

$$m\frac{\partial^2\xi}{\partial t^2}=T\left(\frac{\partial^2\xi}{\partial x^2}+\frac{\partial^2\xi}{\partial y^2}\right)\tag{26}$$

represents the motion of a stretched, two-dimensional-membrane where T is the tension m the mass per unit area ($\rho\times$thickness) and ξ the transverse displacement at a point xy. The velocity of wave motion is $c=\sqrt{(T/m)}$ as in the case of strings. The complete mathematical analysis for stretched membranes of various shapes is given in Rayleigh and Lamb's treatises on Sound. In the case of a circular membrane of radius a the fundamental frequency is shown to be

$$N=\frac{0\cdot765}{2a}\sqrt{\frac{T}{m}}.\tag{26a}$$

In the higher partials the diaphragm becomes divided into nodal rings and diameters.

Membranes approximating to the ideal type have been made from soap films, or films of thin collodion, stretched on a metal ring, the vibrations of such thin films being examined by optical methods. Sheets of parchment or of thin metal (steel) are more suitable when it is required to examine the effects of tension. Wente's condenser microphone (*see* fig. 16a) (*see* MICROPHONE) has a highly tensioned steel membrane of fundamental frequency about 10,000 cycles per second. The various modes of vibration of a steel membrane are conveniently studied by means of a small electro-magnet (the magnet system of any ordinary telephone receiver will serve the purpose) and a valve oscillator with a suitable range of frequency-control. As a rule, the agreement between theory and observation is only approximate, for the theory generally given takes no account of the serious damping and loading of the diaphragm due to the medium (air) in contact with it. The stiffness of the membrane is not always negligible as assumed in the theory. Examples of membranes as sources of sound are to be found in various forms of drums, tamborines, etc.

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[1] A. W. Pierce and J. H. Vincent have excited rods of nickel (and alloys of nickel-iron) into resonant vibration by magnetostriction.

In the drum, the vibrations of the membrane are reinforced by the vibrations of an air cavity in resonance with it.

Vibration of Diaphragms.—When elastic restoring forces are called into play and tension is of secondary importance we come to the case of the diaphragm. Rayleigh has calculated the periods and motions in vacuo, of a thin circular elastic plate rigidly clamped at the edge. By means of a complex analysis he found that the fundamental frequency of vibration is given by

$$N=\frac{2\cdot96}{2\pi}\cdot\frac{h}{a^2}\sqrt{\frac{E}{\rho(1-\sigma^2)}} \qquad (27)$$

where h is the thickness and a the radius of the diaphragm, E Young's modulus, ρ the density and σ Poisson's ratio for the material. More recently, Lamb (*Roy. Soc. Proc.* A., Vol. 98, 1920) has calculated the frequency and damping of circular diaphragms in air and in water, the value of the frequency in air agreeing closely with Rayleigh's estimate. Thus for a steel diaphragm $E = 2 \times 10^{12}$, $\rho = 7\cdot8$, $\sigma = 0\cdot28$, whence $c=\sqrt{[E/\rho(1-\sigma^2)]}=5\cdot27\times10^5$ cms./sec., and $N=2\cdot5\times10^5\cdot h/a^2$ cycles per second. If $h=0\cdot1$ cm. and $a=5$ cms., N will be 1,000 cycles per second in air. The *addition of a load m* to the centre of a diaphragm of mass M has the effect of lowering the frequency given by (27) in the ratio $1/\sqrt{(1+5m/M)}$.

Diaphragm Vibrating in Contact with Water or Other Medium.—The presence of an extensive medium, say water, in contact with the diaphragm has two effects, (1) the frequency is lowered on account of the loading due to the added mass of water vibrating with the diaphragm, and (2) the vibrations are damped owing to the energy radiated as sound waves into the water. Lamb has shown in the case of a diaphragm with one side only in water, that the inertia of the diaphragm is increased in the ratio $(1+\beta)$ where $\beta=0\cdot6689\rho_1 a/\rho h$ (ρ_1 being the density of the water, ρ the density of the material of the diaphragm, a the radius and h the thickness). The frequency given by (27) must therefore be divided by $\sqrt{(1+\beta)}$ in this case. When both sides of the diaphragm are immersed the value of β must be doubled. The *persistence of the vibrations* is given by $N/k=0\cdot385(1+\beta)^{3/2}\rho c_1/\rho_1 c$, where c_1 is the velocity of sound in the medium and c in the material of the diaphragm. Thus, in the above example where the frequency, as modified by the water, is about 550, the range over which the energy will exceed half the maximum (indicating sharpness of resonance, *see* page 8) lies between 530 and 570 p.p.s. The persistence is increased, and the resonance is sharpened, the thinner the diaphragm and the greater the load.

Diaphragms form one of the most convenient means of producing and receiving sounds in air or in water. Numerous forms of diaphragm telephone receivers and microphone transmitters are in daily use. Large diaphragms are used as sources of sound-power for signalling over large distances in air or under water. A diaphragm operated at resonance by electro-magnetic methods may become an efficient generator of sound. By suitably choosing its dimensions the frequency of the sound may have any value up to the limits of audibility. A thick diaphragm of small diameter excited by an electro-magnet provides a very convenient source of high frequency sound as an alternative to a bird call, etc., in experimental work.

Directional property of Membranes and Diaphragms.—If a membrane or a diaphragm be mounted on an annular ring it will possess definite directional properties used either as a transmitter or receiver of sound. Regarding it as a transmitter, the sound emitted from opposite sides will be of the same intensity but in exactly opposite phase. Consequently an observer "edge-on" to the diaphragm will hear nothing at all, for the sounds proceeding from opposite sides of the disc will exactly neutralize each other. In the "broadside-on" position, however, the sound from the back of the diaphragm will be partially screened by the annular ring and by the diaphragm itself, whereas the sound from the front will reach the observer unobstructed. As the transmitter is rotated through 360° therefore, the observer will hear two distinct maxima, 180° apart, separated by two corresponding minima, or zero positions. The maxima will, of course, be of smaller intensity than that observed with one side of the diaphragm completely screened (in which case it is non-directional). The directional properties of an unscreened diaphragm may be simply demonstrated as a *receiver* of sound by means of a "button" granular microphone attached at the centre. The microphone gives maximum and zero response in the "broadside-on" and "edge-on" positions respectively, relative to a fixed source of sound.

Vibration of Plates.—We have already referred to the case of a quartz plate vibrating with equal amplitude and phase over its whole surface, this being treated as a special example of longitudinal vibration. We have also dealt with a circular plate clamped at the edge (*i.e.*, a circular diaphragm), the frequency of the fundamental being $0\cdot47hc/a^2$, and the overtones $1\cdot006hc/a^2$ and $1\cdot827hc/a^2$ for one nodal diameter and one nodal circle respectively. When the plate is free at the edge the mathematical treatment becomes very complex. Near the edge, a peculiar state of strain exists sometimes resulting in abnormally large shearing forces on sections perpendicular to the edge. The *experimental* study of the vibrations of such plates, free at the edge and clamped at the centre of symmetry, begins with Chladni (1787). The method of producing *Chladni's figures* by bowing and touching certain points on the edge of the plate covered with fine sand, is well known. The nodal figures are very striking in their appearance and wonderful variety—nothing further is needed to testify to the complexity of the problem. Chladni preferred to use glass plates, as their transparency permits of the fingers being used to damp points underneath which are shown to be nodal by the sand above. Simple figures correspond to low frequency tones, and the more complicated figures to the higher tones. Chladni obtained 52 different figures with a square plate and 43 with a circular plate. Metal plates of moderate thickness when struck with a hammer are sometimes used as gongs. The Submarine Signalling Company have used such a gong under the sea, describing it as a "disc-bell" for lifeboats.

Curved Plates, Cylinders and Bells.—The complex problem of the flat plate is still further complicated when the plate is curved—for it becomes increasingly difficult to separate the various possible modes of vibration. Rayleigh has calculated the fundamental frequency N of vibration of a thin cylindrical shell, obtaining $N\propto\frac{h}{a^2}\sqrt{\frac{e}{\rho}}$ where e is an elastic modulus involving bulk modulus and rigidity, h the thickness, a the radius, and ρ the density of the cylinder.

A bell may be regarded as a progressive development of a curved plate or, in certain forms, it may be treated as a cylindrical shell with one end closed. The possible variety of forms is far too numerous even to mention here. In practically all cases the bell is supported at the centre of symmetry and is excited by striking near the free edge. Rayleigh made a particular study of the vibrations of church bells, and distinguished five characteristic tones: *Lowest tone* (4 nodal meridians, no nodal circle), *second tone* (4 nodal meridians, one nodal circle), *third tone* (6 nodal meridians, sound best produced when the clapper strikes the bell on the lower thick part termed the "sound bow"), *fourth tone* (6 nodal meridians, best elicited by striking half way up), *fifth and highest tone* (8 nodal meridians). Bell founders in England recognise five chief tones in a church bell, reckoning from the *highest* they are termed the "nominal," "fifth," "tierce," "fundamental," and "hum-note." By suitable distribution of metal in the bell the founder *aims* at making the hum-note, fundamental and nominal successive octaves—but seldom succeeds. Massive bronze bells are used in charted positions, *e.g.*, lightships and buoys, under the sea as a means of signalling to ships suitably fitted with hydrophones (underwater microphones) to receive the sound. Sound travels for long distances under water and these bells can be heard many miles away, if the conditions are favourable.

Vibrations of Air Cavities.—*Columns of Air: Organ pipes.* The simplest case of a vibrating mass of air in a solid enclosure is that of a parallel cylindrical pipe the ends of which may be closed or open. The vibrations of such a column are analogous to the longitudinal vibrations of a solid rod. Provided the diameter of the pipe is not too small, so that viscous drag at the boundary is unimportant, and not too great compared with the length of the pipe and the wave-length of the sound, we can assume at any instant, the motion of particles in any particular cross section to be the same. That is, we are dealing with *plane* waves of sound in the pipe. As in the case of transverse vibrations of strings and longitudinal vibrations of rods, stationary waves are produced in the air column due to the combined effects of the direct and end-reflected waves. Thus the equation of wave motion in the pipe is $\partial^2\xi/\partial t^2 = E/\rho \cdot \partial^2\xi/\partial x^2$, indicating a wave travelling with a velocity $\sqrt{(E/\rho)}$ where E and ρ are the appropriate values of adiabatic elasticity and density of the gas contained in the pipe. Assuming a simple harmonic wave $\xi = a \cos nt$ the solution becomes $\xi = [A \cos(nx/c) + B \sin(nx/c)] \cos nt$. With the appropriate end conditions $\xi = 0$ at a node (a solid end) and $\partial\xi/\partial x = 0$ at an antinode (an open end) the various modes of vibration are readily determined.

Remembering that a pulse of compression is reflected as a rarefaction at an open end and as a compression at a closed end, it will be evident that a wave must travel twice the length of a pipe open at both ends, and four times the length of a pipe closed at one end, before the wave repeats itself, *i.e.*, in one period. If λ is the wave length and N the frequency in the stationary wave then $N = c/\lambda$. For a *pipe open at both ends* each open end must be an antinode and the length of the pipe a multiple of $\lambda/2$, that is, $l = s\lambda/2$ where $s = 1, 2, 3$, etc. We have in this case therefore a *complete* harmonic series of partials whose frequencies are given by $N = \frac{s}{2l}\sqrt{\frac{E}{\rho}}$, the corresponding wave-lengths being proportional to 1, 1/2, 1/3, 1/4, etc.

For a *pipe closed at one end* the closed end must be a node and the length of the pipe an *odd multiple of* $\lambda/4$, that is $l = s\lambda/4$ where $s = 1, 3, 5$, etc. The partials therefore form an *odd* harmonic series the frequencies being $N = \frac{s}{4l}\sqrt{\frac{E}{\rho}}$ where s is an odd integer. The corresponding wave-lengths are proportional to 1, 1/3, 1/5, etc. A closed pipe resonates to the same fundamental frequency as an open pipe of twice the length.

The position of the nodes n and antinodes a for a few of the partials of "open" and "closed" pipes are indicated in fig. 5.

Correction at Open End.—The approximate theory indicated above (due to Bernouilli) assumes an antinode at the open end. A *true* antinode is a point of zero pressure-variation and maximum displacement-amplitude. At the open end of a tube the *stationary plane waves inside* are changing to *spherical progressive waves outside*. In other words, the tube radiates sound energy in all directions from the end of the tube. On account of this radiation, the intensity of the reflected waves from the open end is somewhat less than that of the incident waves, which explains the rapid damping of the vibrations when the forcing ceases. The body of air at the open end has the effect of adding inertia to the air in the tube. Consequently there is a virtual increase in the length of the air column with a corresponding lowering of pitch. Rayleigh has shown that this effective increase of length approximates to 0·6 times the radius r of the tube if the latter is unflanged. This correction applies at each open end, and is therefore $1{\cdot}2r$ for an open tube, and $0{\cdot}6r$ for a closed one. It should be observed also, as in the case of rods, that the simple theory only applies when the diameter of the tube is small relative to the length of a loop $\lambda/2$.

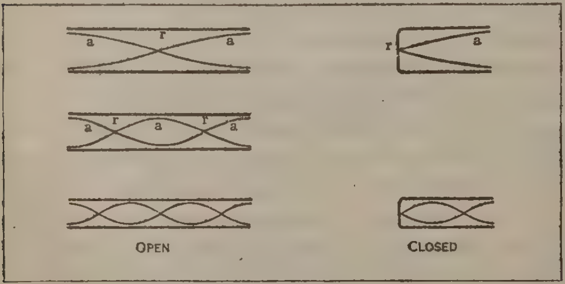

FIG. 5

Resonating Liquids in Metal Tubes.—Columns of liquid enclosed in metal tubes may also be set into resonant vibration. On account of the yielding of the walls of the tube, however, the velocity $\sqrt{(E/\rho)}$ of the wave is slightly modified since the coefficient of elasticity involved is dependent on the extent of such yielding. The subject has been examined theoretically by Lamb (Sound, p. 174) and by Green (*Phil. Mag.*, 45, May 1923) who has also determined experimentally the change of velocity produced in various liquids by this yielding.

Organ Pipes.—One of the most important applications of the vibration of air columns is found in the organ pipe. This usually takes the form of a cylindrical metal tube or a wooden pipe of square section. One end of the tube is specially constructed so that a suitable blast of air will set up resonant vibrations in the column of air. In the *open "flue" organ pipe* the blast of air impinges on a thin lip which forms the upper edge of a narrow slit opening into the tube. When the blast is correctly adjusted the pipe "speaks" and the air column resonates. The fundamental tone is sounded when the blast is moderate, and by increasing the power of the blast the harmonics can successively be produced.

In another form, known as the *"reed" pipe*, the blast of air impinges on a reed which controls the amount of air entering the pipe. The reed is set in vibration and puffs of air are admitted to the pipe which resonates under the correct conditions. The reed cannot be regarded as a freely vibrating spring for it is affected by the air blast and the resonance in the pipe. "Organ" pipes have been made covering a range of frequencies 8 to 16,000 cycles per second, corresponding to lengths of 64 feet to ¼ inch respectively. Fifes, flutes, oboes, etc. are other examples of musical instruments employing resonant air columns.

Small Air Cavities: Helmholtz Resonators.—The vibrations of air cavities almost completely enclosed were first studied by Helmholtz and have considerable practical importance. A volume of enclosed air having only a small "neck" connecting with the external air radiates very little energy when set into resonant vibration. The damping is therefore very small and the tuning is very exact. The device is therefore very sensitive to a narrow range of frequencies. The motion of the air in the cavity is almost negligible compared with that in the narrow neck. Consequently we may regard the air in the neck as a piston having mass $m = \rho l S$ (ρ density, l length, and S area of neck), whilst the air in the cavity functions as a spring of "strength" $f = ES^2/v$ where E is the elasticity ($=\gamma p$) of the gas and v the volume of the cavity. The frequency N of such a mass and spring is $\sqrt{f/m}/2\pi$ *i.e.*, $N = \frac{1}{2\pi}\sqrt{\frac{ES^2}{v \cdot \rho l S}}$ or $\frac{c}{2\pi}\sqrt{\frac{S}{lv}}$ since $c = \sqrt{E/\rho}$. The ratio S/l is called the "conductivity" of the neck. For a circular aperture in a thin wall, Rayleigh shows that this quantity is equal to the diameter ($2a$) whence $2\pi N = c\sqrt{(2a/v)}$. The frequency is independent of the shape of the cavity provided its linear dimensions are not comparable with a wave length of the sound to which it resonates. A "spherical" Helmholtz resonator is shown in fig. 6. A series of resonators of graduated frequencies (*i.e.*, of varying volume or area of mouth) may be used in the frequency analysis of complex sounds. Resonance may be detected by the ear or by means of a sensitive manometric capsule applied to the small pipe at the base of the resonator, or by means of a Tucker hot-wire microphone (*see* p. 31) placed in the mouth. Resonators of large volume, and correspondingly low frequency, fitted with hot-wire microphones were employed in the detection and location of guns during the war. (*See* SOUND RANGING.) Large resonant microphones are also used in the detection of aircraft.

Recently, E. G. Richardson (*Proc. Phys. Soc.*, May 1928) by using acoustic impedance methods, has developed a theory of vibration of air cavities which covers the extreme cases of pipes and resonant cavities, and avoids the necessity for a special open-end correction. He obtains the formula $\tan kL = \kappa/kA$ where $k = 2\pi N/c$, κ is the conductivity of the neck and A is the area of section of the cavity, assumed cylindrical. This formula leads to the recognised values of N for pipes and resonators.

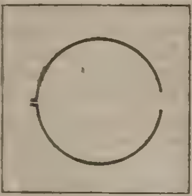

FIG. 6

Double Resonators.—In certain circumstances, where an increased sensitivity is desired, double resonators, consisting, for example, of a resonator of the closed pipe variety combined with one of the Helmholtz type, are usually employed.

By this method, which was first suggested by Boys, a large increase in amplitude may, as a rule, be obtained. The theory of such compound resonators was given by Rayleigh, and has been considerably extended recently by E. T. Paris, who uses them in conjunction with the hot-wire microphone.

Helmholtz Resonator Combined with Tuned Reed.—E. E. Fournier d'Albe has employed a sharply tuned reed (clamped free) with a small mirror attached, to indicate resonance in an air cavity. The resonant vibrations in the air cavity agitate the tuned reed, which lies across the mouth, and cause a spot of light, reflected from the mirror, to oscillate. The combination of reed and air cavity responds to one frequency only, for the overtones of the cavity do not correspond to those of the reed.

The Voice and Speech.—The *human voice* is an excellent example of a combination of vibrating reeds (the vocal cords) and resonant air cavities (the front and back parts of the mouth, separated by the tongue, and the upper or nasal cavity). The analysis and synthesis of speech sounds was commenced by Helmholtz. More recently Paget has shown that "every series of sung or spoken vowels is in fact a trio performed by three instruments, a reed and two resonators—soprano and alto—of which the soprano is in close harmonic relation with the reed." In a series of important papers (*Proc. Roy. Soc.*, 1923, 1924, 1927) Paget has analysed and synthesised the vowel and consonant sounds. Observations on breathed vowel sounds indicated that in *every* case the oral cavity as a whole, from larynx to lips, actually gives *two* simultaneous resonances for each vowel sound. In certain cases, more frequent in American "accent" a third resonance due to the upper or nasal cavity may be introduced. By means of plasticine models Paget successfully reproduced the various vowel and more important consonant sounds, as well as combinations of these in well recognised words. Crandall and Mackenzie (*Phys. Rev.*, March 1922) have determined experimentally the energy distribution in speech as a function of frequency. (*See* curve fig. 7.) The maximum energy of the male voice occurs at a frequency near 120 p.p.s., the female voice having a maximum about an octave higher. In spite of the fact that the energy of the voice is mostly of low pitch it is the high pitched sounds which are essential to intelligibility of speech. The clearness of speech is unimpaired if all sounds up to 500 frequency are "filtered" out (60% of the sound energy being thereby removed). We shall see later that the *ear* is most sensitive in the region 1,000 to 4,000 frequency. The rate of emission of sound energy in conversational speech has been estimated by Sabine (*Phys. Rev.*, 21, 1923) as 125 ergs/sec and for public speech about 2,500 ergs/sec.

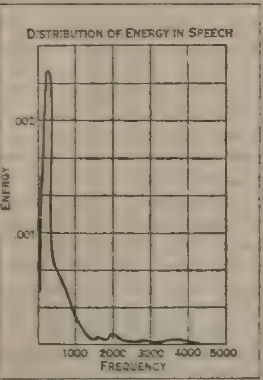

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FIG. 7

Absorption of Sound by Resonators: Sound Filters.—A well tuned resonator absorbs energy of corresponding frequency from the sound-field in which it is placed. This absorption may extend over an area of the order λ^2/π where λ is the wave length of the incident sound ($\lambda = c/N$). Quincke (1866) employed resonators to stop tones of definite pitch from reaching the ear (*see* Rayleigh, *Sound*, vol. ii., p. 210)—the arrangement acting as a sound-filter. A complex sound passing through a pipe could have any particular tone removed, by fitting a suitable side tube to the pipe. This side tube of length l was closed by a sliding piston which served to "tune" the tube ($4l = c/N$) to any frequency N it was desired to absorb from the main pipe. Using a succession of such tuned side tubes a corresponding number of tones could be filtered out of the direct sound. G. W. Stewart (*Phys. Rev.*, 1923–26) has greatly extended the possibilities of sound filters by introducing the analogy of electrical filter circuits and the conception of acoustic impedance. On such a basis it is possible to design "acoustic circuits" functioning as "low-pass," "high-pass" and "band-filters" as in the corresponding electrical cases. The "low-pass" filter transmits only those frequencies below a certain limit, the "high-pass" above a certain limit, and the "band-pass" only within a certain range or ranges. Filters of this nature are used in the laboratory for purifying sounds, *e.g.*, removing harmonics from a complex wave-form to obtain a pure tone; and in connection with speaking devices.

Measurements of Sound Intensity; Using Air Resonators.—The amplitudes at various points in a vibrating air column or cavity may be examined qualitatively by means of small manometric capsules (fitted with tube to a sensitive flame) or by sensitive membranes carrying fine particles or small mirrors. Quantitative results have been obtained by means of a *Rayleigh disc* which, when inclined at 45° to the axis of a neck of a double resonator, forms a very sensitive detector—the disc tending to set itself at right angles to the vibrating air current in the neck of the resonator (*see* p. 14.) Alternatively *the hot-wire "microphone"* (*see* p. 31) may be used.

Kundt's Dust Figures.—To exhibit the nodes and antinodes in a resonating air column contained in a glass tube, Kundt devised the method of spreading fine powder (lycopodium seed or fine dry cork dust) along the inside of the tube. The dust is immediately thrown into a pattern indicating the positions of nodes and loops along the tube. The experiment is capable of a number of variations yielding valuable data relative to the velocity of sound in gases and solid rods. The wave length λ_g in the gas contained in the tube is at once obtained from twice the nodal separation—the wave length λ_r in the rod which excites the vibrations in the air column being, for the fundamental longitudinal vibration, equal to twice the length of the rod. These values give at once the relative velocities in the gas and the rod. (*See* p. 21.)

Sirens.—The sources of sound to which we have hitherto referred are dependent on the principle of resonance for their efficient action. We shall now deal briefly with an entirely different type of sound generator. In the earliest form of siren a revolving disc perforated with a ring of equally spaced holes interrupted a jet of air from the nozzle of a tube mounted opposite the ring of holes. The fundamental frequency of the note produced by the successive puffs of air emerging beyond the disc is clearly equal to the product of the number of holes and the revolutions per second of the disc. This primitive form is known as *Seebeck's Siren* (1805–1849). In later forms of siren (C. de la Tour's form) the holes were drilled obliquely to the surface of the disc so that the blast of air also produced the necessary rotation of the disc. In this form the intensity of the note increased with frequency—the sound amplitude being roughly proportional to the pressure of the air supply. In recent laboratory forms the siren is motor driven, means being provided for indicating the speed of the revolving disc and consequently the frequency of the sound. A motor driven siren forms a very convenient means of determining, by a direct method, the pitch of a note. With a circular nozzle and equal circular holes the siren note is generally impure—containing a plentiful supply of harmonics in addition to the fundamental. Milne and Fowler (*Roy. Soc.*, *98*, 414, 1921) describe a special form of siren which gives comparatively pure tones. The holes in the rotating disc are specially shaped so that the uncovered area of the nozzle varies sinusoidally.

Dove and Helmholtz produced sirens having several rings of holes provided with corresponding nozzles, so that one or more tones could be produced simultaneously. Sirens driven by compressed air or steam are in common use as sources of sound. Similar devices modified to suit the special conditions have been used for signalling under water—the air supply of the ordinary siren being replaced in this case by a jet of water which causes rotation of the disc and gives the necessary vibratory impulses to the surrounding water.

The Diaphone, a powerful long range signalling device for use in air, is essentially a siren of the same group as those of Seebeck and La Tour since it differs from them only in the fact that the opening and closing of the ports is effected by a reciprocating instead of a rotary motion—this reciprocation being produced directly by means of the compressed air supply.

The Centrifugal Siren.—This device consists of a radially-vaned cylindrical rotor revolving in a stationary casing in which ports are cut. The vanes are connected in pairs at their outer edges by cylindrical segments, so that rotation causes opening and closing of the fixed ports. Air is drawn through an axial aperture where the vanes are cut away. The sound is produced by the expulsion of air through the ports by the centrifugal action of the rotor which may be driven by an electric motor or internal combustion engine. Sirens of this type constitute very powerful and efficient sources of sound for long distance transmission in air, *e.g.*, for use on light-vessels or shore stations as a means of signalling to ships at night or in foggy weather.

Sounds Produced by Rotating Propellers.—The hum of an electric fan which increases in pitch with increase of speed can be heard only at a short distance. The noise produced by the propeller (airscrew) of an aeroplane may, under favourable conditions, be heard several miles away. The sound emitted in both these cases arises, in the absence of excessive vibration, from the rotation of the "source and sink system" associated with the pressure differences on the rotating blades. A. Fage (*Roy. Soc. Proc.*, *107*, 1925) has analysed the sounds emitted from various types of airscrews by means of a resonator, of continuously variable tuning, fitted with a Tucker hot wire microphone. He found that the sound of rotation consists of a large number of harmonics having as fundamental a note of frequency equal to the product of the number of blades and the rotational speed. In addition to these sounds, "tearing sounds" associated with the shedding of eddies from the blades were also observed but the frequencies were not determined. Sounds arising from the flexural vibrations of the airscrew blades and the shaft were found to have frequencies in agreement with calculation.

Propellers Under Water.—Most of the under-water noise from a moving ship comes from the screw propeller. As it revolves, "cavitations" are formed just behind the blades. When these cavitations collapse either on themselves or on the blades, a noise is produced. This noise has no predominant frequency, although it is to some extent characterised by the beat of the engines or the rush of the turbines which drive the propeller. If the latter revolves slowly the cavitations are not formed and there is very little noise. With suitable receivers (hydrophones) the noise of a ship proceeding at a moderate speed, say 10 or 15 knots, can be heard several miles away. (*See* Bragg, *World of Sound.*)

Explosive Sounds.—The ejection of a shell from a gun and the subsequent explosion of the shell are both accompanied by a pressure-wave of large amplitude which can be detected at long ranges. This pressure-wave has, however, a different character in the two cases—the explosion at the gun is due to the ignition of cordite which burns relatively slowly when compared with the rate of detonation of the T.N.T. in the shell. Consequently the gun-wave has a wave-front which is much less abrupt than that of the shell detonation. This appears to the ear as the difference between a "boom" and a "crack." An observer of such pressure waves at a distant point receives what appears to be a continuous train of waves, *i.e.*, a reverberation effect, due to the numerous reflected pulses from objects along the track of the primary pulse. Such reverberations may last several seconds. Similar effects are observed under water on the explosion of a mine or a depth charge. The explosion of a few ounces of guncotton under water can be detected and recorded 30 or 40 miles away. A rapid succession of explosions at equal intervals of time may result in a noise of a more or less musical character. This is exemplified in high speed gas or petrol engines, particularly those with several cylinders operating in succession. The note is harsh and the fundamental is accompanied by a long train of harmonics. The musical noise of a high frequency Wehnelt electrolytic interrupter (used in X-ray work) is also due to a regular succession of explosive impulses, arising from the sudden generation of gas under the liquid. The wave-form of such a series of impulses recorded on a cathode-ray oscillograph indicates the extremely abrupt nature of detonations. A single impulse is often sufficient to set a resonator into vibration, thereby producing, indirectly, a musical note.

A single impulse of an explosive nature, produced by a powerful electric spark has been employed in the study of the progress of a sound-wave under controlled conditions—particularly in connection with the complex reflections of sound-waves in auditoriums. (*See* ACOUSTICS OF BUILDINGS.)

Sounds Maintained by Heat.—Most bodies on being heated will expand and in so doing perform a certain amount of mechanical work. If the phases of the forces thus called into play are favourable, a vibration may be set up and maintained.

Trevelyan's rocker is a good example of such a maintained vibration. It consists of a prism of brass or copper almost triangular in section with one edge grooved to form two adjacent parallel ridges. The prism rests with its groove downwards on a block of lead with a rounded top, the end of the prism terminating in a ball which rests on a smooth surface. When the prism is heated and placed on the lead block it begins to vibrate, the weight being carried alternately on one or the other of the two ridges. The cause of these vibrations was ascribed by Leslie to the expansion of the cold block at the point of contact with the hot metal. The effect can be obtained also by a local heating of the points of contact by means of an electric current.

Singing Flames.—Under certain circumstances a small gas flame inserted into a resonant chamber of air or other gas, will emit a musical sound. If heat be given to the air in a vibrating column at the instant of greatest condensation the vibration will be encouraged. If the phase of the heat supply be reversed the vibration will be discouraged. An essential feature of the maintenance of the vibration is the presence of stationary waves in the gas supply tube as well as in the singing tube. The jet must be a node to correspond with a node in the singing tube where the maximum pressure-amplitude occurs. For most satisfactory operation therefore it is necessary (a) that the gas jet should be at or near a node in the singing tube and (b) that the length of the gas supply tube should be an odd multiple of $\lambda/4$ (where λ is the wave-length, *in the gas*, of the note sounded). The tube will not sing at all if the length of the supply tube lies between $\lambda/4$ and $\lambda/2$, $3\lambda/4$ and λ, and so on. Spherical resonators, large globes, may also be employed, and bulbous chimneys as used for paraffin lamps give satisfactory results. The intermittent character of a singing flame is easily demonstrated by means of a revolving mirror, from which it appears that at one phase the flame may withdraw itself entirely within the gas supply tube. The vibrations sometimes reach sufficient intensity to extinguish the flame completely. For a complete discussion of the phenomena of singing flames Rayleigh's *Sound*, vol. ii., p. 224, should be consulted.

Gauze Tones.—Rijke in 1859 made the discovery that a sound of considerable power may be produced by a heated piece of fine metal gauze stretched across the lower part of a vertical open tube containing air. In the earlier experiments the gauze was heated by a gas flame and the sound was observed immediately *after* the removal of the flame. Keeping the gauze hot by means of an electric current the sound may be maintained indefinitely. The maintenance depends on the variable transfer of heat due to the motion of air through the gauze, this motion being a uniform upward convection current with a superposed alternating motion due to the resonant vibration of the air in the tube. In the lower half of the tube the alternating flow assists the direct flow a quarter period *before* the phase of greatest condensation and opposes it a quarter period *after* this phase. Bosscha and Reiss (1859) demonstrated the complementary phenomenon. If a current of *hot* air fall on a *cold* gauze, sound is produced—in this case the phase relationship requires the gauze to be in the *upper* half of the tube, preferably about a quarter the length of the tube from the top.

The Thermophone. Fine Wires or Strips Heated by Alternating Currents.—When an alternating current i sinnt is passed through a fine wire of resistance R the heat developed is proportional to $Ri^2\sin^2 nt=\frac{1}{2}Ri^2(1-\cos 2nt)$. Consequently the heat developed will vary between 0 and $\frac{1}{2}Ri^2$ at a frequency $2n/2\pi$, that is, at twice the frequency of the current. If a sufficiently large initial direct current i_0 be passed through the wire the double frequency term in $R(i_0+i\sin nt)^2$ or $\{R(i_0^2+\frac{1}{2}i^2)+2Ri_0i\sin nt-\frac{1}{2}Ri^2\cos 2nt\}$ may be made negligible—the fluctuations of heating effect then vary with the frequency $n/2\pi$ of the current.

Using very fine platinum wires (10^{-4}cm. thick), P. de Lange (*Roy. Soc. Proc.*, 91, Ap. 1, 1915) demonstrated that the decrease and increase of heat took place synchronously with the A.C. supply. The air surrounding the wire was thereby rapidly heated and cooled, the corresponding expansions and contractions appearing as sound. Ordinary telephonic currents, of speech frequency, were shown to be sufficient to produce easily audible sounds in a small earpiece containing the fine wire heater and a small volume of air. This device is known as a *Thermophone.* The reproduction is of good quality, but somewhat feeble relative to the response of electro-magnet telephone receivers. Provided the frequency is not too high, the thermophone has a possible application as a metrical source of sound.

Directional Sources of Sound.—It is evident that a greater range of transmission will result if a given amount of sound energy is confined to a cone with a small angle of divergence instead of spreading uniformly in all directions. Other advantages of a directional transmitter will be equally apparent. Certain sources of sound exhibit inherent "directional" properties, due to the fact that their dimensions are considerably greater than a wave length of the sound they emit. Other sources may show no inherent directional property but may be made directional by the use of some attachment such as a trumpet or a mirror. A line or an area of equally spaced non-directional sources vibrating in phase may act as a directional compound source.

Sources of Large Area.—The linear dimensions not small compared with a wave-length. Rayleigh (vol. ii., p. 138) refers to the directional properties of a speaking trumpet when used to transmit high pitched sounds, such as a whisper or a hiss. An instructive example of this nature is the case of radiation of high frequency sound waves from one face of a quartz piezo-electric "piston" oscillating with uniform amplitude and phase at all points of its surface (*see* R. W. Boyle, *Proc. Roy. Soc.* Canada, III, 1925, p. 167). The sound-distribution round such a source is analogous to that of plane waves of monochromatic light falling on an aperture and forming a diffraction pattern beyond. Consider the case of a circular piston source of radius a radiating waves of length λ ($\lambda=c/N$ where c is the velocity of sound in the medium and N the frequency of vibration). As in the optical case, the sound is a maximum along the axis of the piston where all the elementary disturbances from the various points of the piston arrive in the same phase. In directions inclined to the axis the intensity is less, diminishing steadily to a minimum when the difference in distance to the nearest and the furthest points of the piston is rather more than half a wave-length. In this case, the effect of the further portion of the disc is just neutralised by the effect of the nearer portion. In directions still more inclined, the sound increases again to an intensity equal to 0·017 of that along the axis. This is succeeded by another minimum value and further maxima of small intensity—corresponding to the various diffraction rings in the optical analogue. The angle α at which the first silence occurs is $\sin^{-1}(0{\cdot}610\lambda/R)$. Thus *the central "beam" of sound will be confined to a cone of small angle when the radius R of the piston is many times the wave-length.* The polar distribution of amplitude is somewhat similar to that shown in figure 8 for a line of small nondirectional sources. When the radius R does not exceed $\lambda/4$ the elementary disturbances from the piston combine without much opposition in phase, and the intensity is nearly the same in all directions—the case of a non-directional source of sound.

Rayleigh obtained general verification of this theory by means of a speaking trumpet and high pitched sounds—a considerable concentration of sound on the axis being obtained. Boyle, using a Langevin type of piezo-electric quartz disc (*see* p. 12) showed that the sound distribution (the polar diagram) in water was in good agreement with theory. In one example $R=7{\cdot}65$ cm., $N=135{,}000$ p.p.sec., $c=1{\cdot}5\times10^5$ cm./sec. for water, $\lambda=1{\cdot}11$ cms. whence $\alpha=5^\circ$ approximately. This angle was verified experimentally. The application of such a high frequency directional sound beam has already been mentioned.

Double Sources.—The "piston" radiator to which we have referred is a *single source of sound*—it radiates from one face only, the anterior face being suitably screened. A vibrating diaphragm mounted on a ring radiates from *both* faces, the radiation from one face being at any instant in opposite phase to that from the other face. Such a vibrator is described as a *double source.* As we have seen (*see* p. 13) a double source, such as a diaphragm on a ring, situated in an open space, air or water, is inaudible from any point in its equatorial plane, maximum sound being received at right angles to this plane.

Nondirectional Source Used with Mirrors, Trumpets, Zone Plates, etc.—As in the case of piston sources of large area, a "directed" source, employing for example a mirror or a trumpet, can exhibit good directional properties only if the dimensions of the mirror, etc., are not small compared with the wave-length of the sound. This condition involves bulky apparatus if the wave-length is appreciable, the alternative being the use of high frequency sounds of short wave-length. If the beam is to be narrow, it is also desirable that the area of the source at the focus of a mirror for example should not be large. This involves a further difficulty when a large sound-output is required, for the source must then have a very large amplitude, a condition which leads to inefficient transmission both in air and in water. In air, serious degradation of energy may take place at large amplitudes (*see* Hart, *Roy. Soc. Proc.*, A. 105, 1924, p. 80) and in water "cavitation" troubles arise (*see* Boyle, *Roy. Soc. Proc.*, Canada, 111, 1922, p. 157). The use of mirrors, trumpets, zone plates, etc., are consequently more suited to the directional *reception* of high frequency sounds—where such troubles do not arise. Concave mirrors of say 1 to 2 feet diameter and 6 to 12 inches focal length are fairly efficient reflectors of high pitched sounds like a watch tick or the notes from a Galton's whistle.

Multiple Sources.—As in the case of a large piston vibrator, a line of small "point," sources, suitably arranged, will have definite directional properties. Suppose we have "m" equidistant sources in a straight line vibrating with the same phase, amplitude, and frequency. We require to know the polar distribution of amplitude in any plane passing through the line of m sources. (*See* fig. 8a.) It is readily proved that the resultant amplitude r at a distant point P is given by

$$r=\frac{\sin(m\pi d/\lambda\cdot\cos\alpha)}{m\sin(\pi d/\lambda\cdot\cos\alpha)}$$

if d is the spacing-distance of the sources each of amplitude $1/m$, and α is the orientation of the point P with respect to the line source. An important case arises when $d=\lambda/2$, *i.e.*, when the sources are spaced half a wave-length apart. Then

$$r=\sin(\pi/2\cdot m\cos\alpha)/m\sin\left(\frac{\pi}{2}\cdot\cos\alpha\right)\cdot$$

This is zero whenever $\sin(\pi/2\cdot m\cos\alpha)$ is zero, *i.e.*, whenever $\cos\alpha\cdot m/2$ is an integer. Suppose, for example there are 6 sources spaced $\lambda/2$ apart, then $m\cdot\cos\alpha\cdot/2$ may be 1, 2, or 3, whence $\alpha=70°\ 48'$, $48°\ 42'$ and $0°$ giving the directions OP of zero amplitude. The primary maximum occurs when $\alpha=90°$ and secondary maxima at $\alpha=60°$ and $30°$ approx. The polar distribution from 0 to π is shown in fig. 8b the value of r being plotted radially from O in the direction α. This distribution is the same in all planes which include the line of sources. When d has other values, the polar distribution includes secondary maxima which may approach the primary in magnitude (*see* paper by H. Stenzel, *Elecktrische Nachrichten Technik*, Band 4, Heft 6, 1927, pp. 239–253). It will be seen that a vertical line of sources spaced $\lambda/2$ apart will give a definite concentration of energy in a horizontal plane at right angles to the line of sources. Such a concentration is, for example, of considerable importance in a fog signalling device, where a maximum energy concentration is required in a horizontal plane surrounding a light-vessel. It may similarly be shown that a number of equidistant sources arranged on a circle and vibrating in phase will give a primary maximum of intensity on the axis, with a number of zero and secondary maxima positions as in the case of a disc.

Aeolian Tones.—The "singing" of telegraph wires and the "whistling" of the wind through tall grass and trees are very familiar sounds. The "thrumming" of a tightly stretched wire in a stream of water is evidently due to a similar cause. Aeolian tones are produced when wind rushes past a stretched wire, their excitation depending on the formation of unstable vortex sheets. When wind of sufficient velocity passes a wire, a double series of vortices are set up immediately behind it, one set revolving in the opposite direction to the other and the flow of air past the wire wavers from side to side. In this manner vibrations are set up in the surrounding air which, under the right conditions, will be audible. Strouhal investigated the effect by revolving a vertical stretched wire about a parallel axis. He found that the frequency was expressed by $N=0\cdot185\ v/d$ where v is the velocity and d the diameter of the wire. When the speed is such that N corresponds with one of the natural frequencies of the wire the sound is greatly increased. Rayleigh showed that the vibrations of the wire are transverse to the direction of the wind. This is readily explained on the vortex theory; the oscillations of air flow behind the wire reacting on the wire itself. The Aeolian harp consists of a number of wires, all of the same low pitch but of different thicknesses stretched on a sounding-board and exposed to the wind. The varying thicknesses of the strings results in a series of different notes.

Noises in General.—In addition to the various sources of sound to which we have referred there are innumerable others. Almost every material object in motion is a source of sound vibration. In all parts of the world there has been a steady increase in traffic noise during recent years, the problem of the reduction of such noise becoming increasingly acute. Relative motion and intermittent contact between solid bodies, such as a vehicle on a road, results in a shock excitation of the numerous resonant vibrations which are possible in a complex structure. A heavy vehicle fitted with solid tyres and having many loose parts is an irritating example of this when it runs over a somewhat irregular road surface. The complex noise issuing from such a vehicle may be analysed into the simpler forms which we have considered above. The prevention of such noises involves many considerations, but obvious improvements may be obtained by (1) use of pneumatic tyres, (2) tightening of all loose "rattling" contacts, (3) balancing of all parts of machinery in rapid motion, (4) use of oil to reduce frictional noises, (5) use of pressure reducers or "silencers" for exhaust gases, etc.

The noise of breaking waves or rushing water may be ascribed to the resonant vibrations of air cavities enclosed momentarily by the water.

TRANSMISSION OF SOUND

It is important now to consider what takes place in an extended elastic medium (solid, liquid or gas) containing a source of sound. *Sound waves* are the inevitable result when vibratory stresses are set up by any means at any point of an elastic medium. Such sound waves consist of alternations of condensation and rarefaction, corresponding to the successive forward and backward movements of the source. The state of compression is passed on from layer to layer of the medium, with the velocity of sound; this being followed in turn by a rarefaction, another compression, and so on, as long as the source continues to vibrate. The phenomena of propagation of such waves of condensation and rarefaction may be demonstrated very simply by means of a long helical spring supported at suitable intervals by thin threads. Simple harmonic longitudinal displacement of one end of such a spring results in the generation of waves which travel along the spring at a definite speed. In such waves, *as in sound-waves, the displacements of individual particles are in the direction of propagation of the wave*—the motion is consequently termed *longitudinal*, as distinct from transverse wave motion in which the displacements are at right angles to the direction in which the wave travels (*e.g.*, ripples on water, or waves travelling along a stretched string). If the condensational wave travels with a uniform velocity c cms./sec and the source of sound has a frequency of N periods per second, it will be clear, without formal proof, that there are N condensation and N rarefactions in the distance c covered by the wave in one second. Now the distance, by which one condensation is ahead of the next, is called the *wave-length* λ *of the sound* in the medium; consequently we have $N\lambda=c$. When a simple harmonic vibration is transmitted through the medium the linear density of the particles, or their state of compression or expansion, is at any instant represented by a simple harmonic curve which repeats itself at regular intervals of a wave-length.

Plane Waves.—The problem in its simplest form is that of transmission of a plane (or non-spreading) simple harmonic wave *in a positive direction* along the axis of x. The particle displacement ξ at any time t of a point whose mean position is x will be given by

$$\xi=a\sin 2\pi(t/\tau-x/\lambda) \tag{1}$$

or

$$\xi=a\sin 2\pi(Nt-x/\lambda) \tag{2}$$

where a is the amplitude, τ and N the period and frequency and λ the wave-length of the vibration. Writing $c=N\lambda=\lambda/\tau$ we obtain other forms of these equations, viz.,

$$\xi=a\sin[2\pi/\lambda\cdot(ct-x)] \tag{3}$$

and

$$\xi=a\sin n(t-x/c) \tag{4}$$

where n has the usual significance and is equal to $2\pi N$. These four alternative expressions for the particle displacement ξ in a progressive plane wave are convenient for most purposes. Comparison of these relations shows that the phases, in the case of progressive waves, may be expressed in terms of fractions of a wave length λ which corresponds to a phase-angle of 2π. Thus the difference of phase between the vibrations of two particles at x_1 and x_2 respectively from the origin will be $2\pi\ (x_2-x_1)/\lambda$. It will be evident that a system of *waves travelling in the negative direction* of x will be represented by the introduction of a positive instead of a negative sign inside the brackets in the above expressions for ξ. A system of simple harmonic progressive waves may, of course, be represented graphically with the displacement ξ plotted as ordinates and the time t as abscissae.

Velocity and Acceleration of Particles in the Wave.—Differentiating ξ with respect to t we obtain the particle velocity, thus

$$\partial\xi/\partial t=na\cos n(t-x/c) \quad \text{or} \quad \partial\xi/\partial t=-c\partial\xi/\partial x. \tag{5}$$

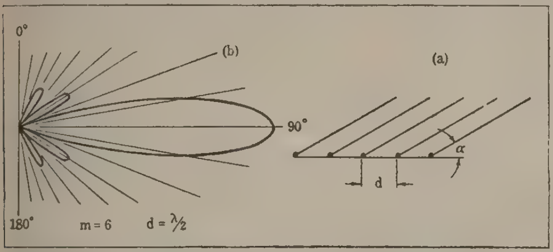
Differentiating again, we obtain the acceleration

$$\partial^2\xi/\partial t^2=-n^2a\sin n(t-x/c) \quad \text{or} \quad \partial^2\xi/\partial t^2=c^2\partial^2\xi/\partial x^2. \tag{6}$$

Relations (5) and (6) give the particle velocity and acceleration in terms of wave velocity c and the slope and curvature of the displacement curve. Equation (6) is the differential equation which characterises wave motion. Its complete solution is

$$\xi=f(ct-x)+F(ct+x) \qquad (6a)$$

which represents two independent systems of waves travelling in opposite directions with the same velocity c. *This velocity is*, within certain limits entirely independent of the form of the wave, being *independent of wave-length* λ *and amplitude* a. Within these limits, *the velocity is determined solely by the physical properties of the medium.* As we shall see, these properties are density and elasticity, corresponding to the factors mass and stiffness in the case of the vibrations of a particle. As the wave travels through the medium the volume and density fluctuate locally, these fluctuations being controlled by the properties of the medium and the applied forces. The following definitions are important:—



FROM STENZEL IN "ELECKTRISCHE NACHRICHTEN-TECHNIK" (WEIDMANN)

FIG. 8

Dilatation Δ is the ratio of the increment of volume δv to the original volume v_o, thus

$$\Delta=\partial v/v_o \quad \text{and} \quad v=v_o(1+\Delta). \qquad (7)$$

Condensation s is the ratio of increment of the density $\partial\rho$ to the original density ρ_o thus

$$s=\partial\rho/\rho_o \quad \text{and} \quad \rho=\rho_o(1+s) \qquad (8)$$

since $\rho v=\rho_o v_o$ and $(1+s)\,(1+\Delta)=1$ (8a)

and $s=-\Delta$ neglecting $s\Delta$ as a small second order quantity.

Volume or Cubic Elasticity κ sometimes known as "bulk modulus" of elasticity.

$$\kappa=\delta p/\delta v/v_o=-v_o\delta p/\delta v=\delta p/s \qquad (9)$$

where δp is the stress and δv the strain; whence we have, for small variations of s,

$$p=p_o+\kappa s \qquad (10)$$

Compressibility C is the reciprocal of κ. Thus

$$C=-1/v_o\cdot\delta v/\delta p=1/\kappa \qquad (11)$$

In the case of plane-waves travelling along the axis of x, the displacements of planes normally at x and $x+\delta x$ will, at a time t, be ξ and $\xi+\delta x\cdot\partial\xi/\partial x$ respectively. The thickness of the layer bounded by the two planes is therefore changed from δx to $(1+\partial\xi/\partial x)\delta x$. Consequently the dilatation $\Delta=\partial\xi/\partial x=-s$. The mass of unit area of the layer is $\rho_o\delta x$. If the excess pressure on the $(x+\delta x)$ face is δp we may equate this force to the product of the acceleration and the mass of the layer, thus $\rho_o\delta x\cdot\partial^2\xi/\partial t^2=-\delta p$ or $\partial^2\xi/\partial t^2=-\delta p/\rho_o\delta x$. Now $\delta p=\kappa s$ from (10), and $s=-\partial\xi/\partial x$,

therefore $$\partial^2\xi/\partial t^2=\kappa/\rho_o\cdot\partial^2\xi/\partial x^2 \qquad (12)$$

or writing $$c=\sqrt{(\kappa/\rho_o)} \qquad (13)$$

$$\frac{\partial^2\xi}{\partial t^2}=c^2\frac{\partial^2\xi}{\partial x^2} \qquad (14)$$

which is equation (6) above, the complete solution being given in (6a). *The velocity of plane-waves in the medium is therefore equal to* $\sqrt{(\kappa/\rho)}$. The above method of treatment applies to all cases of transmission of small amplitude plane-waves in solid, liquid, or gas, provided the appropriate modulus of elasticity is used. The bulk modulus κ is applicable only to large masses of fluid, where change of volume but not change of shape can take place. For a solid in bulk κ must be replaced by $(\kappa+\frac{4}{3}\cdot\mu)$ where μ is the rigidity whilst for a solid rod Young's modulus E is the appropriate elastic constant.

Kinetic Energy in Plane-Waves. Intensity.—The rate of transfer of energy per unit area of cross section of the wave may be regarded as a physical measure of the intensity of the sound transmitted. The kinetic energy of a layer of unit area and thickness δx is $\delta E=\frac{1}{2}\rho_o\,\delta x(\partial\xi/\partial t)^2$. The maximum value of $\partial\xi/\partial t$ is na (from eqn. [5]). Consequently the maximum kinetic energy per unit area and unit length (*i.e.* unit volume) of the wave $=\frac{1}{2}\rho_o n^2a^2$— (15). Since the sum of kinetic and potential energies is a constant, $\frac{1}{2}\rho_o n^2a^2$ *must also be the total energy of the wave motion per unit volume.* This quantity may be described as the *energy density* in the wave. Now the wave travels a distance c per second, therefore the *transmission of energy per second per unit area of wave-front* $=\frac{1}{2}\cdot\rho n^2a^2c$ (16). This may be regarded as a measure of *the intensity of the sound-wave.* The intensity is therefore equal to the product of energy density $(\frac{1}{2}\cdot\rho n^2a^2)$ and wave velocity c. The *maximum particle velocity* $\partial\xi/\partial t$ is from (5) equal to na and the *maximum condensation*

$$s=-\partial\xi/\partial x_{\text{max.}}=na/c,$$

that is, equal to the maximum particle velocity divided by the wave velocity. The expression for the intensity may therefore be written $=\frac{1}{2}\cdot\rho c^3s^2_{\text{max.}}$ Now

$$c^2=\kappa/\rho \quad \text{and} \quad \delta p_{\text{max.}}=\kappa s_{\text{max.}}$$

therefore the *intensity or energy flow/sec.* $=(\delta\rho_{\text{max.}})^2/2\rho c$ (17) a useful expression giving the intensity of the sound-wave in terms of maximum pressure variation in the path of the wave.

Power of Sound Source. Radiation Impedance.—The energy thus present in the sound-wave must be derived from the vibrating source. The rate at which the source does work, that is the power of the source, in producing sound-waves, is equal to the product of pressure variation and particle velocity, *i.e.*, to $\delta p\times\partial\xi/\partial t$ per unit area of wave-front. Now

$$\delta p=\kappa s=\kappa/c\cdot\partial\xi/\partial t, \quad \text{and} \quad c=\sqrt{\kappa/\rho}$$

whence $$\delta p=\sqrt{\kappa\rho}\cdot\partial\xi/\partial t. \qquad (18)$$

Therefore the power expended by the source per unit area of wave-front $=\sqrt{(\kappa\rho)}\cdot(\partial\xi/\partial t)^2$ (19). The relations expressed in (18) and (19) are closely analogous to the relations between e.m.f., current, and resistance in electrical circuits. If we regard δp, $\sqrt{\kappa\rho}$, and $\partial\xi/\partial t$ as corresponding to e.m.f. E, resistance (or impedance) R, and current i respectively we see that eqn. (18) is the mechanical analogue of Ohm's law in electricity, and that (19) is analogous to power dissipation Ri^2 in an electrical circuit. The quantity $\sqrt{\kappa\rho}$ or ρc is consequently designated the *radiation impedance* per unit area of the medium transmitting the sound-wave. This quantity is important in the consideration of the transmission of sound waves through a succession of different media (*see* p. 18).

Spherical-Waves.—The results derived above for the energy in plane-waves hold equally well for spherical-waves at a sufficient distance from the source. Elementary considerations at once indicate that the energy density in the wave will vary inversely as the square of the distance from a point source of spherical-waves, whence it may be inferred that the amplitude (of displacement, pressure or condensation) will vary inversely as the distance. This assumes, of course, that the amplitudes are small at all parts of the wave, and that there is no loss of energy due to viscosity, heat conduction and similar causes.

As in the case of plane-waves, it may be shown that the *intensity* at a point in the wave is given by $(\delta p_{\text{max.}})^2/2\rho c$.

Single and Double Sources. Energy Emission from Solid Vibrators.—A simple point source is a theoretical abstraction, but in practical cases where the source is a vibrating surface of appreciable area, each *element* of this area may be regarded as a simple source of spherical-waves, and the effect of the source as a whole obtained by integrating the effects of the elementary areas. Again, many vibrating bodies are not *simple sources.* For example a diaphragm radiating sound to air on *both* sides is, at any particular instant, sending out a compression pulse on one side and a rarefaction pulse on the other—thus behaving like two sources near together and in opposite phase; in other words acting like a *double source.* The prongs of a tuning fork each act as double sources in a similar way. Lamb (*Dynamical Theory of Sound*) shows that *the rate of energy emission, or power, of a simple source is equal to* $\rho n^2A^2/8\pi c$, where ρ and c are the density and velocity of sound in the surrounding medium, $n/2\pi$ is the frequency, and A is the "strength" of the source (*i.e.*, the maximum rate of emission of fluid at the source); *the power of a double source is equal to* $\rho n^4B^2/24\pi c^3$, B being the "strength" of the double source. In both cases it will be seen that the rate of energy emission increases rapidly with increasing frequency. For the same strength and frequency, the energy emitted in different media will vary directly as the density and inversely as the wave-velocity (or the cube in the case of a double source). In gaseous media, where the velocity varies inversely as $\sqrt{\rho}$, the energy emission at constant frequency will vary inversely as (wave-velocity)^3 and (wave-velocity)^5 respectively in the two cases. These deductions account for the apparent feebleness of a bell or a tuning fork when vibrating in hydrogen as compared with air. The wave-velocity in hydrogen is 3·9 times that in air, therefore the energy emission from the same strength of source will be $(3{\cdot}9)^5$ or 900 times as great in air as in hydrogen. Another example:—the relative densities and wave-velocities for air and water are 1/770 and 1/4·4 respectively—the energy emission, on these grounds, being, for sources of the same strength and frequency, about 3,400 times as great in water as in air. The loading effect of the water and the limitations of output of sound generators must also be considered in dealing with actual cases. The quantities A and B in the above relations, denoting "strength" of source involve the area and form of the vibrating surface, amplitude and frequency. There is consequently for the same amplitude and frequency an increased rate of energy emission with increase of area in contact with the medium—exemplified by the increase of sound emitted when a tuning fork is brought into contact with a sounding board like the top of a table. The sounding board of a piano or a violin radiates practically all the vibrational energy of the strings, the damping of the latter being increased accordingly.

In designing "sound generators" it is important to observe that the sound energy radiated bears a definite relation to the total energy available at the source. The conditions governing efficiency in this connection are similar to the analogous case of an electrical generator supplying power to an external circuit.

"*Local Flow.*"—When the vibrations of a solid body immersed in a fluid medium are very slow, the fluid behaves as if it were incompressible and simply flows locally from one surface of the "double source" to the other surface in opposite phase. In that case no sensible vibration is transmitted through the medium. As the vibrations increase in frequency the local flow is reduced, whilst true alternating pressure-waves, *i.e.*, sound-waves, are set up in the medium. Again, at constant frequency, the higher the velocity of sound in the medium, the more nearly does the medium approach incompressibility, consequently the local flow is greater and less energy is radiated as sound.

On all grounds it is clearly preferable to use the *simple source* rather than the double source type of sound generator, for the local flow is reduced and there is no neutralising effect due to "out of phase vibrations" from a neighbouring surface. The increase of sound radiated from a tuning fork when "local flow" is reduced, may easily be demonstrated (*see* fig. 9). A piece of cardboard is held with one edge parallel and close to a prong of the vibrating fork. In positions A and B no effect is produced, whereas at C the sound is considerably increased in intensity.

The Principle of Superposition.—Huyghens first drew attention to the fact that the passage of one beam of light through an aperture is in no way affected by the passage of another beam through the same aperture. It is a commonplace observation that any number of sound-waves may cross the same air space at the same time without the slightest evidence of confusion due to overlapping. This independence of the separate waves is explained by the principle of superposition, according to which the resultant effect of a number of displacements may be obtained by vector addition. The validity of this important principle is dependent on the assumption that the elastic properties of the medium are such that the stresses are linear functions of the strains—a condition which is fulfilled in the case of small-amplitude sound-waves.

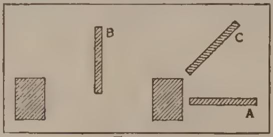


FIG. 9

Huyghens' Secondary Waves.—Another important principle due to Huyghens is the following:—The wave-front of a disturbance may at any instant be obtained as the envelope of the secondary waves proceeding from all points of the wave-front at some preceding instant. Thus the disturbance diverging from a point source may at any time t be regarded as represented by a thin spherical shell of radius ct, each point of which now serves as the origin of further spherical disturbances, the envelope of which becomes the new wave-front.

VELOCITY OF SOUND

It has already been shown that the velocity of sound-waves of small amplitude in an unlimited fluid medium is given by $\sqrt{(\kappa/\rho)}$ where κ is the bulk modulus of elasticity and ρ the density of the medium. In the case of a solid in bulk, κ must be replaced by $(\kappa+\frac{4}{3}\mu)$ where μ is the rigidity of the solid. In special cases where the volume of material is limited, *e.g.*, in solid bars or columns of liquid in tubes, it is important that the appropriate elastic constant be chosen.

In Gases.—When a gas is compressed it is heated, and when rarefied it is cooled. If the heating or cooling effects are not neutralised by removal or supply of heat, *e.g.*, by convection, then the temperature of the gas will rise or fall accordingly. In ordinary sound-waves the alternate condensations and rarefactions take place so rapidly that there is no time for a transfer of heat between adjacent layers of gas. Consequently the temperature rises and falls with the same frequency as the waves of pressure. Such conditions are described thermodynamically as adiabatic. In an adiabatic compression, the relation between pressure p and density ρ of the gas is $p/\rho^\gamma=$constant, that is $p/p_o=(\rho/\rho_o)^\gamma$ where $p_o\,\rho_o$ and $p\,\rho$ refer to initial and final states of pressure and density, and γ is the ratio of specific heats of the gas. Thus $(1+\delta p/p_o)=(1+\delta\rho/\rho_o)^\gamma=(1+\gamma s)$ for small values of the condensation $s(=\delta\rho/\rho)$. Now $\kappa=\delta p/s$ (see equation 9). Therefore $\kappa=\gamma p_0$. Consequently *the velocity of sound is given by*

$$C=\sqrt{(k/\rho)}=\sqrt{(\gamma p_0/\rho_0)}. \tag{20}$$

Now Boyle's law indicates that p/ρ is a constant at constant temperature, consequently *the velocity is independent of the pressure* of the gas, for the density ρ changes in proportion to the pressure p.

Taking $p_o=10^6$ dynes/cm.^{2} and $\rho_o=0.00129$, and assuming $\gamma=1.41$ for air, we obtain a value for the velocity

$$c=3.31\times10^4 \text{ cms./sec. at } 0^\circ\text{ C.}$$

This is in good agreement with observation.

Change of Velocity with Temperature.—Since $\rho\theta=\rho_o/(1+\alpha\theta)$ where α is the temperature coefficient of volume expansion at constant pressure, and θ is the temperature in degrees centigrade, we have $c_\theta=\sqrt{[\gamma p_o(1+\alpha\theta)/\rho_o]}=c_o\sqrt{(1+\alpha\theta)}$. Now for any gas $\alpha\doteq1/273$ per degree centigrade nearly, therefore

$$c_\theta/c_o=\sqrt{T/T_o} \tag{21}$$

where T and T_o are the absolute temperatures. That is, *the velocity* varies *directly as the square root of the absolute temperature. The velocity* given by (20) *is independent of frequency*, but is dependent on the nature of the gas. The velocity varies inversely as the square root of the density, provided γ is the same—thus the velocity is four times as great in hydrogen as in oxygen.

Experimental Determinations of Velocity of Sound in Free Air.—The velocity of sound as measured in free air is affected by the wind, being greater with the wind than against it; in the first case the sum, and in the second the difference, of the velocities of the sound and the wind. It is also affected by humidity. The wind-velocity may be eliminated from the result by the method of reciprocal observation—the sound being produced first at one end and then at the other of a measured base line with a receiver also at each end. Alternatively the wind-velocity may be measured directly and a correction applied to the observed velocity of the sound. The latter method has been employed by Esclangon (*Comptes Rendus*, Jan. 20, 1919). The sound-waves from guns of various calibres were received by sensitive electrical sound-detectors at 1400 m. and 14000 m. along the same line. The time intervals were measured to ±0·002 second, the observations being made under various conditions of wind and humidity. The final result for the speed of sound in dry air at 15° C. was 339·9 metres per second which compares well with Regnault's value 339·7 metres/sec. (1863). Measurements of the velocity of sound at different levels (on mountain heights and plains) confirm the theory that there is no change of velocity with pressure. Observations at low temperatures in the Arctic give a value $c_\theta=(333+0\cdot6\theta)$ metres/sec. at θ° C. Other methods of measuring the velocity in free air are:—(1) *Echo methods*—the time t between the transmission of a sound and arrival of its echo from a reflector at a distance d being measured whence velocity $=2d/t$, (2) *Coincidence Method*—The sound is transmitted at regular, accurately known, time intervals simultaneously from two points at a known variable distance apart. When close together, the sounds are heard together but when one is moved further away the sounds are separated by an interval, at first increasing and then decreasing, till coincidence is again established. The difference in distance between two such positions of coincidence, combined with a knowledge of the time intervals; gives a value of the velocity.

Probably the most accurate determinations were made during the war in connection with gun sound-ranging. Two sensitive resonant hot-wire microphones, at a known distance apart, received the gun-sounds which were automatically recorded by means of an Einthoven string galvanometer, the time intervals being measured to 0·001 second. A large number of such observations, under different atmospheric conditions (wind, temperature and humidity), gave a value *337·16 m/sec. at 10° C. in dry air*, and *337·6 m/sec. at 10°C. in air of average humidity*, the effect of humidity, producing a slight change of density, being therefore very slight.

Velocity in Tubes or Small Volumes of Gas. Kundt's Dust Tube Method. When a gas is only obtainable in small quantities the method of velocity measurement is entirely changed. The best method available in these circumstances is one which is due to the work of Kundt. The gas is confined to a cylindrical tube containing a sprinkling of fine dry powder (lycopodium seed or cork dust) and is set into resonant vibration by any convenient means, *e.g.*, by the longitudinal vibrations of a rod one end of which is inserted in the tube, or by the vibrations of the glass tube which contains the gas. The dust is heaped up in a repeated pattern indicating the nodes and loops in the vibrating gas column. Rayleigh and Ramsey used this method to determine the ratio of specific heats γ of the rare gases argon and helium. The velocity c in a gas is given by $\sqrt{(\gamma p/\rho)}$ where p is the pressure and ρ the density. The value of γ found for the rare monotonic gases was 1·66. Kundt finally used a double-tube apparatus, in which stationary waves were produced simultaneously in two different gases by means of the same vibrating rod. The ratio of velocities in gas (1), rod, and gas (2), being equal to the ratio $\lambda_1:\lambda_r:\lambda_2$, the values of λ_1 and λ_2 are obtained from twice the nodal separation (indicated by the dust heaps), and the value of λ_r is equal to twice the length l of the rod when sounding its fundamental longitudinal vibration. When the frequency N is determined (by monochord and tuning fork, or by a siren) the velocities c in the gas and the rod are known in absolute measure, for $c_{\text{gas}}=N\lambda_{\text{gas}}$ and $c_{\text{rod}}=N\lambda_{\text{rod}}=2Nl$. Alternatively the vibrations may be communicated to the gas by means of a steel diaphragm (a telephone earpiece) one end closed and excited electromagnetically, the frequency being varied until resonance is set up in the gas contained in the tube. This method has obvious advantages over the original "rod" excitation. Using a short steel bar and exciting the vibrations by striking one end, Lang (*Proc. Roy. Soc.*, Canada, 1922) has observed the nodes and antinodes in a Kundt's tube up to a frequency of 50,000 cycles/sec. The mean velocity of sound in the air contained in the tube (1.4 cms. dia.) was found to be 339·3 metres/sec. at 22·8° C., and in the steel bar 5120 m/sec. approximately. Kundt's tube method of measuring sound-velocities, and indirectly, the ratio of specific heats of gases, has been applied by Dixon, Partington and others to vapours and gases at various temperatures, and as a means of measuring temperature coefficients of sound-velocity.

In Liquids.—As in the case of gases the velocity of sound in liquids is given by $\sqrt{(\kappa/\rho)}$, which κ is the adiabatic bulk modulus of elasticity. Taking the isothermal compressibility C of *fresh water* to be 49×10^{-12} per dyne/cm.², at 15° C. the bulk modulus $\kappa(=1/c)=2\cdot04\times10^{10}$, and the velocity

$$\sqrt{(\kappa/\rho)}=1{,}427 \text{ metres/sec.}$$

The value found by Colladon and Sturm (1826) in Lake Geneva was 1435 m./sec. at a temperature of 8° C.

Velocity of Sound in the Sea.—The velocity of sound, particularly explosion-waves, has been measured in the sea by a number of observers with considerable accuracy. Marti (*Comptes Rendus*, Aug. 1919) used three under-water microphones (hydrophones) in a straight line in Cherbourg roadstead, the total base line being 1800 metres. The positions were accurately determined by theodolites. The passage of the sound-wave due to an explosion under water in line with the hydrophones, was registered by an electric chronograph with smoked paper and tuning fork time-trace. At a temperature of 14·5° C. the velocity was found to be 1503·5 metres/sec. in sea water of density 1·0245 gram/cm.³ More recently a careful series of observations has been made by Wood, Browne and Cochrane near Dover with four hydrophones covering a base-line of twelve miles in the sea (*Roy. Soc. Proc.*, May 1923). Accurate temperature and salinity observations were made at points along the base line, and a new method (*multiple charge method*) devised to obviate errors arising through firing the charge at a point not quite in line with the base of hydrophones. The time intervals of passage of the explosion wave between pairs of hydrophones was recorded on four strings of a six stringed Einthoven galvanometer (photographic), the ticks of an accurate chronometer on the fifth, and a wireless signal sent from a destroyer at the instant of firing the charge was recorded on the sixth string. Thus the record showed to an accuracy of ±·001 second the various *time differences and the total time of travel* of the explosion-wave to each receiver. The results obtained in summer and winter were 1510·4 m/sec. at 16·95°C. and 1477·3 m/sec. at 7°C. respectively, the salinity being 35‰ in both cases. (The theoretical values calculated by D. J. Mathews [*see* Tables for Velocity of Sound in Fresh and Sea Water—Stationery Office Publication H.D. 282 1927] are 1510·4 m/sec. and 1476.1m/sec. respectively.) The experimental results are expressed by the relation,

$$\textit{velocity}=4756+13\cdot8\ t-0\cdot12\ t^2\ \textit{ft. per sec.} \tag{22}$$

at 35‰ salinity (or $=4626+13\cdot8\ t-0\cdot12\ t^2+3\cdot73\ s$ where s is the salinity in ‰ at the temperature t° C). The ratio of specific heats (isothermal and adiabatic) for sea water, deduced from these measurements, is 1·0094 as compared with 1·0090 obtained from thermodynamic data. The adiabatic compressibility at 16·95° C and 35‰ salinity is $43\cdot145\times10^{-12}$ per dyne as compared with Ekmann's isothermal value $42\cdot744\times10^{-12}$ per dyne.

Liquids in Tubes.—As in the case of gas-filled tubes stationary waves may be set up in tubes filled with liquid. On account of the small compressibility of a liquid compared with that of gas, however, a correction is required due to the yielding of the walls of the containing tube. This yielding produces an apparent lowering of the wave velocity—the lowering being smaller the thicker the tube. If c_0 be the theoretical velocity of sound in the liquid, and c the actual velocity in the liquid in a tube of small thickness h then

$$c_0 = c\sqrt{(1+2\kappa a/hE)} \qquad (23)$$

where a is the internal radius, K the bulk modulus for the liquid, and E the value of Young's modulus for the material of the tube (*see* Lamb's *Sound*, p. 174). In the other extreme, when the walls are very thick

$$c_0/c = \sqrt{[(\kappa+\mu)/\mu]} \qquad (24)$$

where μ is the rigidity of the material of the tube. Kundt and Lehmann succeeded in obtaining "dust" (fine iron filings) figures in liquids, as in gases, and thus measured the velocity of sound in tubes of different diameters and thickness. Application of Lamb's formula to their experimental values gives a mean value 1436 m/sec. at 19°C for the velocity of sound in open water. At frequencies within the audible range, the resonance of a liquid column can be observed by ear. The vibration is readily excited for example, by means of a steel diaphragm electro-magnetically maintained by current of variable frequency from a valve oscillator.

When the wave-length of the sound in the liquid is sufficiently small compared with the diameter of the tube the "correction" disappears. *Hubbard and Loomis* (*Nature*, Aug. 6, 1927 and *Phil. Mag.*, June 1928) using a quartz oscillator 100 mm. diameter emitting plane-waves at frequencies between 200,000 and 400,000, have determined the velocity of sound in various liquids in a tube, with an accuracy of 1 in 3,000. The results for fresh and salt water at different temperatures agree well with the values obtained by other observers for these liquids in bulk.

In Solids.—The velocity of sound in a solid rod of length l is very simply determined by observing the frequency N of its longitudinal vibration, the rod being clamped at the midpoint. The velocity is equal to $N\lambda$ or $2Nl$. The rod may be excited mechanically by striking or rubbing, or electro-magnetically. The velocity in steel or glass, for example, is about 5×10^5 cms./sec. as compared with $0{\cdot}33\times10^5$ cm./sec. in air and $1{\cdot}5\times10^5$ cm./sec. in water. The values of the velocity determined experimentally in this way agree very closely with the calculated velocities $\sqrt{(E/\rho)}$ where E is Young's modulus of elasticity. The converse of the method is therefore convenient as a means of determining E approximately. Lang (*loc. cit.*) has determined the velocity in short steel rods (5 cms.) vibrating at a frequency of 50,000 using Kundt's tube as a means of estimating the frequency. The values of velocity at supersonic frequencies are found to be the same as at audible frequencies. Apart from seismic observations there is little or no experimental data relating to the velocity of sound-waves in solids in bulk.

Velocity of Waves of Large-Amplitude.—*Explosion-Waves.*—Hitherto it has been assumed that the displacement-amplitude and condensation s are always small, and that the wave travels through the medium with velocity $c=\sqrt{(\kappa/\rho)}$ without change of type. If, however, the condensation becomes large, as in an explosion-wave, the velocity may be considerably modified for the curve connecting pressure p and density ρ is not a straight line. The bulk modulus, $\kappa=-v_0\partial p/\partial v=\rho_0\partial p/\partial\rho$, increases as the density ρ is increased by compression, and diminishes as the density is reduced. Consequently the compression wave travels faster and the rarefaction slower than a "small-amplitude" sound-wave. The result is a change of wave-form as a large-amplitude wave travels through the medium. Lamb (*Sound*, p. 177) shows that *the velocity of propagation is* $c(1+s)$ relative to the undisturbed medium (or $c[1+s]^{\frac{1}{2}(\gamma+1)}$ in the adiabatic case) indicating increase of velocity with increase of condensation s. The parts of the wave of greater density therefore gain continuously on those where it is less—*i.e.*, the crests tend to overtake the troughs, as indicated graphically in figs. 10a and b. The wave becomes steeper in front and more gradual behind. A continuation of such a process would eventually lead to a discontinuity when the wave-front becomes vertical—a condition which is physically impossible. As Rayleigh has remarked, such a tendency is held in check by the divergence of the wave and the influence of viscosity tending to diminish amplitudes and therefore reduce the velocity to its "normal" value. As an illustration, change of type in a progressive wave may be observed when sea waves approach a shelving beach. Here the crests gain on the troughs and the wave "fronts" become steeper and steeper until they curve over and break. A large amplitude explosion wave has initially a velocity considerably greater than ordinary sound-waves, gradually approaching this latter value as the distance from the origin increases. Regnault found that explosion-sounds increased in velocity with increase in the intensity of the explosion. Foley (*Nat. Acad. Soc. Proc.*, June, 1920) showed that the velocity of sound from an intense electric spark varied from 660 m./sec. at a distance of 3·2 mm. from the spark to 380 m./sec. at a distance of 18 metres. The shadow of the high pressure region near the wave-front of the sound-pulse was photographed at known short time intervals after the instant of production of the spark, the velocities at various distances being deduced therefrom.

Shell-Waves. Onde de choc.—When a bullet or a shell, travelling with a velocity greater than that of sound, passes an observer it makes a sound like the crack of an explosion—described by the French as "onde de choc." The tips of the propeller of an aeroplane often exceed the velocity of sound and emit sounds of this nature as they revolve. In the case of a low speed bullet, the air at the nose is compressed, the compression being transmitted in all directions with the velocity of sound (approximately 330m/sec. in air). If however, the speed of the bullet is greater than the velocity of sound the condensation of the air at the nose can be transmitted laterally *but not forwards.* Photographs taken of bullets while in flight show this clearly and reveal the existence of two wave-fronts, one at the head and the other at the base of the projectile. The former can be simply explained on Huyghens' principle of secondary wavelets. If the velocity of sound at the nose of the bullet were normal, the wave-front would be a cone of semi-angle $\sin^{-1}c/V$ (c normal velocity of sound and V velocity of projectile). But the velocity of sound increases with increased amplitude of condensation, consequently *the wave-front is a blunted cone,* as actually recorded in the photograph. From observations of the changing direction of the "onde de choc" it is possible to trace the bullet or shell to its source. (*See* Mallock, *Proc. Roy. Soc.*, p. 115, 1908.) This method was used in the war to locate enemy guns.

Velocity of High Frequency Sounds.—Using a quartz piezo-electric oscillator (*see* p. 12) as a source of high frequency vibrations, G. W. Pierce (*Proc. Amer. Acad.*, vol. 60, Oct. 1925) determined with considerable accuracy the velocity of sound in air and carbon dioxide by the stationary-wave method. He found that the velocity of sound in air at 0°C has the values 331.94, 332.47 and 331.64 metres/sec. at frequencies 1,000, 50,000 and 1.5×10^6 p.p.s. respectively. The effect of humidity was negligible, at 80% humidity differing by less than 0·02% from the velocity in dry air. In CO_2 the velocity at 0° C was found to be 258·82 m/sec. at a frequency of 42,000 cycles/sec. increasing to 260·15 m/sec. at 200,000 cycles/sec. This gas becomes *opaque to sound-waves at still higher frequencies.* Boyle and Taylor (*Proc. Roy. Soc.*, Canada, 1925) observed a diminution of velocity

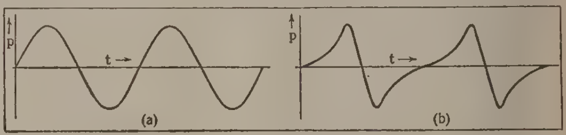


FIG. 10

of high frequency sounds in water at 16° C from $1{\cdot}51\times10^5$ cms./sec. to $1{\cdot}42\times10^5$ cms./sec. at frequencies 43,000 and 598,000 cycles/sec. respectively. The measurements were made in a small tank. The velocity in a viscous oil was found to be the same at 570,000 cycles/sec. as at low frequencies. Lang (*Roy. Soc.*, Canada, 1922) found no change in the velocity of sound in steel bars at any frequency up to 50,000 cycles/sec. Reference has already been made (p. 22) to the piezo-electric measurements of Hubbard and Loomis on the velocity of sounds of frequency 3×10^5 in various liquids contained in tubes.

Change of Medium. Reflection and Transmission.—As in the case of light, when a wave of sound meets the surface of separation of two different media it is partially reflected, and a wave travels back (in the negative direction) through the "incident" medium, with the same velocity as it approached the bounding surface. The laws of reflection are the same as applied to light waves—angles of incidence and reflection being equal and in the same plane. With sound-waves however, we have often to deal with wave-lengths which are comparable with the dimensions of reflecting objects; the phenomena must then eventually be regarded primarily as diffraction. In the cases which we are now considering the wave-length may be regarded as small, or the reflector large, the ordinary optical laws being applicable.

Reflection of Plane-Waves at the Boundary of Two Extended Media.—It is shown in text-books of sound (Rayleigh, vol. ii, p. 81) that the relative amplitudes r and a of the reflected and incident waves are given by

$$\frac{r}{a}=\frac{\rho_2/\rho_1-\cot^1\theta_2/\cot\cdot\theta_1}{\rho_2/\rho_1+\cot\theta_2/\cot\cdot\theta_1} \qquad (25)$$

where ρ_1 and ρ_2 are the respective densities of the first (incident) and second (transmitting) media and θ_1 and θ_2 are the angles of incidence and refraction. The *law of sines* of optical refraction holds in this case also, and we have $\sin\theta_1/\sin\theta_2=c_1/c_2$, where c_1 and c_2 are the velocities in the first and second media. Consequently (25) may be written

$$\frac{r}{a}=\frac{\dfrac{\rho_2}{\rho_1}-\dfrac{c_1\cos\theta_2}{c_2\cos\theta_1}}{\dfrac{\rho_2}{\rho_1}+\dfrac{c_1\cos\theta_2}{c_2\cos\theta_1}} \qquad (26)$$

which becomes

$$\frac{r}{a}=\frac{\rho_2c_2-\rho_1c_1}{\rho_2c_2+\rho_1c_1} \qquad (27)$$

at "*normal*" *incidence* (when $\theta_1=\theta_2=0$). If the velocity in medium (1) be greater than in medium (1), the incident waves being in the *slower velocity* medium, there will be a *critical angle of incidence* ($\sin\theta_1=c_1/c_2$) which, if exceeded, will result in *total reflection.*

As an example, let air and water be the media (1) and (2), sound waves being incident normally on the surface of the water. Equation (27) which *expresses the reflection-amplitude in terms of the radiation impedances* $\rho c\,(=\sqrt{\kappa\rho})$ *per unit area of the two media* (*see* above) gives $r=0{\cdot}99943a$, since the values of ρc for water and air are 14×10^4 and 40 respectively. In such a case, *where the radiation impedances are widely different, there is almost complete reflection*, even at normal incidence. The transmission is a maximum and reflection zero when $\rho_1c_1=\rho_2c_2$, that is, when the radiation impedances of the two media are equal.

Reflection of Plane Waves from a Plate of Finite Thickness.—This case is analogous to the optical example of reflection from a thick plate of glass—the reflected wave being the resultant of multiple reflections at the two bounding surfaces. The ratio of reflected and incident amplitudes for normal incidence now becomes

$$\frac{r}{a}=\left(\frac{\rho_1c_1}{\rho_2c_2}-\frac{\rho_2c_2}{\rho_1c_1}\right)\Big/\left\{4\cot^2\frac{2\pi l}{\lambda_2}+\left(\frac{\rho_1c_1}{\rho_2c_2}+\frac{\rho_2c_2}{\rho_1c_1}\right)^2\right\}^{\frac{1}{2}} \qquad (28)$$

where l is the thickness of the plate and λ_2 the wave-length of the sound in it, ρ_1c_1 and ρ_2c_2 being the respective radiation resistances of the medium (1) and the plate (2). Boyle and Rawlinson (*Proc. Roy. Soc.*, Canada, 1928) have deduced a more general expression for any angle of incidence, and have determined the "critical angle" at which total reflection occurs. It will be seen that the reflected-amplitude r fluctuates between zero and a maximum as the thickness of the plate varies. In the case where $c_2>c_1$ the reflected amplitude is *zero* when $l=0$ or a multiple of $\lambda/2$, and reaches its maximum value when l is a multiple of $\lambda/4$. A *quarter wave-plate* consequently reflects a maximum and transmits a minimum of the incident sound-energy.

These relationships for the reflection of plane-waves from flat plates have been verified by Boyle and Taylor and Boyle and Lehmann in the case of high frequency sound-waves passing through water in which the plate was submerged. Equations (26) (27) and (28) indicate that solid media in air are practically perfect reflectors, whereas in water they are relatively good transmitters of sound. An air film in water or in a solid mass constitutes a perfect reflector, with a reversal of phase at reflection. The practical application of such deductions is dealt with by H. Brillié (*Le Génie Civil*, Aug. and Sept. 1919) in relation to the problem of sound-reception under water.

Stationary Waves.—*Reflection and Absorption Coefficients of Materials.* It has been shown in the case of strings that the resultant displacement y at a point in the stationary-wave formed by combining the direct and reflected-waves is given by

$$y=a\cos n(t-x/c)-a\cos n\,(t+x/c)=2a\sin nt\sin(nx/c).$$

The same relation applies to longitudinal-waves of condensation reflected normally from a plane perfectly reflecting obstacle. If, however, the obstacle is not a perfect reflector some of the incident sound energy is absorbed or transmitted. Consequently the reflected-amplitude r is less than a. The expression for y now becomes

$$y=(a+r)\sin nt\sin(nx/c)+(a-r)\cos nt\cos(nx/c) \qquad (29)$$

in the case of perfect reflection ($r=a$) we obtain the ordinary expression for stationary-waves. The general expression (29) is applicable to all cases, and is represented by fig. 11. The incident energy is proportional to a^2 and the reflected energy to r^2. The reflection coefficient of the obstacle is defined as the ratio r^2/a^2. Equation (29) represents two superimposed stationary-waves of maximum-amplitudes $(a+r)$ and $(a-r)$ respectively, and displaced $\pi/2$ in phase. Consequently the maximum and minimum-amplitudes of the *resultant* stationary-wave are proportional to $(a+r)$ and $(a-r)$ respectively. If we write

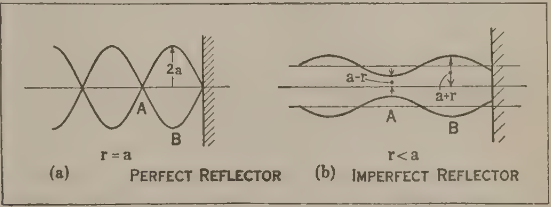


FIG. 11

$$\alpha=(a+r)\ \text{and}\ \beta=(a-r),$$

then the reflection coefficient

$$\frac{r^2}{a^2}=\left(\frac{\alpha-\beta}{\alpha+\beta}\right)^2=\left(\frac{1-\beta/\alpha}{1+\beta/\alpha}\right)^2 \qquad (30)$$

This expression for the reflection coefficient, in terms of the ratio min./max. amplitude in the stationary-wave, serves as a basis for experimental methods of measuring the reflecting properties of materials and, of course, their absorption or transmission properties. The absorption coefficient (which is generally assumed to include transmission) is given by

$$(a^2-r^2)/a^2=4/(2+\alpha/\beta+\beta/\alpha).$$

This method of determining sound absorption coefficients of materials was developed by Tuma (1902), Weisbach (1910) and Hawley Taylor (1913). More recently Paris (*Roy. Soc.*, 1927 and *Phys. Soc. Proc.*, 1927) has refined the experimental procedure by using the hot-wire microphone to obtain accurate values of the ratio β/α, and consequently of the reflection and absorption coefficients. The plane stationary-waves were produced in a tube closed at one end by the reflector under test. The absorption coefficient was found to increase with increasing thickness of the absorber (*e.g.*, felt) and with increase in the frequency of the sound. Such measurements have an important application in the acoustics of buildings *q.v.* Stationary waves may readily be demonstrated when a high pitched sound, from a bird call or Galton's whistle, is reflected normally from a plane solid obstacle. A sensitive flame flares at all points in the path of the wave except at the nodes.

Echoes.—The direct reflection of a sound of short duration from a surface of large area such as a wall or a cliff results in what is familiarly known as "echo". The time-interval t between the initiation of a sound-impulse and the reception of the echo at the same point of observation is given by $t=2d/c$ where d is the distance of the reflector and c is the velocity of sound in the intervening medium. Measurements of t will therefore lead to a value of the velocity c or the distance d according to which of these two quantities is previously known. The principle has important practical applications (*e.g.*, see *Echo Depth Sounding*, p. 35) in the measurement of distance.

Harmonic Echoes.—If the primary sound has a complex waveform, containing high harmonics of a fundamental tone, the component tones will be scattered or diffusely reflected in unequal proportions. The amplitude of the secondary-waves varies inversely as the square of the wave-length (and intensity as $1/\lambda^4$), consequently the higher harmonics of the complex wave are scattered back in far greater proportion than the fundamental. To an observer near the source, therefore, the returning echo appears to be raised in pitch one or more octaves according to the nature of the primary sound.

Reflectors as Sound Screens.—To produce shadows comparable with optical shadows, it is essential that the reflector should be large compared with the wave-length of the sound employed. The high pitched tick of a watch may be effectively screened by a relatively small reflector but the sound of a man's voice or of a motor horn requires a much larger screen. The wave-lengths in the two cases vary from a few inches to several feet, and the linear dimensions of the reflector must consequently vary in the same proportion to produce the same degree of screening. Behind the reflector the sound is generally found to have changed in quality, the high frequency components being more perfectly screened than the lower frequencies—on this account the sound appears to be "purified."

Musical Echoes from Palings. Echelon Reflectors. (Gratings).—If a sharp sound is made near one end of a row of palings, or similar "stepped" structure, the echo takes the form of a musical note. The successive palings each reflect the impulse (or, selectively, its higher harmonics) and the observer receives a succession of reflections which, if sufficiently rapid, blend into a musical note. The time intervals δt are equal to $2\delta x/c$, where δx is the path difference to the successive reflectors, consequently the frequency N of the note will approximate to $C/2\delta x$ or some higher harmonic. If, for example, near a row of palings $\delta x=4$ inches, and $c \doteq 1100$ ft./sec., N will be a multiple of 1650 cycles/sec. *i.e.*, a high pitched note. An echelon structure of this kind serves as the equivalent of a "grating" by which complex high frequency sounds might be analysed (*see* p. 26).

Reflection at Curved Surfaces. *Spherical Mirrors.*—It is shown in books on Optics that a parallel beam (plane-waves) of light when incident on a spherical mirror will be brought to a focus at a distance from the pole of the mirror equal to half the radius of curvature, and conversely a parallel beam of light emerges from such a mirror when a small source is placed at the focus. Similar results are observed with sound-waves of high frequency and reflectors of moderate dimensions.

Whispering Gallery Effects.—The well known whispering gallery of St. Paul's Cathedral, London, owes its peculiar acoustical properties to the reflection of sound by the walls. The gallery takes the form of a circle around the base of the dome. The exact mode of action is still a moot point. Rayleigh (*Sound*, vol. ii., p. 126) pointed out that the sound tends to creep round the inside of a curved wall, being continuously reflected by the wall, without ever getting far from it. "A whisper seems to creep round the gallery horizontally, not necessarily along the shorter arc, but rather along that arc towards which the whisperer faces. This is a consequence of the very unequal audibility of a whisper in front of, and behind, the speaker. The abnormal loudness with which a whisper is heard is not confined to the position diametrically opposite to that occupied by the whisperer and therefore, it would appear, does not depend materially on the symmetry of the dome." It should be noted that whispers contain a higher proportion of high pitched sounds than ordinary speech, and whispering is heard more distinctly than ordinary conversation especially if the speaker looks along the gallery towards the listener. C. V. Raman (*Ind. Assoc. Sci. Proc.*, 1922) describes an investigation of 5 whispering galleries in India which confirm a view held by Sabine of the importance of the inward slope of the wall of the gallery for giving the best effects, and the concentration by a spherical dome of a maximum sound at the opposite end of a diameter. Multiple sounds which are observed are shown not to be echoes, but sound-waves travelling circumferentially round the gallery several times before they are appreciably diminished in intensity.

Rayleigh suggests that the propagation of earthquake disturbances is probably affected by the curvature of the surface of the earth acting like a whispering gallery. It is not improbable also that sounds travelling long distances in the sea are dependent on a similar action, and on repeated reflection at the surface and bottom. Taking the depth of a sea as uniformly 24 fathoms (144 ft.) the maximum possible distance of *direct propagation* of a sound-wave in it will be 29·3 miles approximately —whereas ranges 2 or 3 times this value have actually been observed in the North sea. The possibility of a curved path due to temperature gradients must also be considered in seeking an explanation of these long ranges in the sea.

Refraction of Sound-Waves.—The optical analogy which applies to reflection of sound may, as we have already seen, apply to refraction also. When plane-waves of sound cross the bounding surface between two different media having different wave-velocities c_1 and c_2 the direction of propagation is changed in accordance with the sine law, viz., $\sin\theta_1/\sin\theta_2=c_1/c_2$ where θ_1 and θ_2 are the angles of incidence and refraction respectively. Hence the sound "rays" in passing from one medium to another are bent towards or away from the normal according as the velocity of the wave in the first medium is greater or less than in the second medium. Thus, for example, sound is refracted towards the normal when passing from air into CO_2. The "critical angle", when the sound is totally reflected, and there is no refracted beam, is given by $\sin\theta_1=c_1/c_2$. The critical angle from air to water, $c_1=1{,}100$ ft./sec. and $c_2=4760$ ft./sec., is therefore $13\frac{1}{2}°$ approximately; above this angle no sound whatever can enter the water (we have already shown, p. 23, that even at normal incidence the reflected amplitude is 0·99943 of the incident amplitude). From air to solid materials (steel, glass, wood, etc.) $c_1/c_2=0{\cdot}065$ approx. whence the critical angle is $3\frac{1}{2}°$. Sondhauss (1852) demonstrated the refraction of sound through prisms containing various gases, and determined the refractive index μ relative to air, $\mu=\sin\theta_1/\sin\theta_2=c_1/c_2$. He was also successful in demonstrating the focusing action of a convex lens of carbon dioxide enclosed in a thin envelope of collodion.

Refraction by Wind and Temperature Gradients.—It is well known that sound travels better with the wind than against it. This effect is due to the increase of velocity of the wind from the earth's surface upwards. The effective velocity of sound is equal to its normal velocity $\sqrt{(\gamma p/\rho)}$ plus or minus the velocity of the medium. In still air the wave-front of a sound-beam will travel over the earth's surface parallel to its initial direction, say at right angles to the ground. If, however, a wind is blowing in the same direction, the upper part of the wave where the wind velocity is greater, travels faster than that part near the ground, with the result that the wave-front tends to bend downwards towards the ground. An observer therefore hears by a direct ray which starts with a slightly upward inclination. Similarly a horizontal ray travelling against the wind is bent upwards and, at a moderate distance, passes over the head of an observer. A similar effect may be noticed when there is a gradual change in the temperature of the air from the ground upwards. The warmer the air, the greater the velocity of sound. If the temperature increases upwards, the wave-front will be bent downwards towards the ground; conversely, when the temperature diminishes upwards the sound-beam will be deflected upwards into the higher atmosphere and lost. The curvature of the ray is given by $1/R = -1/c \cdot \partial c/\partial y$ where $\partial c/\partial y$ is the velocity gradient with respect to height—this gradient may be positive or negative.

Audibility of Fog Signals. Tyndall (*Phil. Trans.*, 1874) made extensive researches on the audibility of fog signals across the Channel from South Foreland, and came to the conclusion that "temperature refraction" and a "flocculent" condition of the atmosphere, arising from unequal heating or moisture, were responsible for large fluctuations in the observed ranges of audibility. Contrary to general opinion at the time Tyndall found that the presence of fog favoured the transmission of sound signals—the atmosphere being then in a more homogeneous condition, particularly in regard to temperature gradients. The problem of long-distance transmission of signals has recently been studied by King, Tucker, Paris and others. Using a doubly-resonated hot-wire microphone, Tucker and Paris have made intensity measurements at varying distances and orientations with respect to diaphones and sirens mounted in light-houses at sea. In a particular experiment it was found that the ratio of sound intensities at two miles from the source, *with* the wind and *against* it was 25 to 1. The effects of temperature refraction were also partly responsible for this high value of the ratio at such a short range. Certain fluctuations of intensity were ascribed to moving eddies in the atmosphere. Player, however, as a result of recent observations of a similar nature, reached the conclusion that humidity is the only factor in which the variations are at all comparable with the large and sudden variations in the range of audible transmission.

Zones of Silence. The sound of a large explosion is sometimes observed at very great distances, whilst at intermediate distances nothing at all is heard. Thus the explosion of a large ammunition dump in Holland (Jan. 1923) was recorded at a distance of 850 km. whereas at 100 to 180 km. no sound could be detected. These intermediate zones of silence are not uncommon in such cases. They doubtless arise as a result of peculiar meteorological conditions at the time of the explosion. As we have seen, the action of temperature and wind gradients may cause upward or downward refraction of the sound. Esclangon (*Comptes Rendus*, 1924) has shown that these two factors are sufficient to account for one or a succession of zones of silence, with reinforcement of sound in particular directions. Zones of silence are in certain cases due to the interference between sound-waves reaching the observer by different paths. (See *Interference* above.)

Effect of Temperature Gradients on Sound Propagation Under Water.—The sea is a much more homogeneous medium for sound-transmission than the atmosphere. Sounds of moderate power may be heard at long ranges, 40 or 50 miles, without the corresponding fluctuations of intensity which are so troublesome in air. The effects of tidal currents (analogous to "wind"), say 10 ft./sec., are in most cases negligible, the velocity of sound in water being about 5,000 ft./sec. Seasonal variations in range of signals have been observed (*see* H. Lichte, *Phys. Zeits.*, Sept. 1919) these being ascribed to refraction produced by temperature gradients in horizontal layers of the sea. Such a temperature gradient may cause a sound "ray" to curve *upwards* to the surface where it is reflected down again, only to rise once more. In this way it travels forward along a cycloidal or "festoon" type of track. A temperature gradient of opposite sign causes a bending *downwards* with analogous effects at the sea bed. Surface and bottom reflections play an important part in the long-range transmission of sound in the sea. With a particular sound-transmitter Lichte and Barkhausen (*Ann. d. Physik*, 62, July 1920) noted a change from 10 km. in summer to 20 km. in winter in the Baltic sea.

Interference.—The passage of sound-waves through a medium is in no way affected by the passage of other sound-waves through the same part of the medium. This important principle involving the independence of separate trains of waves is known as the *Principle of Superposition* and was first propounded by Huyghens in dealing with light-waves. The resultant displacement of a particle of the medium is obtained by adding the separate displacements vectorically (*see* p. 20). Thus two periodic motions of the same frequency, of amplitudes a_1, and a_2, and phase difference ϵ combine to form a periodic motion having an amplitude whose square is $(a_1^2 + a_2^2 + 2a_1a_2 \cos\epsilon)$. The principle of superposition applied to the *squares* of amplitudes (*i.e.*, energies) would account for the first two terms only and the results would be erroneous. It is found under certain conditions that two trains of sound-waves may, at certain points in the medium, neutralize each other's effects and produce silence where previously there was a definite sound due to either of the trains of waves. Thus in the above case, if $\epsilon = 180°$, *i.e.*, the two independent sets of vibrations of the particle are in opposite phase $\cos\epsilon = -1$, and the resultant amplitude is $(a_1 - a_2)$, which becomes zero when $a_1 = a_2$; if $\epsilon = 360°$ or $0°$, $\cos\epsilon = +1$ and the resultant-amplitude is $(a_1 + a_2)$ or $2a$, when $a_1 = a_2$. When the observed sound-distribution due to two or more wave-trains of sound is not found to be equal to the sum of the separate wave-trains, the latter are said to have interfered with each other and the phenomenon is described as interference. Interference is a direct result of the principle of superposition. The phenomena of interference may be observed in any smooth water surface which is disturbed simultaneously at two different points. J. H. Vincent has obtained very beautiful photographs of such effects on the surface of mercury (see *Phil. Mag.*, 1897, 8 and 9). The crests and troughs of the two sets of ripples in certain places reinforce each other, whilst in others they neutralize; the result is a definite "interference pattern" superposed on the ordinary wave systems. When sounds of the same frequency and amplitude reach the ear by different paths, or originate with different phases, interference effects may readily be observed. Thus the waves sent out from the prongs of an ordinary tuning fork interfere, producing approximate silence in certain directions and increased intensity in others—the rise and fall of intensity, four times per revolution, as a vibrating fork is rotated near the ear is easily demonstrated. Any "double-source" of sound, such as a vibrating diaphragm exposed on both sides, shows these effects. If sound is led from its source to a receiver by two tubes of equal diameter and length the two sets of waves will arrive together, *i.e.*, in phase. If the length of one tube is gradually varied relatively to the other the path difference will be successively $\lambda/2$, λ, $3\lambda/2$, 2λ, and so on; the resultant effect at the receiver alternating between zero, and maximum. These phenomena can be demonstrated by means of a tuning fork and two tubes of adjustable length, with a common exit placed to the ear. *Stationary-waves* to which we have already referred (p. 23) form a good example of the interference between a primary and a reflected train of waves. Interference between the waves from two sources of sound of *nearly* equal frequency appears as an increase and decrease of intensity *with time*—known as the phenomenon of *beats* (*see* p. 6) and exemplified by two tuning forks of nearly equal pitch. In certain cases the *zones of silence* observed by Tyndall when listening on a ship to the sound of a fog siren on a neighbouring cliff, were ascribed to the interference between the *direct* sound beam with that *reflected* from the surface of the sea—if these paths differ by any odd multiple of half a wave-length the two trains of waves neutralize each other and the siren is not heard. Wood and Young (*Proc. Roy. Soc.*, 100, 1921) observed interference zones *under* water due to a similar cause. Such effects are of considerable importance in the case of *long distance sound transmission in the sea.* The sound-wave is reflected *with reversal of phase* when it reaches the water-air surface. At a considerable distance from the source, the path difference between the direct and surface-reflected wave may become very small compared with the wave-length, resulting in almost complete neutralization. Fortunately, however, the surface of the sea is never smooth and the sea-bed reflects sound very efficiently. The bottom-reflected-wave may therefore, in certain cases, be solely responsible for the sound heard at long ranges.

Diffraction. *Sound-Shadows.*—The bending of sound-waves round the edges of obstacles is one of the most familiar of everyday observations. If it were not for this effect, short distance intercommunication by means of sound would be much more difficult. Fast motor traffic on our roads is vitally dependent upon such a possibility at turnings and crossings. This bending of sound "round the corner" may be regarded as evidence of its nature as a form of wave motion; the effect being similar to that of "diffraction" in the case of light-waves. The sound-shadow and the geometrical shadow of an obstacle are therefore not coincident. The study of diffraction effects is greatly assisted by the use of a principle which is due to Huyghens:—*The wave-front of a disturbance may at any instant be obtained as the envelope of the secondary-waves proceeding from all points of the wave-front at some preceding instant.* A disturbance diverging from a point source with velocity c may at any time t_1 be represented by a thin spherical shell. This shell may therefore be regarded as the disturbed region, and the disturbance at a subsequent time t_2 determined by drawing spheres of radii $c(t_2-t_1)$ round each point of the shell. The outer spherical envelope of these spheres will be the new wave-front at the instant t_2. By this construction it will be found that the direction of advance of the wave is normal to the wave-front. Huyghens' principle of secondary-waves is directly applicable to diffraction problems provided that due allowance is made for the contribution of each surface element of the wave-front to the *amplitude* at the point P under consideration. This estimation of amplitude involves the use of a device due to Fresnel—in which the initial wave-surface is divided into "half-wave zones" (*see* text-books on Optics). These zones are such that their resultant effects at some distant point P are alternately in opposite directions (being $\lambda/2$ different in path length measured from P). Two successive zones therefore neutralize each other's effects at P.

Plane-Waves of Sound Passing a Straight Edge.—Employing the Huyghens-Fresnel principle the distribution of sound beyond the edge of a totally reflecting wall may be determined. *Outside* the geometrical shadow there is a fluctuation of intensity which settles down, after a few oscillations, to the normal value in the absence of the wall. *Inside* the geometrical shadow the intensity steadily falls off from one quarter its normal value at the edge to zero at some distance inside the geometrical shadow. The relatively feeble diffracted sound behind the wall is easily observed by the ear if the incident sound-wave is of audible frequency and of moderate intensity. With high pitched sounds (*e.g.*, from a Galton's whistle or a high frequency diaphragm excited electro-magnetically) and a sensitive receiver the variations of intensity at a diffracting edge can be observed experimentally. A sensitive flame may be used as the indicator of sound intensity or alternatively, if the sound is in the audible range, a stethoscope tube with a small funnel opening may be used to listen directly. The gradual fading away of sound within the geometrical shadow is a common observation at all frequencies.

Circular Obstacle. Scattering of Sound-Waves.—Constructing Fresnel zones outside the edge of a circular obstacle, it will be found that the total effect at a point on the axis is equal to half the effect of the first zone, *i.e.*, the same as if no obstacle at all were interposed This is true whatever the size of the disc relative to the wave-length of the sound. Immediately surrounding the central spot there is a ring of almost complete silence and beyond that a further increase of intensity, and so on. These effects can be demonstrated in the manner suggested above for a straight edge. This case is analogous to that of the bright spot at the central point of the optical shadow of a circular disc—one of the "classical proofs" of the wave theory of light. It finds an important application in the directional reception of sound (*see* p. 28).

Scattering by Small Obstacles.—Rayleigh has shown that the intensity of the sound scattered in all directions by an obstacle is directly proportional to the volume of the obstacle and inversely proportional to the fourth power of the wave-length of the sound. This law also applies to the scattering of light and is used to explain the blue colour of the sky. We have already referred to an illustration in sound, viz., harmonic echoes, in which the higher constituents of a complex sound are scattered more readily than the fundamental, with the result that the scattered or diffusely reflected sound appears raised in pitch by one or more octaves.

Circular Aperture.—The transmission of sound through a circular opening in an extended wall has already been considered in the analogous case of sound radiation from a piston (such as a Langevin quartz oscillator), the sound distribution beyond the opening consisting of a primary beam and a number of secondaries separated by silent regions. An experiment showing the antagonism between the parts of a wave corresponding to the first and second Fresnel zones is described by Rayleigh (*Sound*, Vol. II., p. 141). Sound-waves from a high pitched source fall on a screen with a circular opening of variable diameter. A sensitive flame is situated on the axis on the opposite side of the screen. The flame is unaffected by the sound which gets through a large opening, comprising two opposed Fresnel zones but flares violently when the area is *reduced* to one zone.

Zone Plates.—Let circles be drawn, on a plane reflector, with radii, $r_1\, r_2\, r_3$, etc., given by $r_n^2=n\lambda d$ where $n=1, 2, 3$, etc., and d is the distance of the centre O from a point P on the axis normal to the reflector. The circles divide the surface of the reflector into Fresnel half-wave zones with respect to the point P. It will be seen that these annular zones are of equal area. If alternate zones are cut away, a plane sound-wave falling on the plate and passing through the annular openings *will arrive in phase at* P, resulting in a considerable increase of intensity at that point. A *zone plate* of this kind therefore acts like a convex lens of focal length $OP=f=r_n^2/n\lambda$, r_n being the radius of the nth zone and λ the wave-length of the sound. The focusing properties of such zone plates were demonstrated by Rayleigh by means of high pitched sounds and sensitive flames.

Diffraction Gratings. Reflection from Stepped or Corrugated Surfaces.—The diffraction grating, so familiar in optics, has its counterpart in sound. When sound-waves are reflected from a regular periodic structure, such as a row of palings or a corrugated surface, the reflected-waves may assist or neutralize each other in certain directions depending on the wave-length λ of the sound and the spacing d of the reflectors. The diffracted-waves have maxima in directions θ given by $\sin\theta=\pm n\lambda/d$ where $n=1, 2, 3$, etc. When d is smaller than λ there are no diffracted waves and the incident beam is reflected in the ordinary way. Thus a row of palings or a rough wall reflects sounds of moderate pitch like a perfectly smooth surface, little or no sound being returned towards the source, except in the case of normal incidence. When the sound is high pitched, however, λ being less than d, it is thrown back in all directions reinforcing along certain lines and neutralizing in others. A regular row of palings may serve as a "reflection" or a "transmission" grating. W. Altberg (*Ann. d. Physik*, 23, 1907) demonstrated a diffraction grating of this nature by means of glass rods 1 cm. apart, using a concave reflector to produce plane-waves of sound incident on the grating. The sound was produced by means of a high frequency electric spark emitting waves only a few millimetres in length. A second concave mirror received the diffracted sound and brought it to a focus at a sensitive detector. The sound spectrum was obtained by rotation of the grating with respect to the source and receiver. Wave-lengths of the order 0·2 mm., corresponding to a frequency 1·5 million per second, were measured in this way.

Experimental Study of Wave Transmission.—Many of the "optical" characteristics of sound which we have mentioned may be studied on a laboratory scale by the following methods: (a) *Spark Photography*. The progress of a sound pulse may be observed either by the "Schlieren Method" (due to Töpler 1867) or the "Shadow Method" (due to Dvořák 1880). In the latter case, the sound pulse is produced by an electric spark (the *sound* spark), followed by a second spark (the *light* spark, between magnesium electrodes) at a known short interval of time. The highly compressed region forming the envelope of the sound pulse casts a shadow, when illuminated by the light spark, on a screen or a photographic plate. A succession of photographs at varying time-intervals after production of the sound-spark indicates the progress of the sound-pulse. The various phenomena of reflection, refraction and diffraction have been demonstrated in this way (*see* for example, Foley and Souder, *Phys. Rev.*, 35. 373. 1912). Photographs of this nature are shown in Plate I., figs. 1a to f. (b) *Ripple Photography*. Results of a similar character may be obtained more easily by means of the ripple tank. This method is based on the fact that impulsive ripples on the surface of a liquid, *e.g.*, water or mercury in a small tank, bear a striking resemblance to impulsive sound-waves. The ripples are reflected, refracted and diffracted from objects placed in the liquid for observation purposes. The method was first used by Vincent (*Phil. Mag.*, 43. 17. 1897) to demonstrate interference phenomena, but more recently it has received a wider application in the study of complex reflections occurring in models of buildings (*see* Article on ACOUSTICS OF BUILDINGS; and Davis, *Proc. Phys. Soc.*, 38. 234. 1926). (c) *Bullet photography*. The "bow" wave from a high speed bullet (*see* Plate I., fig. 2) has been utilised to demonstrate the reflection and diffraction of a sound-pulse. Thus in C. V. Boys photographs of a bullet in flight (*Nature*, 47. 415. 440. 1893) the pulse is seen to be reflected according to optical laws. Cranz (*Handbuch der Physik*, Vol. VIII, Geiger and Scheele) has photographed the track of a bullet passing between two parallel plates, and the multiple reflections of the bow-waves are beautifully shown. The method is not so convenient as the spark and ripple methods, but it possesses certain novel features.

Doppler's Principle.—*Moving Sources and Receivers.*—The pitch of a sound is liable to be modified when the source and receiver are in relative motion. Thus an observer approaching the source with velocity v will encounter more sound-waves per second than if he had remained at rest, the number of sound waves per second (the pitch of the note) being increased in the ratio $(c+v)/c$ where c is the normal velocity of sound in the medium. Similarly when the observer is at rest and the source moving, the change of pitch will be in the ratio $(c\pm v)/c$ according as the source is approaching or receding. The whistle of a locomotive is raised in pitch as it approaches, and falls in pitch as it recedes from an observer. The principle of change of pitch by relative motion is due to Doppler, who first enunciated it in connection with the change of colour of certain stars moving in the line of sight of an observer. If the medium is also in motion (*e.g.*, wind) with velocity w in the direction of the sound-wave, the observed pitch N^1 relative to the actual pitch N will be $N^1/N=(c\pm w\pm v)/(c\pm w)$. When $v=0$, $N^1=N$ irrespective of the velocity of the medium. The latter velocity w only affects the ratio N^1/N slightly when the source and observer are in relative motion also. The Doppler effect can be produced in the laboratory by the simple expedient of rotating a maintained source of sound at the end of a bar or cord. Preferably the source should be maintained in vibration by virtue of the rotation. The observer in the plane of rotation hears a note which rises and falls in pitch once per revolution. The observed pitch of the sound from an aeroplane may vary by 20% according to the speed and direction of flight.

Attenuation of Sound-Waves. Viscosity and Heat Conduction.—We have hitherto considered plane or spherical waves travelling through various media without loss of energy. Apart from other considerations it will be evident that energy loss must take place wherever there is relative motion between the various particles comprising the medium, such loss being due to ordinary viscous forces which tend to degrade the sound energy into heat. In addition to this viscous loss there must be energy loss due to thermal conduction and radiation consequent on the compression and rarefaction of the medium. If the compressions and rarefactions succeed each other with sufficient rapidity the process will be strictly adiabatic, that is, there will be no transfer of heat between compressed and rarefied regions or to the parts of the medium unaffected by the sound-wave. Sound-waves of small amplitude in air are propagated under almost perfectly adiabatic conditions. Otherwise, as Stokes proved in 1851, the sound would be rapidly stifled, which is contrary to experience. In the case of sounds of very large-amplitude however (an explosion impulse, or the sound-wave emerging from a very powerful source), it is conceivable that the large temperature fluctuations in each cycle of pressure may be such as to involve appreciable temperature losses due to conduction and radiation even in a very short time interval. This would result in a more rapid decrease of sound-energy with distance than the inverse square law requires, the effect becoming increasingly serious the lower the frequency and the greater the amplitude of the sound waves. With regard to energy loss due to viscosity, Maxwell pointed out that the factor involved is the "kinematic viscosity coefficient" ν, which is equal to the ordinary "static" coefficient μ divided by the density ρ. Thus for air $\nu=0\cdot132$ and for water $\nu=0\cdot013$ at 10° C. The amplitude ξ of the progressive wave therefore diminishes exponentially on account of energy loss on the way. In the case of plane-waves we have

$$\xi=ae^{-x/l}\cos n(t-x/c)$$

where l is the distance travelled by the wave before the amplitude falls to $1/e$ of its initial value. In this expression $l=(3c/8\pi^2\nu)\lambda^2$, indicating a rapid increase of attenuation with diminishing wave-length λ (*i.e.*, with increase of frequency). To include the losses due to heat conduction also Maxwell multiplied ν in the above expression by 2·5, the effect being therefore equivalent to a marked increase (to ν^1) of kinematic viscosity. On the above grounds there is clearly a physical upper limit to the frequency of vibration which can be transmitted an appreciable distance[1]. Rayleigh (Vol. II, p. 28) concludes that the effects of energy losses of the above nature are to be sought for in the damping of the vibration rather than in the altered velocity of propagation. It should be mentioned that changes of velocity with frequency have actually been observed by Pierce in air and CO_2 and by Boyle and Taylor in water, although no such change could be detected by Lang in the case of steel bars.

With regard to attenuation there is ample evidence confirming the above theory which indicates a rapid decrease of range with increasing frequency. For example in air, for sound-waves of frequency 1000, $\lambda=33$ cms., we find $l=40$ kilometres since $\nu^1=2\cdot5\nu=0\cdot33$ for air. The value of l at a frequency 100,000 is consequently 4 metres only. In sea water $\nu=0\cdot013$ that is $\nu^1=0.0325$, and $c=1.5\times10^5$ cms./sec., whence $l=3\cdot9\times10^4$ kilometres at a frequency of 1000 ($\lambda=150$ cms.), and $l=3\cdot9$ kilometres at a frequency of 100,000 ($\lambda=1.5$ cms.). It is thus evident *the attenuation of sound-waves in sea water due to viscosity and heat losses is almost negligible compared with the attenuation at corresponding frequencies in air*. This accounts to some extent for the relatively large ranges of transmission observed under the sea compared with those in air for the same amount of sound energy at the source. A small charge (9 oz.) of guncotton exploded *under water* can be detected (and recorded by an Einthoven galvanometer) at 40 miles (*see* Wood and Browne, *Phys. Soc. Proc.*, 1923). It is extremely improbable that such a range could be obtained in air. This comparison is of course only of a rough nature, for the wave form and the initial "amplitudes" would not be the same in the two cases. There is ample evidence to show, however, that the attenuation of bell sounds and other noises under water is less than in air. On account of other factors (nature of sound sources, homogeneity of medium, etc.) a strict comparison is somewhat difficult. *Attenuation by scattering in a heterogeneous medium* may be a serious factor in regard to loss of range in signalling by sound-waves. Tyndall found that a homogeneous atmosphere, clear or uniformly foggy, transmitted a sound signal to far greater distances than a "patchy" atmosphere containing masses of air at different temperatures, wind eddies, etc. Similarly when sound travels through water it may be seriously interrupted if it meets with a mass of bubbles. The sound of a ship's propeller does not pass very well through the bubbly water in the wake. Air bubbles in the sea may therefore be a serious cause of attenuation, the effects of viscosity and heat conduction being relatively small.

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[1] G. W. Pierce has shown experimentally that CO_2 becomes opapic to sound-waves at a frequency of 2×10^5 p.p.s.

Sound Absorption in Narrow Tubes and Cavities. Porous Bodies.—When sound-waves fall on certain bodies which may be regarded as a mixture of solid and gas, *e.g.*, cork or felt, it is found that a large proportion of the incident energy is absorbed due to viscosity and heat conduction. The influence of these factors is enormously increased on account of the large surface of solid matter in contact with the vibrating gas particles. Viscous forces are increased at the surface of the solid, and the latter serves also as an effective means of reducing the temperature fluctuations in the compressed gas, *i.e.*, the compressions and rarefactions are no longer adiabatic. Rayleigh has shown theoretically (*Sound*, Vol. II, p. 331) that the attenuation of sound-waves in a narrow tube of circular section is proportional to the square root of kinematic viscosity ν^1, and the frequency N, and inversely proportional to the radius of the tube. Porous materials like felt, wool, cork, etc., are effective sound absorbers, and are used to reduce reverberations in auditoriums.

RECEPTION OF SOUND

The manner in which sound-energy is abstracted from the medium carrying the sound-waves is dependent on a wide variety of circumstances and each case must be treated accordingly. In the first place the choice of a receiver must depend on the medium of transmission—a receiver suitable for air being generally quite unsuitable under water or in a solid medium. Again the selection of a receiver will depend on the frequency and wave form of the vibration—sounds of frequencies 500 or 50,000, or a single explosion impulse, requiring entirely different treatment. If the sound-wave is employed in long-range signalling it is important that the receiver should be efficiently designed and tuned to the incoming sound, in order to obtain maximum response to weak signals. Distortion of wave-form in this case may be of secondary importance. On the other hand, if it is required to obtain a faithful record or reproduction of the sound-wave, energy considerations are relatively unimportant whereas an accurate reproduction of the wave-form is vital. In this connection we have to distinguish between resonant and non-resonant receivers. As a general rule a resonant receiver is employed where maximum sensitivity and efficiency are required, whilst a non-resonant receiver is used for faithful recording or reproduction of the sound.

All forms of sound-receivers involve the introduction of some obstacle into the path of the sound-waves, this obstacle either partaking of, or otherwise influencing, the motion of the particles of the medium, or responding in some way to the pressure variations on its surface. Energy may be lost due to reflection and reradiation from this obstacle, but in a good receiver a moderate amount of sound-energy is transferred from the medium and converted into a form convenient for observation. It is often desirable to transform the mechanical vibrations of the medium into another type of vibration or into some other form of energy. For example, longitudinal sound-waves passing through the air from the mouth of a speaker fall on the diaphragm of a telephone transmitter which is set into transverse vibration. This transverse vibration controls electrical energy which is transmitted to a distant diaphragm receiver and reconverted into mechanical energy in a form suitable for transmission to the ear. Many well known forms of sound-recording apparatus (*e.g.*, Webster's *Phonometer*, Millar's *Phonedeik*, and the Hilger *Audiometer*) employ a diaphragm receiver with some optical means of indicating and recording the transverse vibrations. Other forms, exemplified by magnetophones, microphones, piezo-electric receivers, condenser microphones, etc., involve the conversion of mechanical into electrical energy. Sound-vibrations may also be observed by means of such devices as optical interferometry and sound shadow photography or by means of manometric and sensitive flames. Metrical forms of receiver such as the Rayleigh disc and the sound-radiometer (measuring radiation pressure of sound-waves) form another class, which might also include the various "phonometers," the hot-wire microphone, and piezoelectric receivers. The amplification of received sounds by mechanical devices, "mechanical transformers," mirrors, trumpets and resonators, or by electrical means, microphone and valve amplifiers, must also be considered. In certain cases special devices are required, as in sound-reception under water (hydrophones) or in the detection of sounds travelling through the ground (geophones). The above remarks will be sufficient to show the difficulty of attempting a comprehensive classification of sound-receivers. In what follows we shall deal with the more important types, some of which have already been mentioned.

The Ear.—*Sensitivity and Audible Limits.*—By far the most important and most universal receiver of sound is the ear. This "organ of hearing" has a marvellous range of frequency and sensitivity; it can perceive vibrations of frequency varying from 20 to 30,000 cycles/sec., and can detect a sound of amplitude less than 10^{-8} cm. whilst it is not destroyed by a vibration having an amplitude a million times as great. The ear with its associated nerve endings has also remarkable powers of analysis. It can distinguish one complex sound from another and can "listen intelligently" to a number of different sounds at the same time. For a complete description of the complicated structure of the ear, reference should be made to text books of physiology or anatomy. Briefly, it consists of a device which brings the waves of sound to act on a terminal expansion of the auditory nerve. This device is divided anatomically into three parts, the external ear with the auditory meatus, the tympanum and the internal ear. The external ear in the case of the lower animals is very movable, presumably to assist in sound-location. This function in man is rudimentary so that he can hear almost normally with his ears cut off. The external ear is separated from the tympanum by the "drum" of the ear or membrane tympani, which is set in vibration when sound-waves fall upon it. These vibrations are transmitted with diminishing amplitude but increased pressure by a chain of bones (malleus, incus and stapes) acting as a system of levers, to the fluid (perilymph) in the internal ear. The vibrations travel through the perilymph from the vestibule and the "oval window" up the turns of the cochlea and ultimately to the basilar membrane thus affecting the haircells and the ends of the auditory nerve. Many theories, notably the resonance Theory of Helmholtz, have been proposed to explain the function of the various parts of the ear, in particular the cochlea and the basilar membrane (with the "rods of Corti" and the haircells), but none appears to be really satisfactory. It is certain, however, that the more highly developed the cochlea the more perfect is the hearing of an animal. This is shown in birds and mammals which have a far more perfect cochlea than is found in reptiles and fishes.

Sensitivity of the Ear to Intensity and Frequency Variation.—The relation between sensation (loudness) and stimulus (intensity) applicable to all sensations, is generally expressed by *Weber's law*—"The increase of stimulus necessary to produce the minimum perceptible increase of sensation is proportional to the pre-existing stimulus." From this law Fechner derived the relation $S=k \log E$ or $\partial S/\partial E=k/E$, where S is the magnitude of the sensation, E the intensity of the stimulus and k a constant. The "law" obviously approximates to the truth, for the sensitiveness of the ear $\partial S/\partial E$ diminishes rapidly with increase of the total intensity E of the sound. Feeble sounds which are easily heard at night when E is small, cannot be distinguished from the general noise in the daytime when E is much greater. Wood and Young (*Proc. Roy. Soc.*, A. 100, p. 264 and p. 266, 1921), in judging equality of two sounds of the same pitch, remark that under favourable conditions it was possible to distinguish a difference of intensity of 10%. A similar conclusion was reached by V. O. Knudsen (*Phys. Rev.*, 21 Jan. 1923). Measuring the "intensity sensitivity" of the ear $\delta E/E$ where δE is the least perceptible difference of energy and E the total energy of the tone, Knudsen found $\delta E/E$ to be about 0·10 for moderate and large intensities E, but increased to the limiting value of unity as the intensity decreased to the threshold value E_o (the minimum energy of audibility). To include this region of very feeble intensities Knudsen proposed a modification of the Weber-Fechner law, namely, $\delta E/E=k+(1-k)\ (E_o/E)^n$ where $k=0{\cdot}10$ app. and n varies somewhat with frequency, being 1·65 for 200 cycles/sec. and 1·05 for 1,000 cycles/sec., nevertheless at the same loudness level *e.g.*, 10^4E_o, $\delta E/E$ is nearly independent of frequency. More recently R. R. Reisz (*Phys. Rev.*, 31, May, 1928) has found that $\delta E/E$ lies between 0·05 and 0·15 according to frequency. He found also that $\delta E/E$ is a minimum at 2,500 p.p.s.—this minimum being more sharply defined at the smaller sound-intensities. This frequency corresponds to the region of greatest absolute sensitivity of the ear. Fig. 12 indicates the range of the average human ear with regard to both intensity and frequency. The upper curve gives the sound-pressures (root mean square) which produce a sensation of *feeling*, and serves as a practical upper limit to the range of auditory sensation (Wegel, *Bell System. Tech. Journ.*, 1, Nov. 1922) whilst the lower curve indicates the pressures at the threshold of audibility. It will be seen that the ear is most sensitive in the region of frequency 500 to 5,000 p.p.sec. The range of intensity (proportional to square of pressure) appreciated by the ear in this range is of the order 10^{12}. The smallest detectable pressure-amplitude is of the order 10^{-3} dyne/cm.², *i.e.*, 10^{-9} of atmospheric pressure, corresponding to a displacement-amplitude of the order of 10^{-9} cm. Knudsen, Fletcher and Reisz independently conclude that near a frequency of 2,000 the ear can distinguish, under favourable conditions, from 300 to 400 gradations of loudness between the threshold of audibility and the threshold of feeling (a painful intensity 10^{12} times as great)—each step being recognisable by the ear as just perceptibly louder than the one before it.

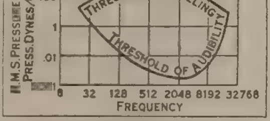

FIG. 12

Audible Limits of Frequency.—The lower and upper limits of frequency for tones audible to the human ear vary according to different observers. A very good average range of frequency may be taken as 20 to 20,000 cycles/sec. Very high and very low pitched sounds of great intensity are felt rather than heard. The ear loses its power to discriminate variations of pitch at very high frequency. The frequency range employed in music extends from about 40 to 4,000 cycles/sec. When two notes within the range 500 to 4,000 cycles/sec. are sounded alternately, the ear can detect a difference of frequency of about 1 in 300. When the two notes are sounded together the discrimination is greatly improved—a frequency difference of one in 20,000 being readily discernible by "beats" (*see* p. 6). Kohlrausch demonstrated experimentally that the sensation of pitch may be excited even with so few as two vibrations.

Perception of Direction. Binaural Audition.—The direction of a sound proceeding from the right or the left is readily determined with fair accuracy, but there is little difference observable between a sound approaching from behind or ahead. For high pitched sounds of short wave-length these directional effects might be explained by the difference of intensity of the sound reaching the two ears, since the head acts to some extent as a screen to the ear which is more remote from the source of sound. When the wave-length of the sound exceeds the perimeter of the head, however, the intensity difference must be very slight and we must look for another explanation of the directional effect. Rayleigh (*Sound*, Vol. II., p. 440) who has examined this question carefully, arrived at the conclusion that the perception of direction is dependent on the relative *phase* of the sounds as they reach the two ears, a small difference of phase being sufficient to indicate the required direction. He found that if the same tone be led by different paths to the two ears, the sound could be made to appear to come from the right or the left at will, by adjusting the path-lengths and consequently the relative phase. The origin of the sound was always attributed to that side on which the phase is in advance (by less than half a period). No explanation of this effect has yet been given.

Pressure of Sound-Waves.—*Radiometers.*—Sound-waves, like light-waves, exert a slight pressure on any surface upon which they fall; and radiometers for measuring sound-intensity have been constructed on this principle. Rayleigh (*Phil. Mag.*, 10, 1905) has determined this pressure on theoretical grounds, but a more simple treatment due to Larmor will suffice here. Plane-waves are incident on a perfectly reflecting wall free to move, the wall being pushed with velocity v to meet the advancing sound-waves of velocity c and mean energy density E (*see* p. 28). The total energy density in front of the wall, if stationary, would be $2E$ due to the incident and reflected trains of waves. The length of the wave-train incident per second on the advancing wall is $(c+v)$ this being compressed during transmission into a length $(c-v)$ due to the approach of the wall. The energy density in the reflected-wave is therefore increased in the ratio

$$(E+\delta E)/E=(c+v)/(c-v)=1+2v/c,$$

that is,

$$\delta E=E\cdot 2v/c.$$

The increase in the total energy in the region of length c in front of the moving wall is consequently $c\cdot\delta E$, and this must inevitably be due to the work done by the wall in compressing the radiation. If P is the radiation pressure, the work done by the wall per second is Pv, whence $Pv=c\cdot\delta E=E\cdot 2v$, that is, $P=2E$, *the mean radiation pressure being equal to the energy density in the medium in front of the wall.* If the wall is a perfect absorber there will be no reflected-wave and $P=E$. Now the intensity of the sound is equal to the energy density × the wave-velocity c (*see* page 22). Provided therefore that the radiation pressure can be measured, and the reflection characteristics of the wall can be determined, we have here an absolute method of measuring sound-intensity. Radiometers for measuring the intensity of high frequency sound-waves under water have been constructed on the above principle by Langevin, Wills, Boyle and others. Boyle (*Proc. Roy. Soc.*, Canada, 1925) constructed torsion pendulums for use with high frequency quartz oscillators under water. The pressure of the "ultra sonic" radiation on the pendulum vane causes a deflection which is reduced to zero by a torsion head. This gives a measure of the twisting moment and consequently the radiation pressure. Comparative measurements with such radiometers confirm the theoretical deduction that the radiation pressure is proportional to the energy density. All absolute measurements of radiation pressure must, of course, make allowance for diffraction at the edge of the reflecting vane. Using the radiometer method, Boyle measured the energy output of high frequency quartz oscillators and the reflection and transmission coefficients of various materials under water. Torsion radiometers have similarly been used to measure sound-intensity in air (Altberg, *Ann. d. Phys.*, 11, 1903). They are only of value, however, in cases where the sound-intensity is very great.

Rayleigh Disc.—A device which is often used in sound-intensity measurements is due to Rayleigh (*Sound*, Vol. II., p. 44). A delicately suspended disc (a small mirror about $\frac{1}{2}$-in. diameter) will tend to face a stream of air (or other medium) flowing past it, whether the flow be direct or alternating. The torque M on the disc tending to diminish θ, the angle which the normal of the disc makes with the stream, is given by $M = \frac{4}{3} \cdot \rho a^3 v^2 \sin 2\theta$, "$a$" being the radius of the disc, ρ the density of the medium and v the velocity of the stream. If the stream be alternating instead of steady, it is only necessary to employ the mean value of v^2. The maximum torque is obtained when $\theta = 45°$. A light galvanometer mirror suspended on a fine quartz fibre provides a very sensitive arrangement, particularly when used inside a double resonator (*see* fig. 13) tuned to the frequency of the sound it is desired to measure. When accurately tuned to the sound falling upon the open end of the resonator R, the instrument can be used to compare the intensities of sounds of the same frequency. The sensitiveness is comparable with that of the ear. The deflections, if small, are proportional to the square of the particle velocity in the undisturbed field. It is important that the diameter of the disc should be small compared with the wave-length of the incident sound. As the double resonator and disc system is very sharply tuned, a large number of instruments would be required to cover a moderate range of frequency and intensity. A disc mounted in the mouth of a single resonator of continuously variable tuning is more generally useful, but is less sensitive.

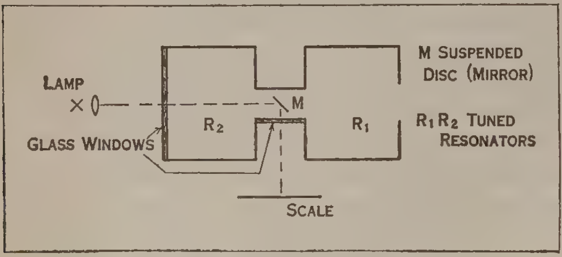

FIG. 13

Resonant Receivers.—When the incoming sound-waves have a predominant frequency it is clearly advantageous to "tune" the receiver to obtain maximum sensitivity. The tuning of a receiver, *e.g.*, an air cavity or a diaphragm is similar to the tuning of a sound transmitter. In many electrical cases the same device may serve either as a transmitter or a receiver, *e.g.*, a telephone earpiece (magnetophone), a Fessenden electro-magnetic oscillator or a piezo-electric oscillator. Under these circumstances it is possible for the tuning to be very exact. A resonant air cavity develops a relatively large amplitude of vibration at its mouth, this amplitude being considerably in excess of that in the surrounding medium. The sound-field near such a resonator is affected by its behaviour as a secondary source, the energy which the resonator emits being drained from the other parts of the sound-field. It can be shown that the area of wave-front from *which energy is extracted* (*and re-radiated*) by a small resonator is λ^2/π where λ is the wave-length of the incident sound to which it is tuned. This area may be considerably greater than the area s of the resonator, the energy amplification being $\lambda^2/\pi s$. In actual resonators, however, only a part of this energy is re-radiated, the remainder being absorbed. The latter portion is partly dissipated in viscous damping and partly converted into a useful form, *i.e.*, is utilised in operating a detector, such as a microphone, or a magneto-phone, or in deflecting a mirror. The efficiency of the receiver is dependent on the proportion of the total energy which is usefully absorbed. Absorption of energy involves damping. The receiver is inefficient if it is underdamped, little or no energy being absorbed, or if it is over-damped, too much or all the energy being absorbed. If the receiver is underdamped it re-radiates too large a proportion of the received energy back into the medium. Overdamping reduces the sharpness of resonance and consequently reduces the area from which energy is obtained, the main advantage of tuning being lost. The most efficient receiver lies between these extremes, *i.e.*, the energy absorbed is equal to the energy re-radiated. In other words, in an efficient tuned receiver the damping due to the medium must be equal to the internal damping in the receiver. It is of course, equally important that the internal damping must be *useful* damping, *i.e.*, the absorbed energy must be used efficiently. Thus if the receiver is electro-magnetic (a telephone receiver) it is important that the ratio of *motional* impedance (measured electrically) to total electrical impedance should be as great as possible. A solid resonator such as a tuned metal diaphragm in air is necessarily inefficient, for a large proportion of the incident energy is reflected or scattered from its surface as from a rigid obstacle. The energy re-radiated to the medium due to the vibration of the diaphragm is extremely small.

Mechanical Transformers.—It is sometimes desirable to convert an oscillation of large displacement and low pressure to one of small displacement and high pressure; a mechanical process analogous to the electrical transformation of a large alternating current at low voltage to a small current at high voltage. Hahneman (*Inst. Radio Eng. Proc.*, II., Feb. 1923) has employed this principle in the design of sound-transmitters and receivers for use under water. As a rule, in such apparatus, one part of a vibrating system is actuated in air whilst another, coupled to it, vibrates in contact with water. In transferring vibratory pressure from air to water a "step-up" pressure transformer is required, and conversely. For this purpose Hahneman employs a mechanical lever of a novel type, the ordinary pivoted lever and link system being useless at even moderate frequencies. He also considers it desirable, as far as possible, to separate the mass and spring factors of the vibrating system, like a weight on a spring, rather than a combined mass and spring as in the prong of a tuning fork. The lever principle is as follows: Two masses m and M are connected as in fig. 14a by a spring of stiffness s. At resonance, neglecting energy radiated, the system will vibrate about its centre of gravity, the amplitudes a and A of m and M being inversely proportional to the masses, i.e., $a/A = M/m$. The spring will be undisplaced at the centre of gravity of the system, *i.e.*, at some point O such that $l_m/l_M = M/m = a/A$.[1] The natural frequency of the two parts on opposite sides of O is

$$N = \frac{1}{2\pi}\sqrt{s\left(\frac{1}{M} + \frac{1}{m}\right)}.$$

In applying this principle to under-water sound transmitters, Hahneman replaces the diagrammatic helical spring by an elastic rod or tube, as in fig. 14b, which combined with the loads m and M tunes to the required frequency. The masses may be pistons or diaphragms suitable for electro-magnetic excitation and for the transmission of vibrations to the water (*see* fig. 3, plate, and *Technical Applications: Sound-Signalling*). S. T. Williams (*Journ. Franklin Inst.*, Oct. 1926) refers to the use of mechanical "transformers" in the design of a gramophone sound-box.

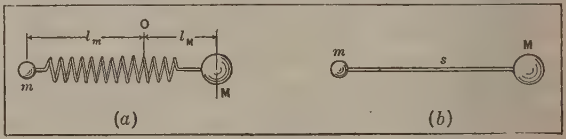

FIG. 14

Diaphragm Receivers.—Unless special precautions are taken to ensure sufficient damping, the diaphragms of microphone transmitters and electro-magnetic receivers used in telephony will have marked resonant frequencies at which they are abnormally sensitive. For speech reception such resonances are undesirable. When maximum sensitiveness is required at one particular frequency it is a great advantage, however, to use a diaphragm tuned to that frequency. Tuned diaphragms with either microphone or magnetophone (electro-magnetic) attachments have been used extensively in under-water signalling. Lamb has shown theoretically that for diaphragms having the same frequency in water the amplitude at resonance is inversely proportional to the area of the diaphragm. When an additional damping factor, such as a granular microphone, is introduced there is a "best size" of diaphragm, increasing with increase of the added damping. (*See* Powell, *Phys. Soc. Proc.*, Feb. 1925.)

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[1] The "mechanical advantage," "velocity ratio" and "mechanical efficiency" of this alternating lever are analogous to those for static levers.

Electro-magnetic Receivers.—The vibrations of a diaphragm may be employed to excite currents in an electrical circuit embracing or lying in a magnetic field. The iron diaphragm of a telephone earpiece by its vibrations varies the magnetic flux passing through a coil and consequently induces alternating currents of the same frequency as the sound vibrations falling on the diaphragm. Similar results are obtained when an iron reed clamped at one end is set into vibration by sound-waves falling on a stiff cone attached to the free end of the reed. In an alternative form the diaphragm or reed, which now may be of non-magnetic material, is attached rigidly to an annular coil of wire which lies in a strong magnetic field. Vibrations of the diaphragm and coil induce currents in the latter of the same frequency as the sound-waves. Telephone, microphone, and loud speaker movements are constructed on these principles. Such instruments can also be used to generate sound-waves by supplying the coil with alternating current of the required frequency. Diaphragm and reed receivers have usually marked resonant frequencies, the sharpness of resonance increasing with the load attached to the diaphragm (*see* p. 8). They may if required be used as "non-resonant" receivers, provided their natural resonances are reduced by damping or are far removed in frequency from that of the sound it is desired to receive. The efficiency of electro-magnetic receivers is determined from observations of damping and motional impedance (*see* p. 9).

Resonant Air Cavity. *Hot-Wire Microphone.*—One of the most sensitive and metrical forms of resonant receiver for sounds in air, is a Helmholtz resonator fitted with a hot-wire microphone. In the hands of Tucker and Paris (*Phil. Trans.*, 221. 1921) this combination has proved of great value in its technical applications and as a laboratory instrument for sound-measurement. It consists essentially of an electrically heated grid of fine platinum wire (0·0006 cm. diameter) placed in the neck of a Helmholtz resonator, or in the second neck of a "double-resonator" such as that shown in fig. 13. The oscillating air currents in the neck at resonance cool the hot grid, the extent of this cooling being measured (by a Wheatstone's bridge) as a change of electrical resistance. This resistance-change is a measure of the *intensity* of the sound. The instrument is calibrated by observing the cooling produced by steady air streams of known velocity. The sensitivity increases with increase of heating current. The tuning of the microphone and resonator is fairly sharp; in a typical example the response fell to one tenth of its maximum by "detuning" 7%, *i.e.*, $n/p = 1 \pm 0{\cdot}07$. In common with other forms of Helmholtz resonator receivers, therefore, a series of instruments is required to cover a moderate range of frequency. The hot wire-microphone increases in sensitiveness towards the lower frequencies (say 100 per second); its upper limit being about 500 to 1,000 cycles/sec. The device has proved extremely useful in measurements of intensity and distribution of sound, particularly for testing trumpets, lenses, mirrors and other sound-concentrating devices and also for investigating the reflection and diffraction of sound-waves generally. Used in connection with resonators of very low frequency the hot-wire microphone proved of great value during the war in detecting and locating the positions of enemy guns. (*See* p. 22.)

Non-Resonant Receivers.—The ideal non-resonant receiver, equally sensitive at all frequencies, is not known. The best approximations aim at uniform sensitivity over a limited range of frequency—the better the receiver the more extended the range. Non-resonant receivers are, as a general rule, considerably less sensitive than the resonant type at a particular frequency but have a good average sensitivity over a wide range. A good example for use in air, is *Wente's condenser microphone* (*see* MICROPHONE) which employs a tightly stretched diaphragm of high natural frequency and a considerable amount of air-damping. *Piezo-electric receivers* are perhaps the best examples of the non-resonant type, for their natural frequencies are always very high (10^4 to 10^6). Rochelle salt, quartz and tourmaline suitably mounted give electrical effects which are an extremely faithful counterpart of the incident sound vibrations, over the whole sonic and a considerable region in the super-sonic range of frequencies. As Boyle, Langevin and others have shown, however, such receivers are most suitable for use in a medium like water. In air they are extremely insensitive, although Nicholson has obtained fairly good results with Rochelle salt receivers (*see* also p. 12). *A multi-resonant receiver* with a number of fairly flat overlapping resonance peaks, due to the various components which make up the receiver, could be designed to have a fairly uniform high sensitivity over a wide frequency range. The principle has been applied with success to gramophone recorders and reproducers (*see* p. 34). (*See* GRAMOPHONE.)

Sensitive Flames are very convenient detectors of high frequency sounds in air. A long narrow gas flame, issuing from a "pinhole" orifice and adjusted to the point of flaring, becomes unstable, flares and shortens when high pitched sounds fall upon it. The action of such flames and sensitive jets of gas is discussed in Tyndall's and Rayleigh's *Sound*. The flame is commonly used to demonstrate the presence of nodes and antinodes in stationary-waves of high frequency, and to indicate the position of the sound focus of a concave reflector.

Under-Water Receivers. *Hydrophones.*—During recent years rapid progress has been made in sound-signalling under water, and the allied navigational problems of sound-ranging, echo-depth-sounding, submarine detection, etc. The earliest and most simple of all subaqueous receivers was known as the "Broca" tube which consisted of a long metal tube with a thin metal capsule fitted with a diaphragm stretched over the end. A similar, but less resonant, device employs a thick-walled rubber bulb in place of the diaphragm. The arrangement is fairly sensitive but is very inconvenient in use—observation at a distant point (on a ship, or at a shore station) being almost impossible. Electrical devices have replaced such tubes, both on the grounds of sensitiveness and convenience. Microphonic and electro-magnetic devices, attached to diaphragms and enclosed in watertight cavities have proved very satisfactory. Such subaqueous sound-receivers are generally known as *hydrophones*. Generally speaking, the diaphragms for use under water are much more massive than those used in air, on grounds of strength, durability and efficiency. A microphone or magnetophone (an electro-magnetic device like a telephone earpiece) attached to a metal diaphragm and immersed in water forms a system which may have one or more resonant frequencies. Such a receiver is therefore suitable where sensitivity is more important than "faithfulness"—*i.e.*, for reception of under-water signals of a definite frequency, a suitably tuned diaphragm and microphone are desirable. Comparatively non-resonant receivers have been constructed of thick rubber—the sensitivity being correspondingly low—these being found valuable in discriminating between various types of ships' noises under water. Receivers of the diaphragm type are essentially *pressure receivers*. Another type of receiver known as the "light body" *displacement receiver* (*see* Wood and Young, *Proc. Roy. Soc.*, 100, 1921) is essentially responsive to displacement or velocity of the water particles and is relatively insensitive to pressure. The two types may be compared with voltmeters and ammeters as electrical pressure and current measuring devices (*see* Drysdale in *Mechanical Properties of Fluids*, p. 293. *See* also Bragg, *World of Sound*, pp. 161–177). Reference has already been made to the use of piezo-electric devices for production and reception of high frequency sounds under water (*see* p. 12).

Geophones.—A simple device first used to detect enemy tunnelling operations in the war, serves to detect sound pulses travelling through the ground. It consists essentially of a cylindrical wooden box of about 3 in. diameter and 2 in. deep, divided into three compartments by two mica discs. The space between the discs is filled with mercury, whilst the two air compartments are connected to the ears by stethoscope tubes. The "geophone" is laid on the ground and vibrations are detected by the relative motion of the box and the mercury. The air spaces are alternately expanded and compressed, the sound pulses being conveyed to the ears via the tubes. Two such instruments, one compartment of each connected to each ear, give a sense of direction as in binaural audition.

Directional Reception.—This may be regarded as the converse of directional transmission of sound which we have already considered (*see* p. 18). We have referred also to the directional properties of a vibrating diaphragm when free to radiate, or receive, waves on both sides (*see* p. 29), and to the perception of direction by a pair of ears (*see* p. 29). These principles have been developed both for air and under-water reception of sound.

Diaphragms.—A single diaphragm or membrane mounted in a heavy annular ring and carrying a microphone at its centre forms a bi-directional receiver. A section of such a receiver is shown in fig. 15 (a) with its "figure of 8" polar curve of sensitivity. The microphone is unaffected when the sound pressure falls symmetrically on both sides of the diaphragm, whilst the response is a maximum when the sound-waves fall broadside on the diaphragm. The mode of action is discussed by Wood and Young in a paper dealing with the Admiralty pattern of "Single Plate Direction Finder" for use under the sea (*Proc. Roy. Soc.*, 100. 1921). A disc of tightly stretched parchment mounted on a ring, with a light "button" microphone at the centre, gives excellent results in air. By means of a suitable screen ("bias" or "baffle plate") on one side of such a diaphragm it is possible to obtain a unidirectional instrument having the polar curve of sensitivity shown in fig. 15 (b). This baffle plate, when used under water, consists of a compound hollow disc containing air and lead shot (or some other suitable damping material to prevent excessive vibration of the walls of the cavity). Its exact function is somewhat complicated, but no doubt it acts partly as a sound screen and partly as a phase-shifting device with respect to the sound vibrations reaching the diaphragm.

Binaural Receivers.—The principle of binaural listening expounded by Rayleigh has been extended to the use of artificial "ears" which can be made very sensitive to a given type of sound and can be arranged at any convenient distance apart or with any orientation with respect to the source of sound. The principle has been applied to aeroplane and to submarine location (see *Mechanical Properties of Fluids*—"Submarine Listening," Drysdale). For example if two similar receiving trumpets are connected by equal lengths of tube to each ear, the trumpets being mounted a fixed distance apart on a rotatable platform, it is possible to locate a source of sound such as an aeroplane with considerable accuracy. The trumpets amplify the sound received by the ears and the directional accuracy is increased by increasing the distance apart of the trumpets. As the platform is swung round, the path-difference of the sound reaching the two ears diminishes on one side and then increases on the other, giving the impression of the sound crossing from one ear to the other. At the point of "cross-over", *i.e.*, of binaural balance, the line joining the trumpets is at right angles to the direction of the source. The same principle can be applied to a pair of underwater receivers. As an alternative to rotation of the line of the receivers it is often more convenient to vary the path-length to the two ears, the difference of path, relative to the distance apart of the receivers, being a measure of the "rotation" required to bring them symmetrical with respect to the source. This is known as the *binaural compensator* principle. The principle has been extended to *multiple receivers*, that is, to a considerable number of similar receivers equally spaced on a long base line. Instead of rotating the whole base line, a suitable rotary compensator is provided, the direction being indicated at the point of binaural balance. The directional properties of multiple receivers are the same as for corresponding multiple sources (*see* p. 31). In the case of electrical receivers the binaural method may be replaced by the *Sum and Difference Method*—the effects at the ear being due to the receivers assisting or opposing each other. The sound received by the ear is a maximum or a minimum respectively, when the normal to the line of the receivers is in the direction of the source of sound.

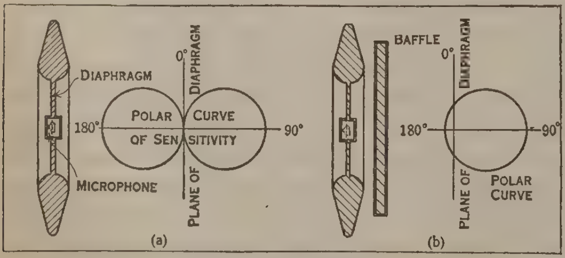

FIG. 15

Receivers of Large Area.—Just as a directional source of sound is obtained by using a vibrating surface of large dimensions compared with a wave-length, so a receiver becomes increasingly directional as its dimensions increase. The piezo-electric quartz directional transmitter used by Boyle and Langevin serves equally well as a directional receiver. Similarly, large trumpets, mirrors and other focusing devices exhibit directional properties with increasing size or with increase in the pitch of the sound (*i.e.*, with diminishing wave-length). Reference has already been made to the reflection which takes place at the open end of a cylindrical pipe or a trumpet acting as a sound receiver. The extent of this reflection diminishes, and the trumpet becomes a more efficient receiver, as the size of the opening increases, provided the length of the trumpet is always large. A parabolic mirror converges the sound energy towards a focus, but it must not be assumed that this is in any way an "optical focus," although it approximates more and more to it as the wave-length of the sound diminishes. A watch tick, the sharp crack of a pistol or an electric spark may be focused very effectively by a mirror of moderate dimensions. The increase of loudness due to curvature depends on the area of the reflecting surface, from which disturbances of uniform phase arrive, as compared with the area of the first Fresnel's zone of a plane reflector in the same position. If the "focal length" of the reflector is considerable and λ is not small, the first Fresnel zone is fairly large, therefore for a reflector of moderate dimensions there is little to be gained by making it concave.

Diffraction Disc Method.—On p. 26 reference was made to the fact that the sound intensity at a point on the axis of a circular obstacle placed normal to a beam of sound is as great as if the obstacle were not present, *i.e.*, the sound "shadow" of the disc has, to quote the optical analogy, a *bright spot* at the centre. A microphone, tuned to the frequency of the incident sound, and placed at a suitable point on the axis of such a disc forms a very sensitive directional receiver, the response being a maximum when the sound is normal to the disc. Discs 20 feet or more in diameter have thus been used in combination with resonant hot-wire microphones as an extremely accurate and sensitive means of locating distant sources of sound in air.

The location of sounds of an explosive nature by the use of a number of receivers on measured base lines is described in the section on Sound-Ranging (*see* p. 35).

Sound-Analysis and Recording.—It is sometimes desirable to determine the nature of a complex sound, more particularly in regard to the relative amplitudes and the frequencies of the component tones. The frequency analysis is relatively simple, but the amplitude measurement is much more difficult. There are numerous ways of determining the various frequencies present in a sound-wave, *e.g.*, we have already referred to the use of Helmholtz resonators for this purpose. In frequency analysis it is more convenient to employ resonators of continuously variable frequency, *e.g.*, by varying the volume of the resonator by means of a sliding piston or a water column. Resonance in such a receiver may be detected in a number of ways, *e.g.*, by ear, optical devices, Rayleigh disc, or some form of microphone, such as the hot-wire microphone. The use of resonators, whilst giving reliable information in regard to the frequencies of the tones present in the sound-wave gives only approximate information regarding the relative intensity of these tones.

Numerous instruments have been devised which are described as intensity or sound-energy-meters, many of which give indications in some way related to sound-intensity. In no case, however, is the device universally applicable to all frequencies and intensities. Many attempts have been made to record wave-forms of sound by means of diaphragms and stretched membranes. The movements of a vibrating diaphragm excited by sound-waves have been recorded in various ways, mechanically, optically and electrically. Mechanical recording is exemplified in the gramophone, where a needle attached via a lever mechanism to the diaphragm traces the wave-form on a revolving disc or cylinder. (*See* Gramophone.) Optical methods have been very commonly used, *e.g.*, in Kenelly's analysis of the motion of telephone diaphragms, in Webster's phonometer, in Millar's phonodeik and in the Hilger audiometer. In all these examples a small mirror reflects the vibrations of the diaphragm on to a moving photographic film. Electrical methods involve the use of a microphonic or electro-magnetic device which responds to the vibrations of the diaphragm, the corresponding electrical oscillations being recorded by means of some form of oscillograph, *e.g.*, the Duddell strip, the Einthoven string or the cathode ray oscillograph (*see* Instruments, Electrical; *see also* Irwin, *Oscillographs*). The majority of such diaphragm receivers are subject to resonances at certain frequencies with the result that the record is a distortion of the actual wave-form, the distortion being greatest in the neighbourhood of the resonance frequencies of the instrument. The defect may be exaggerated or partially compensated by the use of a cone or trumpet to collect the sound and increase the amplitude of the diaphragm. Great care is necessary in the choice of a receiver, and recorder, for a particular type of sound, otherwise a number of factors may contribute to the distortion. Thus in electrical recording, distortion may be caused by resonance in the diaphragm, the microphone mounting, the trumpet or cone collector, the electrical circuit, and in the oscillograph. In addition to this, there may be distortion introduced solely on account of the dimensions of the receiver relative to the wave-lengths of the various components of the sound. As we have seen, a receiver which is large compared with a wave-length exhibits directional properties depending on the ratio λ/D (where D is the diameter of the receiver). One of the best non-resonant receivers developed during recent years is *the stretched diaphragm condenser microphone* of Wente (*Phys. Rev.* 10. 39. 1917). This was specially designed for sound-measurements and is used extensively in analysis and recording of wave-forms of sounds lying within the frequency ranges of speech and music. The microphone, shown in diagram fig. 16a, consists essentially of a tightly stretched thin steel diaphragm (·001 in. thick) separated from a parallel back-plate by an air gap of 0·001 in. approximately. The diaphragm shown with its back-plate form an electrical condenser, the capacity of which is varied when vibration takes place. When 200 volts are applied through a high resistance to the condenser, the vibration results in a fluctuating electromotive force. The variation of sensitiveness of such a microphone with frequency is indicated in fig. 16 b. It will be seen that the output in milli volts (10^{-3} volt) per dyne/cm.^{2} is fairly constant over a frequency range 500 to 5,000 cycles/sec. The microphone is very insensitive when compared with other, more familiar, types (granular and electro-magnetic) but its freedom from resonance over a wide range of frequency renders it most valuable for purposes of sound analysis. The lack of sensitiveness can easily be remedied by the use of a "distortionless" valve-amplifier (resistance-capacity coupled valves). Crandall (Bell. Syst. *Tech. Jour.*, 4. 1925, p. 587) employed Wente's condenser microphone in conjunction with such a valve amplifier to record speech sounds. A well designed amplifier will give practically constant amplification over the range of speech frequencies and will give an output proportional to input. The amplified e.m.f. is recorded by means of an oscillograph which must itself be non-resonant over the range of frequencies to be recorded. With certain limitations a high frequency Duddell strip well damped may serve the purpose, or alternatively an Einthoven oscillograph with a critically damped fibre of silvered quartz may be used. Perhaps the most perfect form of sound recording system is one proposed by Sir J. J. Thomson, namely a piezo-electric crystal receiver used in conjunction with a cathode ray oscillograph. Such a combination was used by Keys (*Phil. Mag.*, Vol. 42, 1921) in recording the pressure-time curve of an explosion-wave under water. The piezo-electric receiver has a very high natural frequency and is consequently non-resonant over a very wide frequency-interval which includes the audible range. The cathode ray oscillograph (*see* A. B. Wood, *Proc. Inst. Elect. Eng.*, Nov., 1925) is a perfect non-resonant recorder of electrical oscillations, having the same sensitivity at *all* frequencies from zero to the highest "radio" frequency. The combination may therefore be regarded as distortionless. The sensitivity for sounds of moderate intensity is, however, very small and amplification is necessary. The faithfulness of reproduction is ultimately dependent on limitations of the amplifier.

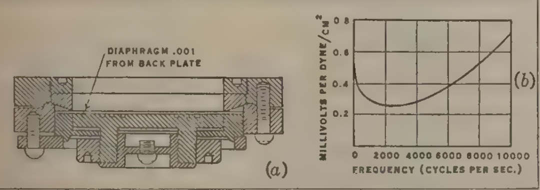

FIG. 16

Measurement of the Amplitude of a Vibrating Body.—W. H. Bragg has described a very simple and ingenious method of measuring the amplitude of a vibrating surface (*e.g.*, of a diaphragm). A small mass supported by a spring is brought into contact with the vibrating surface and the fixed end of the spring displaced through a distance A until there is no longer "chattering" between the mass and the diaphragm. At the point where chattering ceases, the maximum acceleration of the diaphragm is just equal to that of the mass attached to the spring. Thus if a and n and A and N represent the maximum amplitude and the frequency of the diaphragm and the spring respectively, we must have $an^2 = AN^2$ or $a = AN^2/n^2$. Consequently if N is very small compared with n, A will be very large compared with a, in this way yielding a large "magnification" of the amplitude to be measured. As an example, if $n = 1{,}000$ p.p.s. $N = 1$ p.p.s. and $A = 1$ cm., then $a = 10^{-6}$ cm. The method permits of the measurement of very small amplitudes, the chattering being observed electrically. It is important of course to observe that the measuring device is sufficiently light so as not to interfere with the motion of the vibrating surface whose amplitude is required. Measurements of the amplitude of vibration of a diaphragm have also been made by making it one of the reflecting surfaces of a Michelson interferometer (Webster, *Nat. Acad. Sci.*, 5, p. 179, 1919). The displacement of the interference fringes, photographed in vibration as a wavy line, gives a measure of the amplitude in terms of the wave-length of light. Such a diaphragm then forms a standard source of sound. Known amplitudes of vibration may also be obtained by applying measured alternating voltages to piezo-electric crystals, provided resonance-frequencies (usually extremely high) are avoided. Rankine has described (*Proc. Phys. Soc.*, Aug. 1919, and Feb. 1920) a method of recording sound vibrations by means of variations in the *intensity* of a beam of light, the resulting film, of varying transparency, forming a convenient means for reproducing the original sound, using selenium or other photoelectric cells. When a wave-form has been recorded by any of the methods indicated above, it may be analysed into a Fourier series (*see* p. 7) which gives the frequencies and relative amplitudes of the tones of which the sound is composed.

TECHNICAL APPLICATIONS

The past ten or fifteen years mark a period of considerable progress in the technical application of the principles of sound. It is proposed in what follows to deal with the more outstanding of these applications apart from those already mentioned in the foregoing sections. The exigencies of war stimulated the development of apparatus for detecting, identifying, and locating sounds at long ranges. Numerous forms of directional sound-receivers, sound-ranging and sound-signalling devices were realised and applied to urgent problems on land and sea. Since the war, the growth of radio-telephony and "broadcasting" has resulted in improved methods of reproducing sounds of audible frequency. The phenomena of piezo-electricity, discovered by Curie in 1880, have in the hands of Cady and others developed into a means of standardising mechanical and electrical frequencies over a range extending up to millions of vibrations per second. In this respect also improvements in tuning fork design have played an important part. A further application of piezo-electricity, initiated by Langevin and developed by Boyle, employs the supersonic oscillations of quartz in depth sounding at sea and in the echo detection of icebergs. At the other end of the frequency scale, Constantinesco has developed a system of power transmission through water-filled pipes, employing generators, motors, transformers and transmission lines closely analogous to the corresponding electrical devices. Such alternating mechanical systems are capable of dealing with large amounts of power in the form of low frequency pressure-waves. The elimination of objectionable resonance from gramophones and loud-speakers represents a marked degree of progress in the development of apparatus for reproducing speech and music. The study of the characteristics of speech and hearing, notably the work of the staff of the Bell Telephone Laboratory U.S.A., has greatly increased our knowledge of these subjects. The results have proved of great value in the improvement of telephone apparatus, microphones, electro-magnetic receivers, transmission lines, etc., and in the design of all forms of apparatus for recording or reproducing speech and music. In this connection also the introduction of the conception of acoustic impedance, as the analogue of electrical impedance, in dealing with complex acoustical systems has proved of great value. In a recent discourse before the Royal Aeronautical Society, Tucker has dealt with the problem of noise-reduction in aircraft, the deafening roar in the cabins of civil aircraft being a serious hindrance to commercial development. The general question of reduction of traffic noise is becoming increasingly insistent as an urgent practical problem still awaiting solution.

Reproduction of Sound.—The telephone (*q.v.*), the gramophone (*q.v.*) and the radio loud-speaker are among the most familiar types of reproducers of the sounds of speech and music. Any practicable device of this character for reproducing sound must necessarily have its limitations, for the faithful reproduction of even the simplest sounds is very difficult. As we have seen (p. 32), however, the ear is sufficiently accommodating to ignore fairly large defects in reproduction. Thus a 10% error in intensity, or possibly more than this, may pass unnoticed; the accuracy of *intensity* reproduction therefore need not be very great to conform with such a standard. *Frequency* reproduction, however, must be much more accurate to satisfy the ear, and it is indeed fortunate that the practical difficulties in this case are relatively small. Reproduction of sounds involves reception, and possibly transmission and amplification, as a preliminary. The process is well illustrated in the gramophone with either mechanical or electrical recording and reproduction. The recording system involves the direct mechanical action of sound-waves on a diaphragm, lever system, and engraving stylus, or alternatively on a system employing a microphone and a recorder operated electro-magnetically. In reproduction the process takes place in the reverse order, some form of horn, cone or diaphragm being utilised to couple the vibrations of the sound-box or electrical "pick up" with the external body of air. The present practice in design is to regard the complex mechanical system, *e.g.*, of a gramophone, as analogous to a corresponding electrical system. In this respect the analogy with electrical filter circuits, as stated by G. W. Stewart, has proved an extremely fruitful one. S. T. Williams and A. Whitaker have both applied this principle with considerable success in designing gramophone recorders and reproducers. By suitably choosing the inertia, stiffness and damping of the various elements of the sound-box and horn, a moderately good response-curve is obtained free from pronounced resonance within the speech-music range 150–4,000 p.p.sec. Electrical methods of recording and reproducing have recently yielded even better results. The desirable features in gramophones and loud-speakers are dealt with in a number of papers by various authorities in *Proc. Inst. Electrical Engineers*, Nov. 1923. The practical considerations are far too numerous to mention here but the essence of the problem of faithful reproduction lies in the avoidance of predominant resonances in the electrical and mechanical systems. This result may be achieved in some degree (a) by arranging that the natural frequencies of all elements of the system are far removed from any frequency it is desired to reproduce, (b) by the use of heavy damping, or (c) by making use of multiple resonance, *i.e.*, arranging the various resonance peaks to overlap in such a way as to give a fairly uniform response. (*See* Rothwell, *Nature*, Feb. 24, 1923, and Porter, *Phys. Soc.*, Feb. 1924.)

Mention has already been made of the recording of sounds on a film by means of light of variable intensity (Rankine, *loc. cit* p. 33). When a beam of light, after passing through such a film moving at the recording rate, falls on a sensitive cell (selenium, thalofide or photoelectric) the original sounds may be reproduced in a telephone or loud-speaker connected in circuit with the cell and a suitable amplifier. "Speaking films" have been produced successfully on this principle, the speech record being made on the edge of the film simultaneously with the cinema pictures. (*See* SELENIUM CELL.) Numerous other optical methods have been employed, with more or less success, to modulate a beam of light as a means of sound-reproduction, *e.g.*, use has been made of the Kerr electro-optical and the Faraday magneto-optical effects, and of the luminous electric discharge in rarefied gases.

Musical Instruments.—To deal adequately with the technical application of sound to the design and construction of musical instruments would require a very lengthy article in itself. Occasional references to such applications will be found above (section on Sources of Sound), but for detailed information the reader is referred to treatises such as *The Dictionary of Applied Physics* or Millar's *Science of Musical Sounds*.

The Acoustics of Buildings.—This subject is discussed in a separate article under that title.

Sound-Signalling.—In the section on sources of sound, reference has been made to various types of siren and the diaphone (p. 15) for producing powerful sounds in air, mainly for use in fog-signalling from light-houses and light-ships. Under the sea, large bells are used for a similar purpose. A more powerful under-water signalling device, due to Fessenden, employs a large diaphragm forced into resonant vibration under water. The apparatus consists essentially of a transformer, the secondary of which is free to move in a strong radial magnetic field. The primary is supplied with alternating current, and the resulting periodic motion of the secondary (a copper cylinder) is communicated to the submerged steel diaphragm which gives rise to sound waves in the water. The Fessenden oscillator, as it is called, is further mentioned on p. 35. The same device operates, conversely, as a receiver of sound-waves, these being converted into electrical oscillations by the vibration of the copper cylinder in the magnetic field, the induced currents in the primary coil being amplified and passed through telephones. Fessenden has used the apparatus to transmit signals through water to distances exceeding 30 miles and has even used it to transmit speech for a distance of half a mile. The oscillator has also been applied to detect icebergs and to take continuous depth soundings by echo methods (*see* below). In another form of oscillator, which is manufactured by the Signal Gesellschaft. Kiel, Hahneman has obtained powerful signals by means of a diaphragm excited in a different way. The diaphragm forms one member of a coupled system of two masses connected by a stiff spring (metal tubes). A powerful alternating current magnet causes periodic stretching of these tubes with corresponding vibrations of the diaphragm. A transmitter of this type weighing about 5 cwts. and having a diaphragm 18 inches diameter, gives a sound output of 300 to 400 watts, the mechanical efficiency being about 50%. Reference to supersonic directional transmitters of the Langevin type, and to directional receivers, has already been made (*see* pp. 31 and 32 respectively).

Echo Depth Sounding.—Since the war considerable progress has been made in the development of new systems of sounding at sea. These new methods all employ, most appropriately, sound-waves as a means of measuring depths. The saving of time and labour is enormous and such methods are steadily replacing the old lead and wire systems which have survived so long. A sounding in 4,000 fathoms can be made in about 10 seconds by the new "echo" methods, whereas many hours labour are involved to obtain a somewhat uncertain value by the old "wire" system. An additional advantage lies also in the fact that observations of depth can be made whilst the ship is in motion, up to speeds of 15 or 20 knots. The echo method involves the measurement of distance in terms of the time interval between the initiation of a sound impulse and the reception of an echo. This requires a knowledge of the velocity c of the sound waves in the medium, water or air; and depends on the fact that sound is reflected from the sea-bed in the same way that it is reflected in air from buildings and cliffs. The distance travelled by the wave in the time t is $2D$, the depth D is therefore equal to $c/2t$. Various systems have been devised in America, France, Germany, and Great Britain, differing in the manner of producing and receiving the sound impulse and in the measurement of the time interval. In the Behm system, a small detonator is fired under water thereby operating a microphone and relay and setting a graduated disc in motion; the arrival of the echo stops the disc which is engraved in "depths." The angle through which the disc has revolved is a measure of the time interval t and consequently of the depth D. The system developed by the British Admiralty depends on the indirect measurement of the time interval. The transmitter consists essentially of a steel diaphragm which is struck a powerful blow by an electro-magnetic hammer, thereby emitting a heavily damped sound-wave of about 2,000 p.p.s. The receiver is an ordinary "button" carbon granule microphone mounted on a small diaphragm and enclosed in a watertight container. The transmitter and receiver are mounted in water-filled tanks fitted inside the ship's plates at points screened by the hull. A small motor drives two commutator switches at constant speed. One of these commutators actuates the hammer three times per second whilst the other short circuits a pair of brushes across the listening telephones except at one particular moment during which they can "listen." The position of these brushes may be displaced by hand relative to the corresponding brushes in the transmitter circuit, so that a short time interval, proportional to the angular displacement of the brushes, separates the initial sound impulse and the moment when the telephones listen. Nothing is heard therefore unless this moment coincides with the moment of arrival of the echo. The angular displacement of the brushes measures the time interval ($360° \equiv \frac{1}{3}$ second). The dial attached to the rotatable telephone brushes is graduated in feet, or fathoms, and depths may be taken continuously whilst the ship is in motion. Two types of apparatus have been developed, (a) The shallow water set (described above), up to 150 fathoms, and (b) Oceanic depth apparatus, up to 4,000 fathoms or so. Both types are in regular service in numerous British and foreign commercial vessels and in the survey ships of the British Navy. Fessenden (U.S.A.) has devised a depth sounding system similar to the above, using his "oscillator" for the purpose of generating the short sound impulses. He claims in addition to depth sounding, to have used the apparatus to detect icebergs at distances up to $2\frac{1}{2}$ miles, a somewhat remarkable and surprising result, in view of the dimensions of icebergs, the wave-length of the sound (10 ft. approx.) employed, and the poor reflecting properties of ice under water. Boyle and Reid, using a Langevin directional quartz oscillator at supersonic frequencies could not detect an iceberg beyond 200 yards. The echo from ice was found to be very feeble compared with that from a rocky shore. The supersonic method has also been employed by Langevin and by Boyle in depth sounding; a good echo from the bed of the sea being easily distinguishable at considerable depths.

Sound-Ranging.—The location of hostile guns on land, and of submarine explosions at sea, constitutes one of the most important practical applications of sound during the war. Ordinary directional receiving devices such as those already considered are of little service when the sound consists of a sudden impulse or shock. The location of the explosion originating the impulse requires a special technique which is generally called sound-ranging. We shall deal first of all with the war-method or *multiple-point sound-ranging*. In this method three or more receivers are mounted at known positions on surveyed base lines. The spherical explosion wave WF passes over, say, four receivers, 0, 1, 2, 3, in succession, the times of passage being recorded at instants t_1 t_2 t_3 respectively. The construction shown in fig. 17 indicates in a simple manner how the explosion E is located. If we draw circles of radii ct_1 ct_2 and ct_3 with centres at 1, 2, 3, respectively, c being the appropriate velocity of sound, then a circle WF which passes through the receiver 0 and is tangential to the three small circles will have the point of the explosion E at its centre.

The accurate mathematical method of determining E from the values t_1 t_2 and t_3 depends on the fact that this point lies at the intersection of hyperbolae having the various receivers 0, 1, 2, 3, as foci.

Army Sound-Ranging.—Six microphones were generally used, spaced along a base about 9,000 yards long and 4,000 yards behind the front line, a central recording station, to which the microphone leads were brought, being situated 5,000 or 6,000 yards from the front line. For hostile gun-ranging a special type of microphone, particularly sensitive to the low frequency disturbance of the sound of discharge of the gun, was devised. This microphone, known as the *resonant hot-wire microphone*, invented by Tucker, has already been described (*see* p. 31). The hot-wire grid was mounted in the opening of a large Helmholtz resonator of about 16 litres capacity; the system responding only to very low frequency gun-sounds, whilst ignoring shell-wave (onde de choc), detonation of shell, and noises such as speech, traffic, or rifle fire. The resonance set up by a gun-sound produced cooling of the grid with consequent variation of the electrical current flowing through it. This current-change was photographically recorded at the central station by means of an Einthoven string galvanometer fitted with six strings, one for each microphone. The resulting record, which was automatically developed and fixed, showed the six gun "signatures" on lines running parallel to the film. Across these lines, *i.e.*, at right angles to the film, were a series of time marks every hundredth and tenth of a second, providing a direct means of measuring the time intervals with an accuracy of 0·001 second, if the requirement of such was essentially needed. The record was started when a forward observer, or a "sentry" microphone, heard the gun, *i.e.*, a few

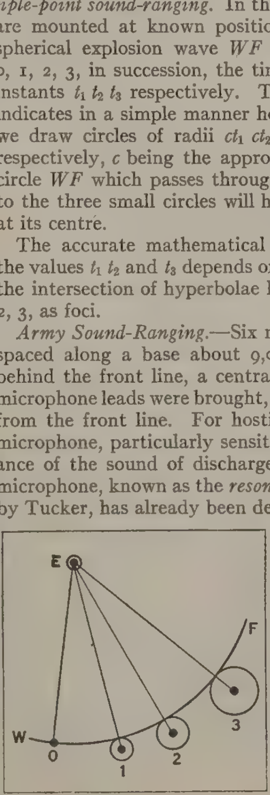

FIG. 17

seconds before the sound-wave reached the first receiver on the base. The measured time intervals were corrected for temperature and wind, which have a considerable influence on the velocity of sound (*see* p. 5). Variation of these factors with height results in troublesome refraction corrections, and under certain conditions of wind gradient, sound-ranging became impossible. The sound-ranging method could, under certain conditions, be employed to locate both an enemy gun and the *answering* shell-burst, in which case the comparative records eliminate uncertainties arising from atmospheric conditions.

Navy Sound-Ranging.—The method employed at sea during the war was based on the same principles, but the receivers were essentially different. Under water, the sound of an explosion was received on a steel diaphragm on which was mounted a sensitive granular microphone. The diaphragm formed the cover of a watertight case mounted on a large tripod which rested on the sea bed. Four or more of such "tripod hydrophones" were laid in accurately surveyed positions on a 12 mile base line. They were connected by means of cables to a six-stringed Einthoven galvanometer in the recording station on shore, the subsequent procedure to obtain photographic records of an explosion being essentially the same as outlined above. Specimen records have been made of such explosions. During the war, explosions of mines, depth charges and torpedoes could be located with great accuracy at distances of 50 or 60 miles from the base line of hydrophones. Since the war the method has been applied to the accurate location of buoys and light-vessels, a small charge being fired under water in the vicinity of the point to be surveyed. For such purposes it was necessary to know the velocity of sound in sea water at different temperatures and salinities, with great accuracy (*see* p. 5). As an alternative to the Einthoven photographic recorder system of measuring time intervals, A. B. Wood and J. M. Ford (see *Jour. Sci. Instr.*, Mar. 1924) have devised a "Phonic Chronometer." This consists essentially of an electromagnetically operated stop-watch with three sets of dials for measuring three independent time intervals. The speed of the chronometer is governed by a tuning fork and phonic motor giving an accuracy of 1 in 10,000. Time intervals are indicated directly on the dials to 0·001 second. Special diaphragm shock receivers were designed for use with the chronometer, which was started and stopped as the explosion-wave passed the various receivers, the time intervals being read directly on the dials.

Radio-Acoustic Sound-Ranging.—This method which for obvious reasons could not be used in war time, was first proposed by Joly, and has recently been developed by A. B. Wood and H. E. Browne for the British Admiralty (*Proc. Phys. Soc.*, April 1923). It consists in the simultaneous emission of a "wireless" signal and an explosion impulse. The former travels with the velocity of light (186,000 miles/sec.) the latter with a velocity about 1 mile a second in water. If, therefore, one string of the Einthoven galvanometer on shore records the radio-signal whilst the others record the arrival of the explosion wave at the various hydrophones, we have a very simple and direct means of locating the explosion. The distance of the explosion from the hydrophones is given by ct_1 ct_2 ct_3, etc., where c is the velocity of the sound in the sea and t_1 t_2 t_3 are the time-intervals between the arrival of the wireless signal and the explosion-wave at the respective hydrophones. A 9 oz. charge of guncotton can be located in this way at 40 miles, whilst larger charges have been located up to 80 miles or more. At 80 miles the sound-wave through the sea arrives $1\frac{1}{2}$ *minutes* after the wireless signal which denotes the instant of firing the charge. The method permits of very great accuracy and has important applications in navigation and hydrographical survey. For navigational purposes great accuracy is sacrificed to speed, it being possible to give a ship in fog 40 miles away a position within a radius of half a mile in less than 10 minutes of receiving her request for a location. In hydrographical survey work the method has been used successfully to fix accurately the positions of buoys and light-vessels out of sight of land. The method is accurate in rough or foggy weather and at all seasons of the year. Various ingenious proposals have been made to safeguard ships in fog, by application of radio-acoustic methods (*see* Joly "Scientific Signalling and Safety at Sea," *Phil. Mag.* July 1918).

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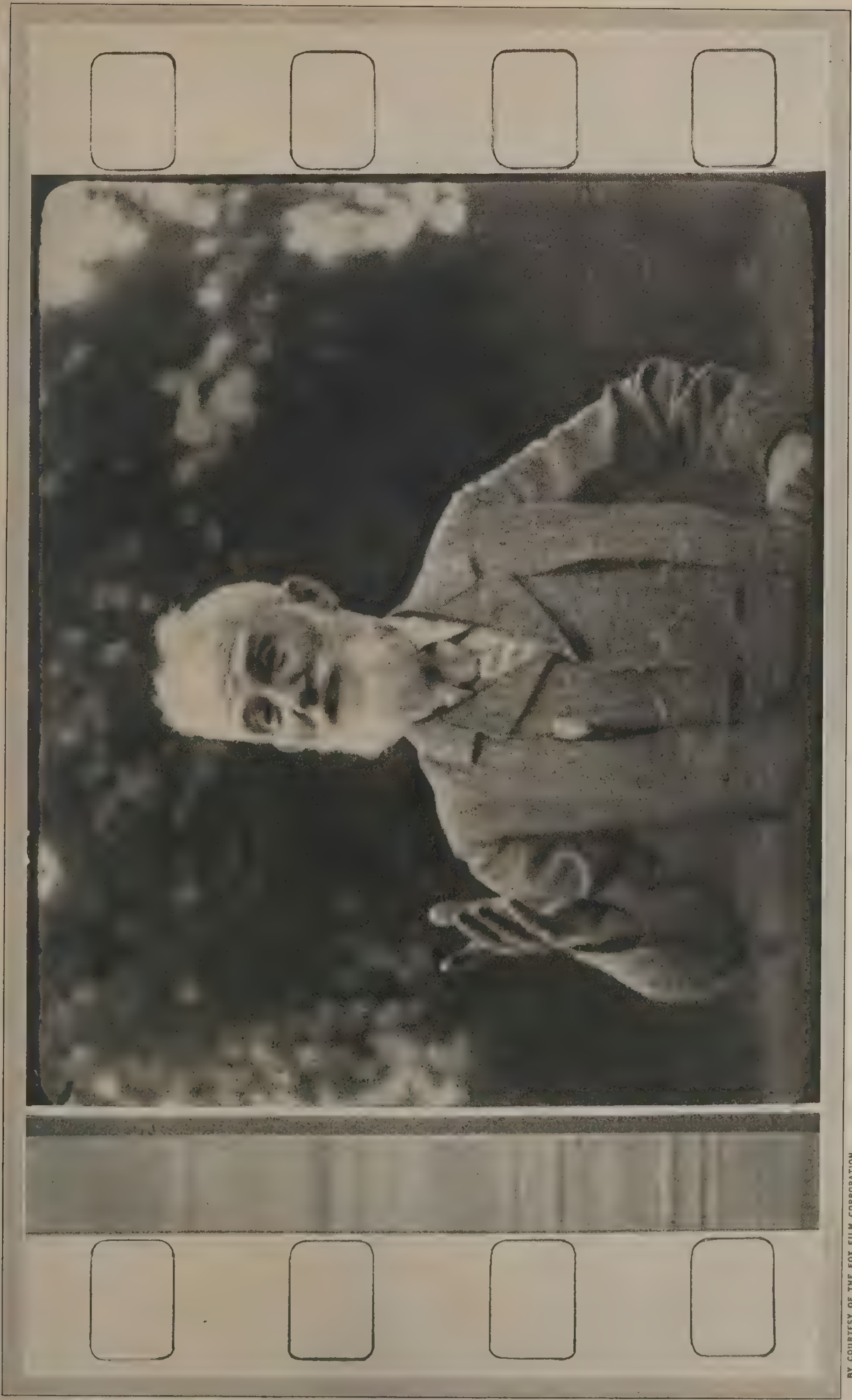
SOUND, THE, the easternmost of the straits giving entrance to the Baltic Sea from the Cattegat, between the Danish island of Zealand and Sweden (Danish *Oresund*). Its extreme length from the promontory of Kullen to that of Falsterbo is 70 m. Its narrowest point is between Helsingör in Denmark and Helsingborg in Sweden, which are 3 m. apart. Its extreme width, 30 m., is where Kjöge Bay indents the coast of Zealand. Three islands lie in it—Hven, belonging to Sweden, and Saltholm and Amager, belonging to Denmark. The strait between Amager and Saltholm is called Drogden, and is used by large vessels passing through the Sound. The extreme depth of the Sound is about 14 fathoms. Navigation is open in winter, though three instances are recorded of the Sound being frozen over: in 1306, 1830 and 1836.

SOUNDING. The determination of the depth of the sea has been practised from very early times for purposes of navigation, but it is only since the introduction of submarine telegraphy that extensive efforts have been made to obtain a complete knowledge of the contour of the ocean-bed (*see* Ocean).

For depths over 20 fathoms sounding machines are often employed and wire has entirely superseded hemp gear. Its smooth surface and minute section, reducing friction to a minimum, give a rate of descent of about 100 fathoms per minute. Reeling in may be accomplished at nearly the same rate. Such soundings can be obtained in any weather short of a fresh gale. A sounding of 1,000 fathoms may be obtained in 25 minutes and 3,000 fathoms in 75 minutes. But beyond that depth, great caution is required, the time occupied is increased, and reeling in must be done very deliberately. A sounding of 5,269 fathoms was obtained near the island of Guam by the U.S. cable-surveying ship "Nero." Soundings at such depths may occupy a period of time lasting as long as five or six hours.

Lucas Machine.—Among the sounding machines in general use the Lucas carries nearly 6,000 fathoms of 20-gauge wire, and is fitted with two brakes—one a screw brake for holding the reel when required, the other an automatic brake for stopping the reel when the weights strike the bottom. A guider for winding the wire uniformly is also attached. After leaving the reel the wire passes over a registering wheel, the dial of which indicates the length of wire run out. Smaller machines are used in boats.

Sounding Rods and Sinkers.—Under 1,000 fathoms a lead of 30 to 40 lb. weight can be recovered, and no detaching rod is necessary. For greater depths the "Baillie rod" is the best apparatus. It is a tube about 2 ft. long, having a rounded conical top, through which passes a movable steel rod. The lower part of the tube screws on and off, and contains a double flap valve to retain the bottom specimen. The sinkers, each 25 lb. in weight, conical in form, and pierced with a cylindrical hole through which the Baillie rod passes loosely, are slung by wire or cod line secured to a flat ring and passing over a projection on a movable rod to which the sounding wire is attached. The weight of the apparatus being taken by the sounding wire, the sinkers remain suspended; but on striking the bottom, the wire slackens, and the weight of the sinkers drags the movable rod down till the projection bears against the curved surface at the top of the rod. The wire sling is forced clear of the projection and the sinkers are slipped. In descending, the valves opening upwards, allow the



BY COURTESY OF THE FOX FILM CORPORATION

ENLARGEMENT OF A SINGLE FRAME OF A "MOVIETONE" FILM SHOWING, TO THE LEFT, THE SOUND TRACK

The sound record on the motion picture film here shown is a long narrow band of variable density of developed silver deposit. The variations correspond to the wave outlines of the sound to be reproduced, which in this case is the speaking voice of George Bernard Shaw, on the occasion of his first appearance before the camera and microphone of the sound motion pictures

water to pass through freely; but on drawing up they are closed thus retaining the material with which the tube is filled. For depths under 2,000 fathoms two sinkers are sufficient. In deeper water a third cylindrical weight of 20 lb. should be put between them. It is important to interpose a hemp line, some 20 fathoms long, between the end of the wire (into which a thimble is seized) and the lead or rod. This prevents the wire from kinking on the lead striking the bottom.

Method of Sounding.—The machine is placed on a projecting platform on the forecastle. As the wire runs out the brake must be gradually screwed up, so as to increase the power in proportion to the amount of wire out. The regulating screw is marked for each 500 fathoms. In fairly smooth water the brake will at once act when the weight strikes the bottom and the reel stops. Under 3,000 fathoms one spring is sufficient, beyond that depth two springs are required.

Handling the Ship.—Sounding from forward is preferable as it enables the ship to be handled with greater ease; in heavy weather when impossible to work on the forecastle, soundings may be obtained from a machine mounted over the stern. The ship's head must be kept in a direction which is the resultant of the direction and force of the wind and current; and this is arrived at by altering the course while sounding, point by point, until the wire can be kept up and down by moving the engines slowly ahead as necessary.

Observations of Temperature.—The temperature of the water is usually taken at intervals of 100 fathoms to a depth of 1,000 fathoms, and at closer intervals in the first 100 fathoms. If a second wire machine is available, the observations may be made from aft whilst the sounding is being taken forward. A 30-lb. sinker is attached to the end of the wire, and the registering thermometers are secured to the wire by the metal clips at the back of the cases, at the required intervals. To avoid heavy loss, no more than four thermometers should be on the wire at one time. When sounding a thermometer is usually attached to the line a short distance above the lead.

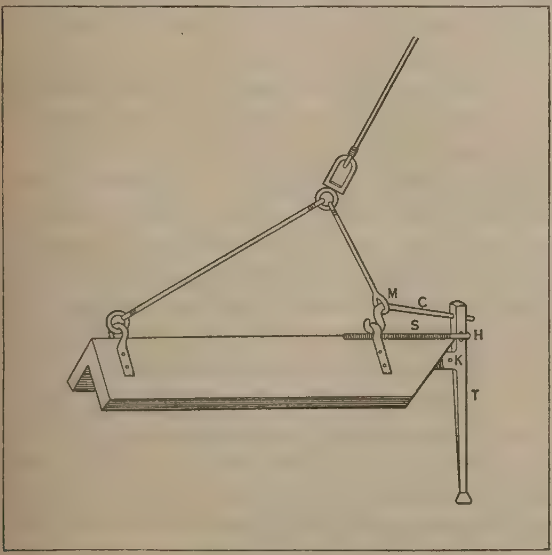


FIG. 1.—SUBMARINE SENTRY

Submarine Sentry.—The primary object of the machine called the "submarine sentry" is to supply an automatic warning of shallow water; it has been instrumental in discovering many unsuspected banks in imperfectly surveyed waters. By means of a single stout wire the sinker, an inverted kite, called the "sentry," can be towed steadily for any length of time, at any required vertical depth to 40 fathoms; should it strike the bottom, it will free itself and rise to the surface, simultaneously sounding an alarm gong. The vertical depth at which the sentry sets itself when a given length of wire is paid out is not changed by any variation of speed between five and 13 knots.

The kite in its position when being towed is indicated in fig. 1. The point of the catch C, passing through a thimble M in the short leg of the sling, is slipped into the hole at the top of trigger T, which is hinged at K and kept in its place by the spring S attached to the hook H. On the trigger striking the bottom the catch is released, the short leg of the sling slips off, and the sentry, which then rises to the surface, is left towing by the long leg. The winch is fitted with two handles for heaving in the wire; one gives great power and slow speed, and the other, acting on the drum spindle direct, winds in quickly. The wire supplied with the machine has a steady breaking strain of about 1,000 lb.

For ship as opposed to boat work, in depths up to 50 fathoms the best known British systems are the "Douglas-Schafer" and "Somerville"; these appliances are fitted in all British surveying vessels, and enable accurate and rapid soundings to be obtained when steaming at the rate of about four knots. Both methods use a wire traveller carrying a lead between the stern of the vessel and a spar projecting from the bows and permit the lead being disengaged at its greatest distance forward, thus enabling a vertical sounding to be obtained as it passes the stern.

Echo Sounding.—This new method depends upon the principle that any sound originating at or near the surface travels through the water at a known speed, and after striking any large object or the bottom of the sea is reflected back to the surface, the time between the emission of the sound and its reception back again being a matter for accurate measurement.

The time necessary for obtaining a sounding is almost infinitesimal, the sounding in extreme depths taking little more time than one in the shallowest water. The speed of the vessel is maintained throughout the soundings, the soundings themselves may be accurately taken at extremely short intervals and bad weather does not affect the work. *See* also CHART and SOUND.

See *The Hydrographical Review,* vol. 1, 2 and 5, published by the International Hydrographical Bureau, Monaco. *Echo Sounding* published by H.M. Stationery Office. (J. A. ED.)

SOUND MOTION PICTURES. Since the first days of motion pictures efforts have been made to provide the addition of an appropriate sound accompaniment or speech, accurately synchronized with the motion picture, which would add realism and artistic value to the performance. The requirements of such a system are that the picture shall be as clear as heretofore, that the sound produced shall be appropriate and reasonably natural in quality and that the synchronism, or exact time relation, between the pictures and the sound shall be maintained, preferably by automatic means. (*See* MOTION PICTURE PROJECTION.) The reproduction of sound may be accomplished either from a phonograph record or from a sound record on the motion picture film itself that may be made in several ways; *e.g.,* it may be a long narrow band of variable density of developed silver deposit, the density variations corresponding to the wave outlines of the sound to be reproduced; or it may be in the form of a long narrow band, the width of which at any point varies as the wave form of the sound to be reproduced. It has also been suggested that the sound record on the film might be a mechanical indentation or wavy line impressed into the celluloid or the emulsion, in which groove a needle will rest as in a phonograph (*q.v.*).

The initial stages in recording on a film are similar to the first stages in electrical phonograph recording or in radio broadcast transmission. The performers appear before a microphone of high quality, the output of which is amplified by a vacuum tube amplifying system. The output of the amplifier is used to control the recording device. In some cases the intensity of a light source, *e.g.,* a *neon,* or other gas-filled glow-tube, is systematically controlled, and this variable light is caused to shine on a narrow slit, or its optical equivalent, placed over the rapidly moving negative film. In other cases the light from a constant source passes through a light valve or an aperture of variable width or a Kerr cell or similar device controlled by the amplifier output, and then falls on the stationary narrow slit placed over the moving negative film. In each of the two preceding methods a variable density record is produced. In another method of recording, a sharply limited beam of light from a constant source is reflected from an oscillograph mirror and focused upon a narrow slit or its optical equivalent, placed over the moving film. In this case a variable width record is produced.

The process of reproducing variable density, or variable width film sound records, consists in throwing on the continuously moving film a narrow line of light which optically takes the place of the phonograph needle. The light line, which is perpendicular to the direction of motion of the film and perpendicular to the sound track, on passing through the film is caught by a photoelectric cell, the varying output of which is suitably amplified electrically by vacuum tubes and used to actuate the loud speakers. The applications of sound motion pictures even at present are diverse. Films have been orchestrated, *i.e.*, provided with a suitable orchestral accompaniment permanently available to any theatre having the necessary reproducing equipment. News reel features have had embodied in them the synchronized sound of speeches, street noises, aeroplane motors in action, and the like. The reproduction of plays with the speech of the actors recorded as well as their appearance is now being developed, so giving the illusion of an actual occurrence or of a theatre performance.

See Motion Picture: *Technology*. (A. N. G.)

SOUP, a liquid food consisting usually of stock (water in which meat or vegetables have been boiled) with or without other ingredients. Soups are also made without stock. As clear soups are largely water, they have little food value in themselves, but they act as appetizers. Cream soups, vegetable purées and chowders are higher in food value, and may be used as main dishes.

Stock.—In boiling meat for soup the meat is put into cold water in order to extract as much of the "goodness" as possible during the five or six hours of slow cooking, and it is usually cut small. The meat with which a good stock is made becomes a mass of fibrous, almost tasteless matter, which can be used only in some made dish to which seasonings are added. In some countries the meat is kept in one piece, so that it may be more usable as a main dish, but the stock in that case loses in richness.

Meat stocks are of two types, white and brown. For the first, the bones and meat of veal, chicken and turkey are used, often in combination. For brown stock the foundation is of beef and beef bones, one being a marrow bone tied in cheesecloth to prevent the escape of all the marrow. The usual combination stock is made of beef and veal. For white fish stock the heads and tails of fish are used, with no vegetables that will darken the mixture. Brown fish stock (court bouillon) is made with sliced fish, and vegetables that will make the liquid brown. The term vegetable stock is applied to the water in which vegetables have been boiled.

Brown stock is the traditional French *pot-au-feu.* To make, put a piece of beef, beef bones and if desired bones, legs and neck of a fowl into salted cold water. Bring slowly to boiling point. All scum must be removed from any stock the instant it appears. Reduce the liquid to the simmering point and add the vegetables—two onions stuck with a clove, two or three carrots, one turnip, one leek, one tomato, celery, pepper, salt and bayleaf. Simmer from five to six hours. For a clear soup the vegetables should cook no longer than two hours, and should be tied in bunches before adding. All stock is strained through cheesecloth or a sieve as soon as it is done. This is the clear soup or consommé with which many other soups can be made. If the stock needs clarifying, this is done by cooking with egg white and egg shells. A simpler way of making brown stock is to place the bones, two-thirds of the meat and the water in the stockpot to soak for one hour. The rest of the meat and one-third of the vegetables may be browned in a little fat. These are added to the pot, and the mixture simmered from three to five hours, the rest of the vegetables being added from one to two hours before the end of the cooking. For white stock the vegetables are onion and celery, with other white vegetables if desired, and the cooking time is an hour less than for brown stock. Fish stocks cook in one hour or a little more. Any stock may be used as the basis of other soups, the proper ingredients for the flavour wished being added.

Cream Soups.—These may have white stock, milk, cream or white sauce as the foundation. The last three are valuable ways of adding milk to the diet. A milk cream soup has 2½ cups milk to ¼ cup strained cooked vegetable. A cream soup with white sauce adds ¼ cup cooked strained vegetable or shellfish (bisque) to 3 cups thin white sauce. A cream soup with white stock adds 1½ cups strained cooked vegetable to 2 cups of the stock. Any of these proportions may be varied to suit individual taste.

Vegetable Soups.—These may have a stock foundation, may be cream soup, or may be made of vegetables, water and seasonings. Vegetable stock makes an excellent basis for a vegetable soup. A thick soup is called a purée, and those made of the legumes (usually dried) are of high food value. The combinations of vegetables possible are endless. Onion is an invariable ingredient, though this may be in the form of leeks or chives. The vegetables should be cut up and tossed for two minutes in butter. This preliminary frying adds richness and flavour. Boiling water is added and the liquid allowed to simmer for at least two hours.

Chowders.—These are hearty soups that might in some cases be called stews. Fish chowders are many, of which the most famous is the Bouillabaisse from Marseilles. Clam chowder is a favourite in the United States. Vegetable chowders are made of combinations of vegetables, sometimes with a single vegetable giving the predominating flavour, as in parsnip chowder or green corn (maize) chowder. Gumbos are thick soups made with okra.

The soups associated with certain nations are hearty ones, sufficient with bread and perhaps cheese to serve as a main dish. France has the *pot-au-feu* and the *petite marmite* (adding chicken to the *pot-au-feu*), Italy *minestrone,* Russia *borch,* Holland *erwtensoep,* Spain *puchero,* South-western France *garbure.*

SOUR-SOP, called also guanabana (botanical name *Anona muricata;* family Anonaceae), a small evergreen tree, about 20 ft. high, native to tropical America. It bears a large, dark-green bluntly conical or heart-shaped fruit, 6 to 8 in. long and 1 to 5 lb. in weight, covered with short fleshy spines. The white, juicy, slightly acid, aromatic pulp has a flavour of mango and pineapple, and makes excellent jelly and preserves. The sour-sop is cultivated in the West Indies, tropical South America, Mexico. India, Cochin China, parts of Polynesia and the west coast of Africa. With some frost protection, it can be grown along the Florida coast as far north as Palm Beach. It is propagated by growing seedlings and by shield-budding. (*See* Cherimoya; Custard Apple; Sweet-sop.)

SOUSA, JOHN PHILIP (1854–), American composer and bandmaster, was born at Washington (D.C.) on Nov. 6, 1854. His grandparents were Portuguese refugees. He was a pupil of John Esputa and G. F. Benkert for harmony and composition, beginning his musical education at six. At 19 he conducted for Milton Nobles; played in Offenbach's orchestra, Centennial Exhibition, Philadelphia, in 1876; and conducted *H.M.S. Pinafore* before Gilbert and Sullivan went to America, in 1879, for the New York production. In 1880, he became bandmaster of the U.S. Marine Corps band, which acquired a high reputation under his control. The title of the "march king" was bestowed upon him by an English brass band journal for his many marches. In 1892 he organized Sousa's Band, which won great renown. It visited Europe (1900, 1901 and 1903) and toured the world (1910–12). The golden jubilee of this veteran bandmaster and composer was celebrated in 1927. Belgian, English and French decorations were awarded him. His compositions include the comic operas, *The Smugglers, Désirée, Queen of Hearts, El Capitán, The Bride Elect, The Charlatan, Chris and the Wonderful Lamp, The Free Lance, The Glass Blowers* and *The American Maid;* many songs; 15 suites; more than 100 marches, of which the most popular were *The Washington Post, High School Cadets, Liberty Bell, Semper Fidelis* and *The Stars and Stripes Forever; The Chariot Race* (Ben Hur), a symphonic poem; and *The Last Crusade,* a short cantata for orchestra, organ and choir. He wrote *The Fifth String, Pipetown Sandy, Through the Year with Sousa, The Transit of Venus* and an autobiography.

SOUSA, LUIZ DE [Manoel de Sousa Coutinho] (1555–1632), Portuguese historian, was born at Santarem. After an extremely adventurous life he entered the Dominican monastery at

Bemfica in 1613, and took the name by which he is known as a writer, Frei Luiz de Sousa. In 1616, on the death of Frei Luiz Cacegas, another notable Dominican who had collected materials for a history of the order and for a life of the famous archbishop of Braga, D. Frei Bartholomew of the Martyrs, the task of writing these books was confided to Frei Luiz. The *Life of the Archbishop* appeared in 1619, and the first part of the *Chronicle of St. Dominic* in 1623, while the second and third parts appeared posthumously in 1662 and 1678; in addition he wrote, by order of the government, the *Annals of D. John III.*, which were published by Herculano in 1846. After a life of about nineteen years spent in religion, he died in 1632, leaving behind him a memory of strict observance and personal holiness. He was of noble family.

There are many editions of the *Life of the Archbishop*, and it appeared in French (Paris, 1663, 1679 and 1825), in Italian (Rome, 1727–28), in Spanish (Madrid, 1645 and 1727) and in English (London, 1890). The *Historia de S. Domingos* may be read in a modern edition (6 vols., Lisbon, 1866).

AUTHORITIES.—*Obras de D. Francisco Alexandre Lobo*, ii. 61–171; Innocencio da Silva, *Diccionario bibliographico portuguez*, v. 327, xvi. 72; Dr. Sousa Viterbo, *Manoel de Sousa Coutinho* (Lisbon, 1902).

SOUSLIK, terrestrial *Sciuridae* of medium size, with short flattened tails and cheek pouches, representing the genus *Citellus;* distributed widely over the Northern Hemisphere from Hungary eastward through Asia and North America to the United States. Formerly the Souslik inhabited Great Britain.

SOUSSE, a harbour town of Tunisia. Pop. about 21,000. It occupies the site of the ancient Hadrumetum, an important Phoenician city which served Hannibal as his base of operations at the end of the Second Punic War. Trajan made it a colony: the epithet *frugifera* (fruitful) which was given to it, alludes to the fertility of the surrounding country. At the end of the 3rd century A.D. it became the capital of the new province of Byzacena, and later it received the name of Justinianopolis. Fine mosaics are preserved and there are remains of the ancient harbour works and large Christian catacombs. The native town, surrounded by mediaeval walls, has a citadel (Kasba); the "souks" (covered streets with shops) are interesting. Phosphates are exported and there are oil mills.

SOUTH, ROBERT (1634–1716), English divine, born at Hackney, Middlesex, Sept. 1634, educated at Westminster school and Christ Church, Oxford. Before taking orders in 1658 he preached as a Calvinist against Socinianism and Arminianism, but after the Restoration his views changed. On Aug. 10, 1660, he was chosen public orator to the university; in 1661 he became domestic chaplain to Lord Clarendon; in March 1663 prebendary of Westminster, and in 1667 chaplain to the duke of York. A zealous advocate of the doctrine of passive obedience, he strongly opposed the Toleration Act. In 1667 he was appointed chaplain to Lawrence Hyde (afterwards earl of Rochester), ambassador-extraordinary to the king of Poland. In 1678 he was presented to the rectory of Islip, Oxfordshire. In 1693 South published *Animadversions on Dr. Sherlock's Book, entitled a Vindication of the Holy and Ever Blessed Trinity,* bitterly attacking the views of Wm. Sherlock. To Sherlock's answer, *A Defence* (1694), he replied with *Tritheism charged upon Dr. Sherlock's New Notion of the Trinity, and the Charge Made Good.* The controversy was finally stopped by the king. In 1710 South became a partisan of Sacheverell. In 1713 he declined the see of Rochester and the deanery of Westminster. He died on July 8, 1716, and was buried in Westminster Abbey.

His *Sermons* (6 vols., 1692) were reprinted many times; there is a modern edition in Bohn's classics (2 vols., 1845), and a complete edition of his *Works* (5 vols., 1842). *See* also W. C. Lake, *Classic Preachers of the English Church* (1st series, 1877).

SOUTH, THE, a large area of the United States which presents certain distinctive characteristics.

The south-eastern quarter of the country includes 6 of the original 13 States, Delaware, Maryland, Virginia, North Carolina, South Carolina and Georgia, and 11 States added since the formation of the Union, viz., Kentucky (1792), Tennessee (1796), Louisiana (1812), Mississippi (1817), Alabama (1819), Missouri (1821), Arkansas (1836), Florida (1845), Texas (1845), West Virginia (1863) and Oklahoma (1907). Delaware, Maryland, West Virginia, Kentucky and Missouri which lie next to the Northern States are often referred to as "border" States, and because of their location the differences which distinguish the South from the North are in them less defined. During the Civil War, for instance, the border States, although slave-holding States, did not secede from the Union. Delaware, since the Civil War, generally considers itself a Northern State, while Missouri has become definitely mid-western. Texas and Oklahoma also share many of the Western characteristics. Because they were settled by Southerners, however, and were slave States they are considered historically as part of the South.

Historical Development.—At the time of the first census in 1790 the populations of the two major divisions of the country then existing, the North and the South, were practically equal (1,967,197 and 1,962,428 respectively), and their influence in the control of the Federal Government was about evenly divided. In the decade 1790 to 1800 the population increase in the North (36·5%) was slightly more than in the South (33·7%). In each succeeding decade up to 1860 the growth of the North was greater, and that of the South less, than its increment in the initial decade until, in 1860, the numbers were 20,309,960 and 11,133,361 respectively. Because of its proportional loss in population, the South was forced to wage an increasingly desperate struggle to retain its former influence in the Federal Government, and thus to protect its peculiar interests, the chief of which was the institution of slavery. Slavery, which had in colonial times become rooted in Virginia and Maryland in connection with the raising of tobacco and along the Carolina coast in connection with the raising of cotton, spread rapidly after the introduction of the cotton gin about 1800. The gin made profitable the raising of a kind of cotton containing many seeds which grew in the upland Piedmont regions and in the interior, where the cotton with fewer seeds would not grow. Under this stimulus plantations grew rapidly in the fresher lands of the newer Gulf States to the west, while the tobacco industry also found fresh ground in Kentucky and Tennessee. Slavery also assisted agriculture.

Despite the difference in population the number of Slave States and free States remained equal until the admission of California as a free State in 1850, and because of this the South kept its influence in the Senate unshaken until that date. The decreasing power was evident long before, however, and the South was led to the adoption and development of the doctrine of State sovereignty to protect its interests. This doctrine was resorted to in 1832 to defend itself against a tariff imposed by Northern interests which the South believed to bear heavily upon itself, but the matter was smoothed over for the time being by a compromise tariff. Compromises upon the slavery question were also made in 1820 and in 1850, but neither was permanent, and by the very nature of the institution it seemed a permanent compromise was impossible. Finally, in defence of slavery, the Southern States carried their doctrine of State sovereignty to its ultimate conclusion and seceded from the Union, forming a union of their own, known as the Confederate States of America. After four years of bitter Civil War the South was left beaten and exhausted.

There followed a long period of both economic and spiritual depression in the South which was felt not only by the generation of adults then living, but by the next generation as well. The recovery might have been more rapid had President Lincoln's wise and humane plan of reconstruction been carried through, but Lincoln's assassination and his successor's unfortunate quarrel with the dominant Republican Congress proved a disaster for the South. By the Reconstruction Act of 1867 the seceded States, except Tennessee, were divided into five military districts, each under the command of a Northern army general. The defeated States were not to be readmitted into the Union until they had met a programme of requirements, which was not done by any of them until 1869 and 1870. In the meantime control of the governments in most of the States had been in the hands of ignorant negroes or newcomers from the North, generally stigmatized as "carpet baggers," and it was not until a decade after the close of the war that the Southern whites again gained control. Only then was economic habilitation able to go forward on a firm basis. It was a generation before education and allied cultural developments gathered momentum enough to again move forward.

Because they felt that the Republican Party had forced the Civil War and the reconstruction programme upon them the secession States after their readmission were solidly Democratic in their political sympathies until 1928. The border States, Delaware, Maryland, West Virginia and Kentucky, however, fell away from Democratic allegiance with the McKinley election of 1896, and Missouri followed in 1904. (X.)

INDUSTRIAL DEVELOPMENTS

The industrial history of the South falls into four periods: (1) healthy beginnings, manufactures mixed with agriculture, to the end of the War of 1812, when British manufactures coming into America put an end to industries already on the wane; (2) lapse of manufacturing to the end of reconstruction, or, say, 1880, due to absorption in cultivation of staple crops with slave labour; (3) industrial revival with recovery from war, passing of political vexations and re-emergence of free white labour, reaching to the outbreak of the World War; (4) expansion and diversification of industry, marked by southward migration of capital.

The South in 1925 had about 33,500,000 population, or approximately 28% of that of the country, and the total value of its manufactured products was $7,755,195,000, or approximately 12%. Per caput production of manufactures in the South (measured by value of product) was in 1925 about $231, or less than half of that for the United States as a whole. However, the percentage value of Southern manufactured products has constantly mounted (with the exception of a slight recession between 1920 and 1923) from 6·2% in 1880 to 12·37% in 1925.

Between 1910 and 1920 the proportion of all Southerners gainfully employed in manufacturing and mechanical industries rose from 14·7% to 18·2%. In the United States as a whole, the figures for the same years were 27·8 and 30·8%. Thus the South has rather more than half as many of its wage-earners in industry as the whole country. Of the aggregate value of industrial products in the South in 1925, cotton manufacture was responsible for 10·5%. General manufactures, however, have made greater progress than cotton goods in the past few years. Hydro-electric power ushers in a period of more wide-spread and varied industry. The South in 1925 had 5,696,809 primary horse-power, which was 15·93% of that for the country. Of this total, electric motors driven by purchased current had 2,212,805 h.p., being 13·94% of the purchased electric current of the country. That is, about 31% of the total horse-power in the South is rented current, as opposed to about 50% in the entire country—a good showing for a district in which manufacturing is comparatively recent. The power companies, steam and hydro, which are springing up throughout the South, are duplicating campaigns of the railroads with the purpose of drawing new industries to the region. Southern society is beginning to coagulate, as it were; in 1900 about 14% of the population of the section was urban; in 1929 more than 25% live in cities.

Textiles.—Cotton manufacturing is the South's predominant industry. The cotton mills convert the South's characteristic raw material, and employ roughly one-third of all industrial workers. This is one of the few manufactures, capable of being conducted elsewhere, in which the South has assumed leading place. In 1926 the South's 814 cotton mills contained 48% of the spindles in the United States, but of more significance is the fact that the South's 17,612,000 active spindles were nearly 57% of the country's total. The South had almost half of America's looms. The cotton-growing States in 1925 turned out cotton goods worth $929,107,255 or 53% of the country's total, using, for the year ending July 31, 1926, 4,796,000 bales of cotton, or two-thirds of the total American consumption of American cotton. North Carolina, both in number of wage-earners (84,183 in 1925) and value of products ($316,324,008) was the leading Southern State in cotton manufacture, with South Carolina, Georgia and Alabama next in order. The cotton mills in the South prior to 1880 were generally small, scattered, inefficient and made a coarse product, mostly yarns. At that time the South had recovered in a measure from the Civil War, sectional bitterness was allayed, and the abolition of slavery brought the "poor whites" to public notice as a labour asset. Manufacture of the everywhere-present cotton seemed the obvious recourse. Towns vied with each other in a boom of mill building, 78 new plants appearing by 1890 and 162 more by 1900. In these two decades active spindles in the South increased from 561,000 to 4,368,000. Local communities sought capital with which to put up the buildings, and leaders in the ventures went North to secure working funds and equipment. Ordinarily commission firms taking stock were given the selling account of the mill, and machinery makers, who were glad of orders after the long depression, accepted shares in payment. Where water-power was not available, steam was eagerly turned to. These mills were extraordinarily successful, regularly making profits up to 50% of the invested capital. Cotton was bought locally at a saving, and was in the best condition, coming frequently directly from the gin without baling. Wages were much less than in the North, hours were longer, the proportion of women workers was large and child labour was universal. There was no complaint against these conditions. What the poor whites wanted was security, and they found this in the mill villages. Cotton mills employ whites. They come from all regions; at first, principally from Piedmont and the mountains. A very few negroes are employed separately.

Costs of cotton manufacturing in the South are lower than in the North. Probably the most careful estimate is that of Charles T. Main and Frank M. Gunby, of the American Society of Mechanical Engineers, published in Oct. 1926. Their conclusion was that a Southern mill running 55 hours a week had a cost 16·8% less than a Massachusetts mill operating 48 hours a week, taking no account of the expenses connected with maintenance of a mill village. This is equivalent to a saving to the Southern manufacturer of $6.73 per spindle per year, of which saving lower labour costs were responsible for $4.53. If the cost of mill villages North and South is included, there is still a differential in favour of the South of 14%, or $5.60 per spindle per year.

In 1925 the average earnings of the cotton mill operative in the ten leading Southern States were $632.95, or a weekly wage of $12.17. If we take only the four leading Southern States—North and South Carolina, Georgia and Alabama—the average wage for 1925 becomes less, $625.53 for the year, or $12.02 per week. The average annual earnings in the four leading New England States—Massachusetts, Connecticut, Rhode Island and New Hampshire—were $969.45, or 55% higher than the same item for the four leading Southern States.

There is a high labour turnover in Southern cotton mills, estimates two decades ago running as high as 30% of the proportion of "floaters" in the working population, though it is by some manufacturers believed now to be as low as 10%. Companies seek to anchor their help through welfare provisions, but the family's belongings do not make more than a wagon load, and moving on to the next mill town is one of the few ways in which the workers can declare their independence. The value added by manufacture is greater in the Northern mills than in the Southern. Wages formed a higher percentage of the value added by manufacture in Northern States than in Southern, the greatest spread being between 76% for Maine and 42% for Virginia and Alabama (figures for 1923). All of the Southern States were below the national average of wages, and all of the Northern were equal to or above it.

All of the principal Southern States have (1929) laws forbidding the work of children below the age of 14 in cotton mills, but above this age they may work as long as adults, with the exception of North Carolina, where a child of 14 without a fourth-grade schooling may not work more than eight hours. Between 1870 and 1900, while other sections of the country decreased their percentages of child workers by a half to two-thirds, in the South the percentage of children to all wage-earners increased from 23 to 25. Northern and Western cotton mills now have about the same proportion of children employed as Southern mills, though the hours of the latter are longer.

The low wages of Southern operatives have been the principal cause of the working of all available members of the family group. Income to the family is further supplemented by the free or very cheap services which employers render. The typical Southern mill is surrounded by a village owned and administered by the company. It has been estimated that 25% of the capital of the Southern cotton manufacturer is invested in the village—in operatives' houses, stores, streets, schools and welfare and recreational facilities. The average Southern operative pays for his house only 25 cents per room per week, in exceptional cases the rent is 75 cents per room per week for excellent cottages, and sometimes the employer furnishes houses entirely free of rent.

Beginning about 1923, there has been a conspicuous drift of the American cotton manufacturing industry to the Southern States. An unofficial estimate is that since then more than $100,000,000 has been invested in the building of new mills in the South or the purchase of existing Southern plants, mostly by New England interests. Still, the capital in Southern cotton mills is probably more than 80% owned in the South. Between 1924 and 1925, the South passed New England in the number of active spindles, and this lead has greatly increased since. From July 31, 1922 to July 31, 1926 the South gained 1,668,000 active spindles, while New England showed a loss of 2,413,000 and the rest of the country a loss of 213,000. Of spindles in place, in the same period, the South gained 1,800,000, while New England lost 910,000, and other States lost 249,000; to take the extremes, North Carolina gained 782,000 spindles while Massachusetts lost 506,000. Every one of the six Southern States listed by the census in this connection gained spindleage, while every one of the New England and middle States lost. Comparing the average amount of cotton consumed, 1921–25 and 1925–26, the South gained 689,000 bales, while New England lost 104,000 bales and the rest of the country gained 2,000 bales. Between 1923 and 1926 the South gained 7,919,000,000 spindle hours, as against a gain of 1,439,000,000 for New England and 223,000,000 for the rest of the country. Between 1923 and 1925, the value of all cotton manufactures of the United States decreased (those of the South only a third as much as those of New England), but between 1921 and 1925 the products of Southern mills increased in value 65·4%, while those of New England increased 5·7% and those of the entire country 34·1%.

Southern textiles have been of a coarse nature, and this is still true in the main, but a steady progress in quality and variety of output has characterized the years since 1915. The South manufactures cotton goods falling in all of the 28 more general classifications of the 1925 census, and it is notable that in all but three instances—bunting and bandage cloths, table damask and tyre fabrics other than duck—the South either led New England in the per cent of increase, or suffered a less decrease than New England. Of 31 more particular classes of goods, the South contributes to 21 and is represented by individual plants in others.

The manufacture of knit goods, chiefly from unmercerized cotton yarns, but also from silk and rayon, has had a striking growth in the South, adding an important branch of the textile industry. The total value of products for 1925 was $123,352,791, a gain of $14,613,442 over 1923. In 1923 Tennessee was the leading Southern State in knit goods, and in 1925 this industry still ranked first in the State in number of wage-earners (14,986) and value of product ($44,006,467), but by the latter year North Carolina had passed it in value of product—111 plants turning out goods, chiefly hosiery, worth $44,300,819. Half of the production of Tennessee is hosiery, and one-fourth knit underwear. While there are 241 knit goods plants in eight Southern States, the chief centres are Durham and Winston-Salem, N.C., and Knoxville and Chattanooga, Tenn. Georgia ranks third in the industry in the South, with products worth $17,020,011. Negro operatives are used in part in this industry, particularly in North Carolina, on coarser grades of output. Wages in the knit goods industry, as in cotton manufacturing proper, are conspicuously lower in the South. Southern knitting mills are turning to the national market with their finer and more specialized products. While the industry in the South has grown remarkably, it does not as yet threaten the older centres such as New York and Pennsylvania.

Except for scattered plants, the South until recently had no means of dyeing, bleaching and finishing its textiles within the section, but was wholly tributary to New England in this important department. Finishing plants were being established rapidly in the South, there being 23 in 1923 and well over 40 in 1928, North Carolina having the largest number. The new rayon industry is adding another branch to Southern textiles. In the two years ending in 1928 more than $25,000,000 has been invested in rayon manufacture in the South, mainly in central and eastern Tennessee, and Virginia and West Virginia.

Tobacco.—Tobacco manufacture, in one form and another, is as old as the South. Before the Civil War a crude manufacture was carried on in the homes of the farmers, and factories were scattered through the rural districts and small towns, as well as in the cities. The Civil War brought the first movement toward concentration by destroying many of the weaker factories. While it reduced the number in the cities (in Richmond from 50 to 38, in Lynchburg from 35 to 16, for example) it also worked a compensation by popularizing smoking in addition to the older habit of chewing. The soldiers used tobacco universally, and the Northern armies acquired a liking for the Southern tobacco.

Early in the '70s, though checked by the panic of 1873, production mounted. The heavy taxes on manufactured tobacco, which affected Southern manufacturers immediately the war was over, favoured the factory owner who had a little more capital than his competitors and was a little more cunning in evasion. Thus concentration in the industry was further encouraged. Then came the cigarette machines. Cigarettes were not much smoked in the United States until about 1880, and then were made by hand. The cigarette machines led on to formation by a young Southerner, James B. Duke, of the American Tobacco Company, the "Tobacco Trust," in 1890. Duke, after a promising success with his father and brother at Durham, during which time he invented the sliding cardboard cigarette package, had established a branch cigarette factory in New York city. For six years he set the pace in the "tobacco war" between rival large manufacturers, in which millions were poured out for advertising competing brands. Finally, five firms were forced into a combination. The combination, of which Duke was president, paid high dividends, and branched out into the manufacture of plug tobacco and all-tobacco cigarettes. The older plug tobacco factories in the South had employed a large proportion of negro men, with negro women working as stemmers. The cigarette factories, where the work was light, though confining, tedious and unhealthy, brought a shift to white operatives. The tobacco factories exploited the poor whites of the South, especially women and children. In 1905 in Virginia, North Carolina and Kentucky, the average annual wage of men was $272, of women $183 and of children $119. In the North wages ranged at least 25% higher. Though the proportion of children in the industry the country over fell from 21 to 9% between 1880 and 1905, North Carolina, which remained the worst offender, had almost 20% children in the latter year.

The tobacco industry in the South is given more largely to machine production than that of the country generally. The manufacture of cigars in Florida, mostly by hand, is the outstanding exception, this State in 1926 paying a larger internal revenue tax on cigars ($4,089,643) than any States except Pennsylvania and New York. This industry is far more localized than textiles, the chief Southern States being North Carolina, Virginia and Kentucky, in order. Winston-Salem is the largest tobacco manufacturing centre, and Reidsville, Durham and Statesville, N.C., are the other chief points in that State. The extent to which the North Carolina industry is mechanized, is indicated in the fact that while it employs a little over one-third more workers than Florida, the value of its products is eight times as great. North Carolina in 1925 produced almost 35 thousand million more cigarettes than New York, its closest rival in this branch. While machine tobacco workers in the South are still poorly paid, it is probable that they have more to spend, on the whole, than textile operatives.

Iron.—The national importance of this industry in the South dates from the founding of Birmingham, Ala., in 1870. Birmingham has coal, iron ore and fluxes almost within a stone's throw of each other. The main coal fields are the Warrior, to the west of

Birmingham valley, producing about 85% of the coal output of the State; the Cahaba on the east, producing 12%, and more to the east the Coosa field, producing about 4%. Between the Warrior and Cahaba coal fields, on the ridges just above the geologic horizon, lie the hematite or red ore, and limonite or brown ore; for fluxing, the bed of the valley contains great areas of limestone and dolomite. The red ore is the main reliance of the district, being mined chiefly from the Red mountain outcrop between Birmingham and Bessemer. Grey hematite of Talladega county may be important in the future. The red hematite is of two varieties, popularly termed soft and hard. The soft ore is that reaching down from a few feet to 400 ft. below the outcrop, in which the action of water has leached out the lime carbonate, thus increasing proportionately the content of iron oxide and other constituents. Limited in extent, easily mined and rich in iron, the soft ores were worked out first, and are no longer important. The hard ore of the Birmingham district ranges from 32 to 45% metallic iron, with varying percentages of lime, silica, alumina, magnesia, sulphur and phosphorus. The phosphorus content runs from 0·25 to 1·5%, thus rendering the ore unfit for the Bessemer process of steel-making. The Birmingham district must now reach its hard ore by vertical shafts 1,000 to 2,000 ft. deep, or by slopes three or four times the length, but there is the compensation that these deeper-lying ores may contain enough lime to be self-fluxing.

Alabama has coal reserves of about 66 thousand million short tons. Half a million tons were mined in 1880, the industry really getting under way only after the opening of the Birmingham iron district. Iron making at Birmingham, despite the presence of coal, began with charcoal as fuel. The Tennessee industry was wholly of this nature. Coke was first made in Alabama in 1854, and the next year, near Ragland, was applied to foundry use, but the iron and coke industries in this State did not receive their impetus until in 1876 coke of the native coal, made in bee-hive ovens at the Oxmoor furnace in Jefferson county, was used to produce pig iron. From 1,262 tons of pig iron made with coke in this year, the production has grown to upwards of three million tons in 1925. The first steel was poured in Alabama in 1888, but up to 1897 the total tonnage of basic open-hearth steel made at North Birmingham did not exceed 3,500 tons. Prior to 1890 Birmingham iron masters exported much of their product. This did well enough until the great Mesabi range in the Lake Superior region was opened. Bessemer pig iron at Pittsburgh fell off sharply in price, due to the cheap new ore—from $23.60 in Jan. 1890, to $13.60 in Jan. 1893. In the years of lowest prices, 1897–98, Mesabi non-Bessemer ore, after paying all costs of mining and shipping, was selling at Lake Erie ports at $1.70 to $1.80 per ton, and Bessemer ore at $2.10 to $2.15. This revolution in the industry was almost disastrous to the Birmingham district, its merchant mills having to pay heavy freights to the markets. The demand was for Bessemer steel, and iron too high in phosphorus content for this process, such as that smelted from ores of the Birmingham district, was in the discard. The panic in 1893 and the depression that followed added a critical strain; capital was lacking in the South, and one reorganization followed another in the Birmingham companies.

The only salvation was to convert Southern pig iron into steel. Deliverance came from two quarters at once. In 1897 the pig iron industry the country over revived a little, in 1898 the output was up 22%, and another 16% increase by 1899 found resources taxed, and the price rose abruptly. Birmingham foundry iron delivered at Cincinnati sold for $9.33 a ton in 1897, was up 13 cents the next year, and by 1899 averaged $16.58, a gain of $7. By 1902 the price was $20. Just when this grateful rise in the price of pig was occurring, open hearth steel began to be made in the Birmingham district on a large scale. In Nov. 1899, a specially organized subsidiary of the Tennessee Coal, Iron and Railroad Company poured its first steel from ten 50-ton tilting furnaces which had an annual ingot capacity of 300,000 tons. It was established now that Birmingham, turning its basic pig iron into steel by the open-hearth method, could successfully compete in the steel markets; its unusual advantages, once the domination of Bessemer steel was removed, came rapidly into play. The years that followed were marked by the rise of new companies and the consolidation of old ones. The culmination came in 1907. A new and progressive syndicate controlling the Tennessee Coal, Iron and Railroad Company had embarked on the most extensive scheme of steel and iron development the South had known, embracing the construction of a large duplex process steel plant at Ensley, 7 m. W. of Birmingham. By the late fall of 1907, the company had outstanding loans of some $33,000,000, and as a result of the panic of that year the Tennessee Company was bought by the United States Steel Corporation, Nov. 5, for $35,317,632.64.

Twenty-five years ago 70% of the raw foundry iron made in the South was shipped to the North and West, and only 30% was retained for Southern markets. In 1928 less than 20% was shipped out, more than 80% being worked up at home (86% of that of the Birmingham district). The first iron-using plants erected in the South on a large scale were those making water and gas pipe. Soil-pipe plants were soon established. Of the pig iron produced in the South, 50% is consumed by more than 600 grey iron foundries in the section, by far the largest number of which make stoves, radiators, agricultural implements, car wheels and machinery. The smaller number of these foundries, however, the pipe shops, use almost twice as much pig iron as the rest. Thus the iron industry of the South, like the textile manufacture, is no longer confined to crude production, but embraces finer fabrication. Birmingham, in the great variety of its products, is an excellent example.

Cotton-seed Oil.—The cotton-seed oil industry has had a spectacular history. For many years cotton-seed, though known to have value as a fertilizer if spread on the land, was almost entirely wasted. The great heaps of seed which accumulated about the gins constituted a nuisance, having an offensive odour when rotting. Small quantities of oil were expressed from cotton-seed in the South early in the 19th century, but these operations were mostly experimental, and the industry did not begin on a commercial basis until shortly before the Civil War. After the war the manufacture was revived, and was firmly rooted by 1880. In that year about 5% of the seed produced was crushed, whereas in 1926, 80% was crushed, and it is estimated that the industry now produces wealth to the extent of $500,000,000. There has been more combination in the cotton-seed oil industry than in the textile industry, and it has a higher proportion of outside capital (of packers and soap manufacturers, for example), but deflation of the business since the over-expansion just before and during the World War has opened new opportunity for local enterprise. In 1914 there were 882 mills in operation, but since 1922 the number has been less than 600 (570 in 1926).

Though the number of mills has decreased since 1922, the volume of products has, with trifling exceptions, increased. In 1926, 6,305,775 tons of seed were crushed, producing 251,721,354 gal. of oil and 2,840,084 tons of cake and meal; there were 1,854,389 tons of hulls and 1,041,864 bales of linters. In 1925 the average number of wage-earners was 16,215, a large proportion negroes. Products in 1925 were worth $295,685,000, an increase of $69,297,000 over 1923. Texas has three times as many oil mills as any other State.

Furniture.—A new industry in the South is furniture manufacturing. The first plant was built at High Point, N.C., in 1888; by 1900 this State had six small factories with $125,000 capital and products worth $159,000. The Southern States had 312 furniture factories in 1921, 346 in 1923 and 371 in 1925. The leading States are North Carolina, with 13,567 wage-earners in 1925 and products valued at $51,208,238; Virginia, 4,376 wage-earners and products valued at $18,792,297; Tennessee, 2,915 wage-earners and products valued at $9,532,520; Georgia, 2,457 wage-earners and products valued at $7,969,154. The South-eastern States and Virginia produced furniture in 1921 valued at $41,039,000, and in 1925 the product amounted to $89,339,000. All of the States shared in this remarkable increase, but North Carolina in 1925 had three times as many furniture factories (127) as Tennessee, its closest competitor in the South.

High Point is the parent and chief centre. In 1921 the Southern Furniture Exposition building was erected here. This has helped develop a Southern market in rivalry to those at Grand Rapids, Mich., and Jamestown, N.Y. The North Carolina Piedmont at the inception of the industry had an ample supply of cheap labour, cheap hardwoods near at hand and excellent railway facilities. The furniture manufactured, most of it for Southern consumption, was durable but of inexpensive grades. As the labour became more skilled and the cost of raw material increased better grades of product were turned to. Good furniture, comparing favourably with that made in the North, now comprises the bulk of the North Carolina output. The increase in real wages since the World War, and the spread of instalment buying, have been powerful factors in the prosperity and improved character of the furniture industry in the South as elsewhere. Many Southern factories enjoy a national distribution of their product, and make goods for foreign shipment as well.

The Southern Appalachian hardwoods are being rapidly exhausted—the last virgin growth has been entered. While Southern factories get their oak chiefly from North Carolina and eastern Tennessee, and their yellow poplar (used for cores for veneers) from the swamps of the eastern Carolinas, hauls of 500 to 800 m. in the supply of lumber are not uncommon. In 1909 only 5% of the raw material used in North Carolina came from other States, while in 1919 the amount brought in was 31%. Black walnut and mahogany veneers, coming from the Middle West, are increasingly used. Raw materials are now hardly cheaper in the Southern Piedmont than elsewhere, though labour, which is the largest single item in the cost of furniture manufacture, is paid less than in the North. It is believed that within little more than a decade the lower Mississippi valley will be drawn upon heavily not only by the Southern furniture industry, but that of the whole country. Already methods of economizing on the use of hardwood are used in the South—veneers are more and more employed, and steel and glass are being introduced. Waste is being reduced and by-products are being developed.

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CULTURAL DEVELOPMENTS

It took the South a very long time to recover from the Civil War and the reconstruction governments. Worse even than the obvious economic and social effects were the effects on education and on the state of public opinion; provincialism, sensitiveness to criticism from without or within, solidarity of thinking not only about politics but about all other major subjects, a temperamental conservatism that resisted the tendencies of modern life and thought—all these qualities of mind that had become manifest even in the *ante-bellum* period were now accentuated. Slowly and surely a more liberal and national point of view, aided by industrial progress and the gradual development of an educational system, has made its way.

Despite certain sporadic attempts in some of the States before the Civil War to provide a public school system, it remained for leaders like Atticus G. Haygood, J. L. M. Curry, Charles D. McIver, Edwin A. Alderman, and others in the '80s and '90s to lead a crusade for universal education, as the only genuine basis for a democracy. Thomas Jefferson's advocacy of a complete system of public education had borne but little fruit in the section that had accepted him as a political leader, but his ideas were now accepted as the gospel of political leaders like Charles B. Aycock of North Carolina. Men came to see that the controversy over slavery and secession and the fatal results that had followed had deflected the South from its true course as defined by leaders who played such conspicuous parts in the early days of the republic. Walter Hines Page was one of the first to realize this unfulfilled career of the South and to lay down the programme for the rebuilding of old commonwealths; he and his co-workers in the Southern Education Board and Conference were willing to face the facts of illiteracy and its effect on the poverty, health and efficiency of the masses. They drew contrasts between Western and Southern States not at all favourable to the latter; they found inspiration in the work of Horace Mann in Massachusetts; they fought for the idea that taxation for education was the wisest economy and that the wealth of a State had in trust the social welfare of every human being.

These pioneers were followed by men in every State who have worked out in detail a comprehensive plan of education. State departments of education have increased from one man, generally a politician, to a body of a dozen or more experts in their respective fields. Teachers' colleges and departments of education in universities have been established that bring teacher training within reach of the most backward rural sections. School terms have been increased from four months or less to eight months or more; four-year high schools have been increased from 100 in 1900 to 2,500 in 1924, and the students in these schools from 165,000 in 1913 to more than half a million in 1926. Meanwhile, schools have been consolidated, buildings improved, salaries of teachers raised. Even negro schools, hitherto supported by outside philanthropy, have received an increasing, though still inadequate, proportion of public funds. In North Carolina especially, the State department of education, so progressive in its policies, has handled the whole problem of negro education with wisdom and generosity. The emphasis on agricultural and industrial training in the Rosenwald schools and at Hampton and Tuskegee extends to the white schools and colleges.

In the field of higher education progress had gone on apace. In 1895 there were only seven institutions that could meet the minimum requirements of admission laid down by the newly organized Southern Association of Colleges; in 1928 there were more than a hundred that met still higher requirements. The various religious denominations, retiring gradually from the field of secondary education, have enlarged their funds for colleges and universities. Independent institutions like Vanderbilt, Tulane and Washington and Lee have received large funds from private sources and educational boards. Several State universities have received appropriations for maintenance and building that would have seemed miraculous 20 years earlier. Duke university, by reason of the benefactions of J. B. Duke, was in 1929 engaged in a building programme and in the reorganization of the institution that will make it in time one of the outstanding universities of America. The university of North Carolina is a striking illustration of the growth of a State university. Within 20 years its income grew from less than $100,000 to more than a million, while its building programme has included, among other buildings, a $500,000 chemistry building and a $600,000 library. Its faculty included a score or more of men with national reputations by reason of research they have done. What is true of this university is true, to a less degree, of other universities. The Medical school of Vanderbilt university, the Law school of the University of Virginia, the department of education in the Peabody college for teachers, the department of agriculture of the University of Tennessee, the engineering school of the Georgia School of Technology, compare with the best in America.

The *Sewanee Review,* maintained at the University of the South since 1892, the *South Atlantic Quarterly* established at Trinity college (Duke university) in 1902, the *Journal of Social Forces* at the University of North Carolina, the *Virginia Quarterly Review* at the University of Virginia, the *Southwest Review* at Southern Methodist university, have been organs of liberal thought. Such books as Edgar Gardner Murphy's *The Present South* and Walter H. Page's *The Rebuilding of Old Commonwealths* defined in clear, forceful and courageous words the issues dominant in Southern thought while an increasing number of biographies and histories have given evidence of a scientific and critical handling in striking contrast with the more sentimental books of an earlier period. A growing liberalism is manifest in some of the best newspapers.

Likewise there has been a notable change in the character and quality of creative literature. From 1875 through the '90s, Joel Chandler Harris, George W. Cable, Charles Egbert Craddock (Miss Murfree), Thomas Nelson Page, John Fox and Mary Johnston made full use of the picturesque types, romantic stories and atmosphere of the various parts of the South. The Southern colonel and his lady, the old-time negro, the creole, the mountaineer and the plantation legend were in line with the main tendency in American literature of the period. More recently there has been a marked tendency towards a critical handling of Southern material, even to the point of realism and naturalism. Dubose Heyward's *Angel* and *Porgy,* Julia Peterkin's *Black April,* Paul Green's *In Abraham's Bosom,* Stribling's *Birthright* and *Teeftallow,* Elizabeth Roberts' *Time of Man,* compare favourably with the best contemporary fiction and drama in literary technique and in objectivity of treatment. Especially noteworthy is "the revolt against chivalry in chivalry's old home" as seen in the novels of Frances Newman and Isa Glenn. Better balanced work is found in the stories of Corra Harris and Ellen Glasgow, the latter best representing in a series of novels the transition from the old South to the new. The contrast between the fiction of the two periods is similar to the contrast between the poetry of Henry Timrod and Sidney Lanier and that of John Crowe Ransom, Donald Davidson, Dubose Heyward and other members of poetry societies that have sprung up in Southern cities.

In these and other ways the stubborn individualism of the Southern people is being replaced by co-operative efforts for the good of communities and States. Municipal and State programmes of health and education are being projected. There is still a long way to go. One of the chief hindrances to development in the South is a too facile optimism with regard to actual achievement. There is too much of an insistence on poverty as a justification for delay, too much harking back to a golden age that never was, too much of a tendency to adopt local standards.

The fundamental question is whether the industrial and educational progress now so well under way will result in the loss of regional consciousness and traditions to such an extent that the South will become standardized along with the rest of the country. Will industrial development destroy something that is fine and unique in the Southern temperament and tradition? By reason of its backwardness, due to obvious historical reasons, the South may be able to avoid some of the extremes of modern life and thus make distinct contributions to the nation and to the world.

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SOUTH AFRICA, UNION OF. South Africa, geographically, is held to be that part of the Continent south of the middle course of the Zambezi, but for convenience the term is usually considered to be identical with the expression Union of South Africa. The total area is 473,089 sq.m. The Union is divided into four provinces, which consist of the Cape Province, or Cape Colony, covering 276,966 sq.m.; Natal (including Zululand), 35,284 sq.m.; the Orange Free State, 50,389 sq.m.; and the Transvaal, 110,450 sq. miles. Along its northern borders lie Portuguese East Africa, Rhodesia, Bechuanaland and South-West Africa, the latter being mandated territory of the Union. Basutoland, 11,716 sq.m., which is entirely surrounded by the Union, and Swaziland, lying between Natal, the Transvaal and Portuguese East Africa, are not included in the Union. The shores are washed by the Atlantic, and the Indian oceans, the conventional division between the two being the line of longitude, 20° E.

STRUCTURE

South Africa as a whole is an elevated region, over 40% of its area being more than 4,000 ft. above sea-level. The area below 1,500 ft. is practically confined to a coastal strip and to part of the Limpopo valley. The whole region is part of a remarkably stable land block, which has known no serious encroachment of the sea since Devonian times, with the exception of some transgression in the Cretaceous Period in the south, and along the coasts of Natal and Zululand. Since the Triassic Period it has probably been exposed to sub-aerial conditions. In Cretaceous and post-Cretaceous times it appears to have been greatly uplifted. The gradients of most of the rivers are steep between the great escarpment and the coast, and marine deposits, believed to be of Miocene and Pliocene Age, are known to occur up to 1,300 feet above the present sea-level. In consequence, perhaps, of this movement the coast line is remarkably uniform, and there is a striking absence of good natural harbours. A subsequent, but smaller, depression of the land led to the submergence of the coastward ends of the valleys, and produced a series of estuaries, such as those of the Umkomaas, Umzimkulu, Keurbooms and Knysna. The value of these estuaries for shipping has been almost destroyed by the silting action of the rivers, and by the formation of barriers of deposition across their mouths. The smaller ones have in many cases been converted in flat areas of alluvium or marsh.

On broad, topographical lines the country can be divided into an interior plateau, which includes much of the elevated country, and which is bounded by the great escarpment, and the region between the escarpment and the sea.

Much of the interior plateau is formed of Karroo rocks, which are horizontal, or gently inclined. This portion consists of great, undulating plains, broken by flat-topped, steep-sided hills, which are due to the resistance of certain beds of sandstone or sills of dolerite. Good examples of such hills may be seen in the Platberg, near Harrismith, and in numerous hills along the Basutoland border. In the regions to the west and north-west, older rocks outcrop to form more irregular hills, *e.g.,* Magaliesberg, and many small ranges in Griqualand West and Namaqualand. The dolomites of the Transvaal system occur over a considerable extent of country about Pretoria, Rustenberg, Marico and Lichtenburg. They are an important water-bearing series, and here may be found numbers of springs, and the sources of rivers. Between the Asbestos-Kuruman hills and the Campbell Rand escarpment, on the western side of the Dry Harts valley, is a limestone area, forming part of the Kaap Plateau, an area of underground drainage. The highest points in South Africa generally occur about the margins of the interior plateau.

For about 1,400 m. the Great Escarpment can be traced through the Union, bounding the interior plateau, and running more or less parallel with the coast. Different sections are known by various names, such as the Drakenberg in the Transvaal, the Drakenberg or Kahlamba in Natal, and the Transkei and the Stormberg in the north-east of the Cape province, and then, proceeding westward, as the Sneeuwberg, Nieuweveld, Roggeveld, Bokkeveld and Kamiesberg. Under less well known names it can be traced along the western side of South Africa to beyond the Kunene. For about 1,200 miles its structure is well known, and it can be shown, that it is a feature due to denudation. The degree of boldness of the escarpment is related to the resistance of the rocks which take part in its formation. In the northern and southern portions of the Transvaal section the scarp has been eroded in granite, but in the central part of this section Black Reef Quartzites and dolomites come in, and the height and boldness of the Drakenberg increase with the thickness of these beds. The peak of Iron Crown, near Haenertsburg, reaches 6,964 ft., and Mount Anderson, east of Lydenburg, 7,484 feet. Toward Natal stratified Karroo rocks enter into the escarpment, higher and higher beds appearing as it is followed toward the south. The escarpment attains its greatest development between Basutoland and Natal, where it is formed entirely of Upper Karroo beds. The upper part of the Kahlamba consists of about 4,000 ft. of lavas, underlain by the Cave Sandstone and other beds of the Stormberg series. Several peaks exceed 10,000 ft., as, for example, Giants' Castle, Mont aux Sources, Cathkin Peak, etc. The Kahlamba does not rise in a simple wall. Many ridges reach out from it towards the east, and bear witness of its former more easterly situation. In this section is to be found some of the finest mountain scenery in South Africa. It is a region of deep, picturesque valleys, which lead up at their heads to great walls of rock, whose tops are weathered and riven into pinnacles and turrets, like some cyclopean castellation. The lavas persist for about 280 m., and then disappear from the face of the escarpment in the Stormberg, and are replaced towards the west by successively lower and lower beds, until, in the Van Rhynsdorp district, Nama, and even older, rocks enter into its composition. The height diminishes after the volcanics have gone. From the Sneeuwberg to the Roggeveld the altitude is generally less than 3,500 feet.

Between the escarpment and the coast lie the Great Karroo and the zone of fold mountains to the south, the south-eastern area to the south-east and the low country in the north-east about the Limpopo river and to the west of the Lebombo range. For descriptions of the geological formation of the country *see* the articles on Cape Colony, Natal and Orange Free State.

CLIMATE

Owing to its situation in the southern hemisphere, its elevation and its comparatively narrow shape, South Africa is cooler than most places in the northern hemisphere, which are the same distance from the equator. The mean annual temperature is remarkably uniform everywhere, because the country, to a large extent, increases in altitude as it decreases in latitude. At the meteorological station at Cape Agulhas, 50 ft. above sea-level, and situated 34° 50′ S., the mean annual temperature is 61·5°; at Johannesburg, 5,750 ft. and 26° 11′ S., it is 60·6. The highest mean annual temperature is 73°, recorded at Komatipoort, 460 ft. above the sea, and situated on the borders between the Transvaal and Portuguese East Africa: the lowest is 54·7° for a station on Table Mountain (Cape Town), 2,496 ft. The area with a mean annual temperature of 71° is confined to a coastal strip of northern Natal and Zululand, and to the low veld of the northern and eastern Transvaal. Ocean currents affect the temperature of the coastal districts. Along the west coast flows the cold Benguela current, and Port Nolloth, 29° 16′ S., has a mean annual temperature of 57·5°. The effect of the warm Mozambique current along the east coast is to be seen in the mean annual temperature of 70·8° for Durban, 29° 57′ S.

Mean temperatures, however, are liable to mask important differences, which exist in the climates of South Africa. Both the annual and diurnal temperature ranges increase with distance from the sea, with altitude, situation and with dryness of the atmosphere. The differences between the mean temperature of the hottest and coolest months is 12° at Durban, 15·8° at Pietermaritzburg, and 25·6° at Kimberley, which is 340 m. from the coast, and over 4,000 ft. above sea-level. A range of 25° shows the effect of local situation at Weenen, which is only 80 m. from the sea, and 2,840 ft. in altitude, but which is situated in a large, saucer-shaped hollow. Places in the Karroo also experience great ranges of temperature, because of the intense dryness of the atmosphere. The diurnal range is a very marked feature of the climate of South Africa, particularly inland. Sudden falls of temperature often take place at sunset, especially in the dry season. They may also be caused by a sudden change in the direction of the wind. Extremes of temperature are liable to occur. In the summer months the thermometer may rise to over 100°, even at places more than 4,000 ft. above sea-level. Cases of sunstroke are curiously rare, even though no special precautions, such as the use of pith helmets, may be taken to guard against it. Apart from the lower regions of the north-east Transvaal, parts of Zululand and a narrow belt of country along the coasts, the whole of South Africa is liable to frosts, though the number of these, and their severity, vary from one district to another. Ground frosts may occur in the Karroo, even in summer.

The rainfall is very variable both in the seasonal amount, and in the time at which it falls. In general it decreases from east to west. Durban receives a little over 40 in. per annum, Ladysmith 27·31, Prieska 9·75 and Port Nolloth 2·17 inches. Topographical features, of course, produce local variations. In Natal the edges of escarpments facing the sea often form well-marked mist belts in the summer months. In the Cape Province the contrast between two flanks of a mountain range is often very sharp. For instance, George has a rainfall of 34·36 in., while Ezeljagt, 12 m. away, but on the landward side of the Outeniqua range, has only 14·98 inches. The highest rainfall, so far recorded, occurs in the mountains near Paarl, where several stations receive about 200 inches. This, however, only applies to a small area, and is not representative of South African conditions. In the Cape Province, out of a total area of 276,966 sq.m., 177,677 have a rainfall of from 5 to 15 in. per annum. In the Orange Free State, the total area of which is 50,389 sq.m., 32,660 receive 15–25 inches. In the Transvaal, 70,764 sq.m., out of a total of 110,450, have an annual rainfall of 15–25 inches. In Natal, 21,231 sq.m. out of a total of 35,291, receive 25–35 inches, while a further 14,060 sq.m. have an annual amount of 35–50 inches.

Over the greater part of South Africa, most of the rain falls in the summer months (October to March, inclusive). If an irregular line be drawn from near East London in a westerly direction to near Laingsburg, then northward through Fraserburg, and curving north-westward to the coast, about 23° S., the area to the north and east of it is one that receives at least 60% of its rain in summer. Part of it receives over 90% of its total amount during these months. The south-west of the Cape Province is a region of winter rains. The area, lying to the west of another irregular line, drawn from about Bredasdorp, at first northward, and bending north-westward to meet the coast at 25° S., has 60% or more of its rain in the winter months. Between these two areas is one where the rain is distributed fairly evenly throughout the year. At some places near the south coast, these rains may be appreciable in quantity, and here patches of forest occur.

In the summer rainfall area, much rain falls during thunderstorms, the downpour often being very violent, causing much loss of water by run-off, and much soil erosion. Such storms are more characteristic of the inland districts. In the southern Karroo five or six thunderstorms a year are recorded: at Johannesburg, 61. At the latter station lightning is seen on the average on 114 days every year. Precipitation during thunderstorms is often in the form of hail, which falls in the Transvaal on from 80 to 133 days in the year. Much damage is often done; crops may be entirely beaten down and ruined; small stock may be killed, and many roof tiles and windows broken. Snow falls principally in the mountains, especially along the great escarpment. Along the Basutoland section it may be seen even at midsummer. On Table Mountain (Cape Town) it falls about one year in six. In Natal it is rarely, if ever, seen below 4,000 feet.

South Africa is a land of intense sunlight, which is related to the clearness of the atmosphere, itself connected with high altitudes and dryness. The average amount of bright sunlight received each day throughout the year is 7·51 hours at Cape Town, 8·7 at Johannesburg, and 9·41 at Kimberley. With these figures may be compared the 3·8 hours for London. Evaporation is correspondingly high. The evaporation from a free water surface at Johannesburg is 74·67 inches per annum. This again diminishes the value of the rainfall to vegetation.

VEGETATION

Owing to the small rainfall and high rate of run-off and evaporation, South Africa is poorly supplied with forests. The country is covered with grasses, or, in the drier parts with low xerophytic shrubs and bushes. The grassland is best developed in the eastern half of the country. Three varieties of it are generally recognized: (1) The High Veld, which includes most of Basutoland, the Orange Free State, and the southern Transvaal, is a steppe region, with thorn trees growing on the rocky slopes. The dominant grass is the red grass (*Themeda triandra*). Species of Andropogon, Panicum and Digitaria are also common. Herbaceous perennials are common. In the summer months the veld is in many places made beautiful by innumerable pink, white and mauve flowers of cosmos, which has spread among the indigenous flora. (2) The Eastern Mountain Grassland occurs along the slopes of the Stormberg and Drakensberg at altitudes of from 4,000 to 8,000 feet. The characteristic grasses are species of Andropogon, Heteropogon, Panicum and Themeda. They all grow in tussocks and tufts. In this zone the bracken fern (*Pteris aquilina*) and composites are common. Tree ferns grow near the streams, and in some areas numerous, but scattered, protea bushes occur. (3) The Eastern Grass Veld is found over a strip of country extending between the great escarpment and the coast belt, from about Port Elizabeth northward through Natal, at heights ranging from 1,000 to 4,000 feet. The broad monotony of the grassland is broken in places by low trees or bushes, which occur either individually or in small clumps. Among these are various species of thorn trees (*Acacia spp., Zizyphus mueronata*), the Cape lilac (*Ehretia hottentotica*). Aloes flourish on dry, rocky sites. On many slopes facing the north, the grassland is replaced, owing to intense insolation, dryness and exposure to hot winds, by an assemblage of thorn trees, aloes and euphorbias.

Desert or semi-desert associations cover much of the west and south: (1) Between the fold mountains of Cape Colony and the Escarpment, Karroo vegetation extends from the Olifants river, in the west, to about the Sundays river in the east. The rainfall is from 5 to 15 in. per annum. The plants include succulents, such as Mesembryanthemum, Euphorbia, Aloes, Pelargonium, Stapelia, etc.; low shrubs, like the Karroo bush (Pentzia incana), and compositae. There are many bulbous and tuberous plants, which bloom for a short time after rains. Trees grow only along the dry river courses and on the mountain slopes in the east. (2) The upper Karroo comprises part of the interior plateau, south of the Orange river, and west of a line from Queenstown to Fauresmith, and the eastern part of Bushmanland. This, too, is a treeless area. The vegetation consists of small shrubs and low bushes. The most conspicuous of the succulent plants is Mesembryanthemum spinosum; aloes are common; grasses also occur, among the commonest being Aristida scabrivalvis, Eragrostis truncata and E. obtusa. (3) Namaqualand: this botanical province includes part of Bushmanland, Little Namaqualand and most of Great Namaqualand above 2,000 feet. The rainfall is 5–10 inches. Tufted grasses grow on the higher plateaux and on sandy plains, but scattered, drought resisting shrubs and bushes, with succulents in the lower valleys and on rocky slopes are perhaps more characteristic. (4) The Namib extends northward in a belt 18–35 m. wide along the west coast from Olifant's river. This area experiences the most arid conditions in South Africa, the rainfall being from 1 to 5 inches. On rocky hills grow species of Mesembryanthemum, Euphorbia virosa, Aloe dichotoma, etc. On the sand-dunes a few tufts of grass are to be found—Eragrostes spinosa, E. cyperoides—together with Mesembryanthemum Marlothi, and ganna bush (*Salsola Zeyheri*). Where underground water can be reached the naras flourish (*Acanthosicyos horrida*) and the tamarisk (*Tamarix articulata*). The gravel plains are the most barren of all. In places only an annual Mesembryanthemum occurs; in others only lichens. Welwitschia mirabilis is found in a few places. The characteristic plant is the Bushman's Candle (*Sarcocaulon Burmanni*).

Forest covers only a small proportion of South Africa. Most of the patches, in which it occurs, are to be found in the eastern and moister half: (1) Along a sub-tropical coastal belt from Port Elizabeth through Natal proper, and widening when traced northward through Zululand, was formerly a low forest which in Natal and in much of Zululand, has largely been destroyed and replaced by sugar plantations. (2) Along the slopes of the Drakensberg and Stormberg, and on the ridges which extend from them, patches of forest occur at altitudes of from 3,000 to 8,000. They are generally found on slopes, which face between south-east and south-west, and which are therefore turned toward the rain-bearing winds, and away from the hot, desiccating winds. (3) In the Cape Province forests grow on the seaward slopes of the Outeniqua, Langkloof and Zitzikamma mountains. In all these patches of forest the trees are mostly evergreens. They include the yellowwoods (*Podocarpus latifolia, P. elongata*), black ironwood (Olea laurifolia), assegai wood (*Curtisea faginea*), white pear (*Apodytes dimidiata*), black stinkwood (*Ocotea bullata*), etc. In the sub-tropical regions species with tropical affinities occur. Here are to be found the umzimbiti (*Milletia caffra*), flat crown (*Albizzia fastigiata*), red ivory (*Rhamnus Zeyheri*), etc. In the Cape forests the witels (*Platylophus trifoliatus*) is well represented.

Many trees of foreign origin have been introduced, and grow well in the country. The black wattle of Australia (*Acacia decurreus var. mollis*) is cultivated on a large scale in the midlands of Natal, where its plantations cover over 200,000 ac., and in parts of the Transvaal. The gums are now widely spread in plantations, about farms and along the streets of many towns. Oak trees are planted for ornamental purposes and to provide shade. Well-grown examples line the streets of Stellenbosch, George, Kokstadm, etc. In Natal, and in parts of the high Veld, the beautiful jacaranda tree is grown, while some of the streets of Durban are lined with flamboyants, which are definitely restricted to the sub-tropical districts.

Scattered bush occupies much of the northern, central and eastern regions of South Africa. (1) The East Coast bush occurs along a narrow littoral strip from East London to the north of Natal. It is dense, and has many climbing plants. The trees rarely exceed 30 ft. in height. The most characteristic plants are the palms (*Hyphaene crinita*, and *Phoenix reclinata*) and the wild banana (*Strelitzia augusta*). Other common trees are the red milkwood (*Mimusops caffra*), Kafirboom (*Erythrina caffra*), Amatungula (*Carissa grandiflora*), white pear (*Apodytes dimidiata*), etc.; aloes also occur. (2) The Limpopo bushveld covers much of the basin of the Limpopo in Portuguese East Africa, southern Rhodesia, the Transvaal and south-east Bechuanaland. Most of it lies below 3,000 feet. This is a park-like country. The trees, which are from 30 to 50 ft. high, are fairly well spaced with bushes and shrubs growing between them. In the east many of the trees are evergreen, but toward the west deciduous trees are common. Among the components of this bush are the baobab (*Adansonia digitata*), mahogany (*Afzelia quanzensis*), mopane (*Copaifera mopane*), and several species of acacia. Palms grow near the rivers and vleis. Toward the south the bush is less luxuriant where it merges into the High Veld. (3) The Kalahari Thorn Veld extends over much of central South Africa as far as the Orange river. It is well developed over a great part of Bechuanaland and the Damara plateau. It consists of bush and scattered trees. The dominant tree is the camel thorn (*Acacia giraffae*), but several other species of acacia also occur. The chief grasses include species of Eragrostis, especially E. superbus, Aristida, Pennisetum, etc. (3) The scrub, or Macchia, in the south-west of the Cape Province is found throughout the area bounded on the west by the Olifants river, by Van Stadens mountains on the east, and on the north by the Cedarberg, Cold Bokkeveld, Hex River mountains, Zwartberg and Elandsberg. Its chief components are low bushes and shrubs, from 1 to 6 ft. high, with small dull greyish green, leathery leaves. Among them are species of Proteaceae, Ericaceae, Restiaceae, Thymelaeaceae, etc. Large tracts are covered by the rhenoster bush (*Elyptropappus rhinocerotis*). Bulbous and tuberous plants belonging to the Iridaceae, Liliaceae and Oxalidaceae are common. (*See* CAPE COLONY.) The Cape flora appears to be more closely related to that of south-west Australia than to that of the Mediterranean area.

FAUNA

Zoologically South Africa belongs to the Ethiopian region, and is characterized by the absence of bears and deer, and by the presence of a great variety of antelopes, which range in size from the diminutive blue buck or mipiti to the eland. Some of the more strictly tropical forms are unrepresented, such as the gorilla, chimpanzee and many of the parrots. Some animals, as for example the lion, crocodile, and some antelopes, have a continuous distribution from the Sudan, along the East African corridor between the great equatorial forests and the coast belt down to South Africa. On the other hand the country may be regarded as a distinct sub-region of the Ethiopian area on account of a number of forms which are peculiar to it. Among these are the springbuck, black wildebeest, the long-tailed sugar bird, which appears to have a distribution closely related to that of the Proteaceae, and a great variety of insects, adapted to the Cape flora. Since the white man entered the country with his rifle, his enclosures and his domestic animals, the numbers of the larger native animals have been enormously reduced. A few species like the quagga have become extinct. Several species of buck only survive in a semi-domesticated state on some of the large farms, or in game reserves. The white rhinoceros, which occurs about the sources of the Nile, and which used to be common in the area between the Zambesi and the Orange rivers, is now represented only by a few individuals about the Umfolosi in Natal. The elephant still survives in the Knysna forest, the Addo bush and the game reserve in the north-eastern Transvaal and in Bechuanaland, and a herd of about 400 mountain zebra is preserved in Cape Colony.

Of the rodents there are about 150 species, including squirrels, hares and porcupines. Two species of Insectivora—the golden mole and the elephant shrew—are peculiar to South Africa. The Edentata include the scaly ant-eater, and the aardvark, or ant-bear, the structure of whose teeth (molars) has no analogy among the mammals. Several species of whales are caught in South African waters. The primates are not well represented, but monkeys are found in the forests, and baboons are common in nearly all the mountainous areas. Of the Carnivora the leopard is still fairly secure in some of the mountain kloofs: lions are confined to the northern Transvaal, and the Sabie game reserve. Several of the smaller Felidae—wild cat, lynx, spotted serval, etc.—are moderately numerous. Hyaenas are becoming scarce, but the Canidae are still well represented by the black-backed and striped jackal and the wild, or Cape, hunting dog.

Over a thousand species of birds are known including migrants such as the European swallow, red-backed shrike, white stork, curlew, etc. Parrots and hornbills reach from the tropics to Damaraland on the west, and on the east through Natal to the Knysna forests. The jackass penguin, which breeds in large numbers on the islands of the south and west coasts, represents an antarctic element. Eagles, kites, falcons, harriers, hawks and owls occur. The secretary bird, with its long legs and terrestrial habit, is related to the eagles and hawks, and is protected on account of its reputation as a snake-killer. It is peculiar to South Africa. Among the birds which are shot for sport or food are the francolins (locally known as pheasants and partridges), guinea fowls, sand grouse, ducks and geese. The ostrich still exists in the wild condition in unenclosed parts of the country. The common European starling is rapidly spreading about Cape Town and in the coastal parts of Natal; the Indian mynah is well established, and is pushing away some of the native species.

The reptiles include over 350 species. The crocodile does not occur south of the Kunene and Tugela rivers. Tortoises and especially lizards are numerous. Snakes are represented by 125 species. Among these are the puff and night adders, cobra, python, and the swift and deadly imamba (*Dendraspis angusticeps*).

There are 200 species of fresh-water fish. By far the commonest are representatives of the carp family, known in South Africa as barbel. The tiger fish (*Hydrocyon lineaties*) is the finest indigenous sporting fish, and occurs in the Komati and Crocodile rivers. There is only one native species of eel; it is confined to the rivers flowing into the Indian ocean. Brown, rainbow and Loch Leven trout have been acclimatised, and many rivers in the cooler parts of the country are well stocked. In Natal they do well above 4,000 ft. South Africa has many varieties of scorpions and spiders. Of insects, it is estimated that there are at least 40,000 species. Those of the north-eastern and eastern districts have affinities with central Africa. Mention can only be made of the mantis, or Hottentot god, the white ants or termites, which are often destructive of timber and trees; of the bees including honey bees, which are common; of several types of mosquitoes, including the anophelene mosquito, and the tsetse fly (*Glossina*).

POPULATION

The population of South Africa is divided as indicated in the following table:—

	Cape	Natal	O.F.S.	Transvaal	Total
Europeans (1921)	650,609	136,838	188,556	543,485	1,519,488
Europeans (1926)	706,137	158,916	202,985	608,622	1,676,660
Natives (1921)	1,640,162	1,139,804	421,978	1,495,869	4,697,813
Percentage of total pop.	58·94%	79·74%	67·11%	71·65%	67·80%
Asiatics	6,498	141,336	100	13,405	161,339
Mixed and Others (estimated)	485,024	11,142	17,751	32,253	545,548
Total (all races)					6,928,580

By Europeans is implied persons of European origin, without any infusion of Bantu, Hottentot, Indian or other blood. The term native is applied to the Bantu tribes. "Mixed and Others" implies persons who are the result of crosses between Europeans and Bantu, Hottentot, Malays, etc., as well as Hottentots and Bushmen, who would, however, probably not number more than a few thousands. The Asiatics consist chiefly of people brought over as coolies from south India, and of Mohammedan traders. Between 1911 and 1921 the Europeans increased by 19·06%, Natives by 16·89%, Asiatics by 8·89% and the Mixed and Others by 3·73% (*see* other articles on Basuto, Hottentots, etc.):—

Density of Population per sq. mile (1921)

	Cape	Natal	O.F.S.	Transvaal	Total
Europeans	2·35	3·88	3·80	4·92	3·22
Total (all races)	10·05	40·51	12·67	18·90	14·67

The distribution of the native population is very uneven, especially in the Cape, where the range is from about one person per sq.m. or less, in the western and northern districts, to over 70 in the King William's Town district. (*See* CAPE COLONY.)

The white population increases very slowly as the result of immigration. During the years 1922–26 the average yearly number of white immigrants, intending permanent residence, was 27,586, and the corresponding number of white emigrants, relinquishing domicile, 25,635. The country had therefore a net yearly gain of 1,951 settlers, or one person per 242·4 sq. miles. In 1926 the number of Asiatics relinquishing domicile exceeded that of permanent immigrants by 1,611.

An important element of the white South African population is formed by the "poor whites," whose numbers in the rural districts are estimated at 100,000 to 150,000. Several causes operate to produce this depressed class. In the rural areas men may lose their hold on the land as the result of drought or disease, or of the fractioning of the farms among descendants, according to the

Roman-Dutch system of inheritance. Most of them are imbued with the idea that all manual labour is "Kafirs' work." Some of these people drift into the towns, but having no skill they must compete in the unskilled labour market with the low-paid native, with whom their relations are often far from satisfactory, and form a grave social problem. The Government has established several afforestation schemes where the labour is done by "poor whites" on a piece-work basis. From the afforestation settlements suitable men are drafted on to irrigated areas, where they are trained to work land under discipline. Labour colonies have been established, to which a man who is habitually idle can be committed from one to five years. Nearly all the unskilled and most of the semi-skilled work is done by natives, Indians and coloured people.

Towns.—The principal towns of South Africa have grown up as seaports—Cape Town (212,997), Durban (151,642), Port Elizabeth (52,298), East London (34,673): in connection with the exploitation of minerals—Johannesburg (288,131), Kimberley (39,702): or as administrative and educational centres—Pietermaritzburg (36,023), Bloemfontein (39,034), Grahamstown (14,909), Pretoria (74,052). The other centres are usually small country towns, which have grown up in most places about a church, and have become market and social centres for the surrounding country. They are nearly all laid out on a rectangular plan, with broad, straight streets, often lined with trees, and sometimes with runnels of water flowing along them, as in Stellenbosch, Graaff Reinet, Kokstad, etc. Homes of wood and corrugated iron are often replaced by stone or brick. Roofs are of iron, slates and where there are no severe hailstorms, tiles. The towns were originally surrounded by commons for pasture. In some cases these have been built over, but they still exist about the smaller towns. Every municipality is obliged, by the Natives Urban Areas Act, 1921, to provide housing for its natives.

Health.—The country is on the whole a healthy one. Diphtheria is liable to occur at some places in winter, and bacterial dysentery is fairly frequent in summer. Enteric, which used to be so common, has been greatly reduced by improved sanitation, and water supply. Leprosy is not uncommon among the native peoples, though the extent to which it occurs in the native reserves is not accurately known. It appears to be most prevalent in the Transkei. In 1922 there were 2,474 lepers in the Union. They are segregated in six settlements—Robben Island (Table Bay), Emjanyana (Transkei), Inkambati (Pondoland), Amatikulu (Zululand), Pretoria, and Bochem (Transvaal). Malaria is endemic in the lower areas of the north and east Transvaal, and Zululand. In some years it becomes epidemic over much of the Transvaal, except the High veld.

ECONOMIC CONDITIONS

Economic.—Up to 1870 South Africa was entirely a pastoral and agricultural country. The discovery of diamonds at Kimberley in 1870 marked the beginning of a new period. General railway construction began in 1874 and was accelerated by the gold rush of the '80s. In 1892 Johannesburg was linked with the Cape ports, and in 1895, with Durban. Farming was for a time neglected in favour of prospecting, but eventually farmers returned with increased capital. The mining areas provided a market for agricultural products. The chief industry was wagon-making. After the Boer war, state departments were formed to deal with agriculture, forestry, irrigation, geological survey, and mining. The World War, by making imported goods scarce, gave an impetus to small industries.

The South African railway system is well organized and efficiently worked. In 1926 there were just over 12,000 miles of line belonging to the State, and 400 m. privately owned. The standard gauge is 3 feet 6 inches. From the principal ports railways run to the Witwatersrand and Pretoria, and there are a number of cross connections. The elevation of the interior plateau increased the difficulties of constructing and working the railways. The escarpment everywhere necessitates a steep climb. The sparse population and the aridity of much of the country are further handicaps. Along the main lines where there is a large amount of traffic some sections have been electrified. To cope with the rush of maize from the High Veld after the harvests, and with the heavy coal trade towards Durban, 171 miles of Natal's main line, from Glencoe Junction to Pietermaritzburg have been electrified. The suburban lines about Cape Town are also being converted. Narrow gauge branches serve some districts. They often follow very tortuous courses. Also, there are motor services, under the control of the railway authorities. In June, 1926, there were 45 of these routes, totalling 2,500 miles. The railways are in the main single tracked. The coaches are nearly all of the side corridor type, convertible into sleepers. The roads of South Africa are still largely undeveloped.

Stockbreeding.—The industry has been handicapped by various animal diseases. In 1896 rinderpest swept through the country and in some districts carried off 90% of the cattle. Future outbreaks could probably be checked at the beginning by modern methods, and precautions. Of greater importance at the present time are diseases caused by certain species of grass ticks. Among these is East Coast fever, which in 1906 was nearly as destructive as rinderpest had been. It has become endemic. War is being waged on the ticks, and all cattle are dipped at short intervals, so that the disease is now held in check. Anthrax is also not uncommon. Since the second Boer war great improvement has been wrought by the introduction of good European bulls. The basis of the South African herds is the old Afrikander breed, which probably has a strong infusion of oriental blood, as is witnessed by its distinct hump. This type has been crossed with various European breeds—shorthorns, Devons, Frisians, etc. There are also a considerable number of pure bred herds of good quality. Most of the cattle owned by the natives are of inferior or "scrub" type. The following figures apply to the year 1926:

	Cape	Natal	O.F.S.	Transvaal	Total
Cattle	3,351,269	2,152,100	1,955,772	3,055,140	10,514,281
Woolled sheep	18,927,421	1,890,761	10,340,465	4,219,097	35,377,744
Other sheep	2,927,569	248,049	139,685	327,198	3,642,501
Angora goats	1,700,070	31,578	72,071	27,609	1.831 328
Other goats	4,163,826	1,101,254	90,711	800,395	6,156,183
Horses	361,278	106,529	265,748	154,096	887,651
Mules	86,963	10,472	14,822	26,199	138,456
Asses	394,687	78,314	54,416	266,766	796,183

By far the majority of the cattle is concentrated in the moister, eastern half of the country. Since the Act of Union, 1910, there has been a great development in the dairying industry. In 1898, cheese, butter and substitutes were imported to a value of £387,474: in 1918 butter and cheese were produced in sufficient quantities to satisfy the home market, and to export a quantity valued at £122,667; creameries and cheese factories have been established, and an export trade is being built up.

Sheep farming is important in the eastern part of the Cape Province, in the Orange Free State and the higher parts of the Transvaal. Sheep are to a large extent excluded by aridity from the western parts of the country, and by heat and diseases from the low parts of the Transvaal and Natal. The original type of sheep, which is still bred in considerable numbers, is the hairy long-eared, fat-tailed variety. Many English and Dutch breeds have been introduced, as well as merinos from Spain and Australia. Goats thrive in regions, in which the pasture is too poor for sheep. They are bred largely in the Karroo and to a considerable extent in the Orange Free State and the Transvaal. Many of them are of the Angora type. The production of wool and mohair for 1925–26 is given in the table:

	Cape	Natal	O.F.S.	Transvaal	Total
	lb.	lb.	lb.	lb.	lb.
Wool	91,256,894	7,191,117	51,713,737	17,759,762	167,921,510
Mohair	7,602,001	52,045	181,967	43,620	7,879,633

The distribution of horses is somewhat the same as that of sheep. South Africa formerly exported horses to India, Australia, and Egypt, but horse sickness is a handicap. The disease breaks out in the moist season, and lasts from about Christmas until the first

BY COURTESY OF THE SOUTH AFRICAN RAILWAYS

LANDSCAPE AND URBAN SCENES IN SOUTH AFRICA

1. General view of Pretoria, capital of the Union of South Africa showing administrative buildings in the foreground
2. Cape Town, second largest town of South Africa, and in the distance, Table Mountain seen from Signal Hill. The mist on the mountain is usually referred to as its "Tablecloth"
3. Magoebus Kloof, characteristic of the landscape in the North Transvaal region where the Boers settled
4. Johannesburg, the chief commercial city in the Union of South Africa, situated among the Rand goldfields on the slope of Witwatersrand
5. West Street, the chief street of Durban, the principal seaport of Natal. The Library and the Museum are seen on the left and the Post Office on the right
6. Groote Schuur, Capetown, the house built and bequeathed by Cecil Rhodes for use as the residence of the Prime Minister of South Africa

frosts. The lower areas suffer most severely. Basutoland, and the adjacent parts of the Orange Free State appear to be unaffected. The sickness with the decreased demand for horses has somewhat reduced horse-breeding.

The South African horses are related to the thoroughbred, and have a certain infusion of Arab blood. As a rule they are small, owing to insufficient feeding in winter and during times of drought. Heavy types are beginning to be used for draught purposes in the towns, and to some extent in the wine-growing districts. The mule is popular as a transport animal. It suffers from horse sickness, but to a less extent than the horse. It is largely used in Zululand, and in the south-west of the Cape Province, especially about Malmesbury. The ass was originally imported from the Cape Verde Islands. It is used for draught purposes, where the horse and the ox are debarred by disease, or lack of pasture. Ostrich farming was formerly a very profitable industry, centred about Oudtshoorn. It attained its greatest development in 1913 when there were 776,313 birds in the country. As a result of the Great War, and the change of fashions, the number had fallen in 1926 to 104,578.

Agriculture.—There is naturally a large variety of agricultural productions in a country where the climate and topographical differences are so great. In the south-west of Cape Colony, an area of winter rain, the products are of the Mediterranean type, and include grapes, peaches, apricots, pears, citrus fruit, and wheat. (*See* CAPE COLONY.) Wheat is also grown in the eastern districts of the Orange Free State. In the sub-tropical coast-belt of Natal and Zululand, and in the northern Transvaal many sub-tropical fruits are grown, such as pine-apples, papaws, bananas, mangoes, and much citrus fruit. The coast belt of Natal is almost entirely devoted to sugar plantations. Some tea is grown along the north coast of Natal. Tobacco is cultivated in the Transvaal, in the Rustenburg, Megaliesberg and Piet Retief districts, and in Cape Colony about Oudtshoorn, Swellendam, Stellenbosch, and the Paarl. The staple grain crop is maize, which is grown widely in the country. Gradually, however, there has come to be defined a maize area, in which rain falls in sufficient quantity, at the proper time, and in showers of the requisite intensity. This area embraces part of the southern Transvaal and much of the Orange Free State, excepting the dry, south-western region.

The annual production of maize varies with the seasons. In the year 1924–25 the total production was 4,859,116,000 lb.; the following year it was 2,183,983,000 lb. Kafir corn (sorghum) is a potential forage and grain crop in areas where the rainfall is too uncertain for maize. It is the favourite grain of the native cultivator, and is used in the brewing of native beer. The grain is also being used as a food for cattle and poultry. In 1925 the total production was 487,305,000 lb. This fell in 1926 to 150,548,000 lb. (*See* also NATAL, TRANSVAAL and ORANGE FREE STATE.)

Conditions do not appear to be favourable to irrigation. The flow of the rivers is very variable and many river channels have been cut well down below the level of the surrounding country. There are, however, several irrigation schemes in existence, as for example the Hartebeestpoort, about 25 m. west of Pretoria, in connection with which there are about 40,000 ac. of irrigable land, Lake Mentz (Sunday's river) 38,000 ac., Tarka (tributary of Great Fish river) 35,000 ac., Kamanassie river 27,000 acres, Grass Ridge (Great Brak river) 20,000 ac., etc.

Industries.—The South African customs are of a protective character, but rebates of duties are granted in favour of Great Britain and those parts of the empire, such as Canada and New Zealand, which have afforded reciprocal treatment. By an arrangement with Portuguese East Africa and the Transvaal the products of the soil of both territories may be freely exchanged; and goods may be imported to or exported from the Transvaal by way of Portuguese East Africa under practically the same conditions as obtain in the Union ports. Under an agreement of 1925 Northern and Southern Rhodesia consent to apply the scale of customs operative in the Union, reserving the right to continue certain rebates on British empire goods. Agreement was also made for the free exchange of the products and manufactures of the three parties, subject to certain restrictions on potable spirits, tobacco, beef and cattle. The agreement was not to apply to that part of Northern Rhodesia which falls in the Congo basin.

For the purposes of trade statistics, Basutoland, the Bechuanaland Protectorate, and Swaziland are treated as integral parts of the Union of South Africa. In 1926 imports of various classes, including Government stores, but excluding specie, were valued at £72,598,157: of this amount, manufactured articles, the principal items being textiles, were valued at over £56,000,000 and food and drink at £7,268,442. The exports from the Union in 1926, of South African products, excluding specie, were valued at £72,324,241. The products of mines were estimated to be worth £47,668,153, and the agricultural and pastoral products £21,314,301.

The principal metal in point of value produced in South Africa is gold, of which in 1926 the output was 9,954,762 fine ozs., valued at £42,285,139. All of this came from the Transvaal. Next in value were diamonds, £10,683,597, almost entirely from the Cape Province and the Transvaal. Coal was mined to the extent of 13,734,463 tons, chiefly in the Transvaal (7,593,468 tons) and in Natal (5,159,549 tons). 981,333 fine oz. of silver were produced in the Transvaal. Among the other mineral products, mention may be made of 14,097 tons of asbestos (£216,466), 5,996 tons of corundum (£44,871), 4,951 ozs. of platinum (£93,307), and 1,785 tons of tin (£310,899), all almost entirely from the Transvaal; and 9,235 tons of copper (£494,852) from the last-named province and the Cape.

Various industries, mostly on a comparatively small scale, are growing up in the country to supply the local market. These are largely concerned with the preparation of foods and drinks and the manufacture of vehicles (wagons, etc.), furniture, boots and saddlery, bricks, tiles and cement, chemicals, etc. The total number of factories in South Africa in 1925–26 was 7,085. They provided employment for 75,987 Europeans and 117,435 non-Europeans, and produced materials valued at £91,536,926. The average wage paid to European workers in 1924–25 was £239, and to non-European employees £49.

The following figures will give some indication of the direction and nature of South Africa's overseas trade in 1926.

A.—IMPORTS

From	Value	Chief constituents
	£	
Great Britain	35,501,000	Cotton and piece goods, apparel, machinery and cutlery, railway material.
U.S.A.	11,384,000	Motor cars, mineral oils, machinery, cotton goods.
Germany	4,540,000	Railway material, hardware and cutlery, fencing material, electrical material, iron pipes; cotton goods; musical instruments.
India	2,582,000	Bags, rice, teak, paraffin wax.
Canada	2,075,000	Motor cars, agricultural implements, wheat, paper.
Australia	1,910,000	Wheat and flour; railway sleepers.
France	1,431,000	Silks; haberdashery and millinery, apparel and slops.
Belgium	1,265,000	Railway material, cotton goods, fencing standards.
Sweden	1,196,000	Wood, paper.
Japan	1,117,000	Silk and cotton goods.
Holland	1,107,000	Condensed milk, fertilizers, cotton goods.

B.—EXPORTS

To	Value	Chief constituents
	£	
Great Britain	46,010,000	Gold, diamonds, wool, mohair, sugar, fruit.
India	7,661,000	Gold (£7,373,487), silver, coal.
France	3,354,000	Wool, hides and skins.
Germany	2,482,000	Wool, wattle bark and extract, skins.
U.S.A.	1,963,000	Skins, wool and mohair, diamonds.
Holland	1,489,000	Diamonds, wool, whale oil.
Belgium	1,443,000	Wool, diamonds, wattle bark.
N. and S. Rhodesia	1,329,000	Food and drink, cigarettes, explosives.
Australia	566,000	Maize.

The Weights and Measures Act, No. 32 of 1922, embodied the principle of the optional use of Imperial or metric standards. In practice the use of English measures is nearly universal, with the addition in some areas of the morgen (2·11654 ac.), the muid (about 3 bushels), the leaguer (126½ gal.), etc. The official time is the standard time of the 30th meridian east of Greenwich.

Education and Universities.—Education for white children is compulsory between the ages of 7 and 15 (16 in Cape Province and Orange Free State). Primary education is free. The medium of instruction in the lower standards is the home language, either English or Afrikaans. All education except university education, is under the control of the provincial councils, and different systems are in use in the different provinces.

South Africa has four universities. The University of South Africa has its headquarters in Pretoria, and includes internal and external students. It has six constituent colleges, situated at Pretoria, Potchefstroom, Bloemfontein, Pietermaritzburg, Grahamstown, and Wellington.

Also, there are the University of Cape Town, of the Witwatersrand, at Johannesburg, and the Stellenbosch university. The latter is said to specialize in agriculture and theology.

Language.—South Africa has two official languages, English and Afrikaans. The latter is derived from the Dutch of the 17th century, which was brought out by the early settlers, who were largely discharged soldiers and sailors. The vocabulary is somewhat limited, and the structure considerably simplified to meet the ordinary requirements of a rural population, and to be intelligible to the Bantu and Hottentots in its service. It is now being taught in practically all the schools in the country. An Afrikaans translation of the Bible is being undertaken. In 1921, of the total European population of the Union, over 7 years of age, 50·71% spoke both languages, 25·16% spoke only English, and 23·79% only Afrikaans.

Religion.—The following figures will indicate the relative importance of the different religious organizations in 1921. They represent the percentage of each denomination of the total European and non-European population.

	Dutch Churches	Anglican Church	Presbyterian	Congregational	Methodist	Lutheran	Church of Rome	Baptist	Hebrew	Heathen and no religion
European	55·21	19·35	4·94	·7	6·76	1·26	4·03	1·02	4·09	·21
Non-European . .	5·11	7·77	2·14	2·7	13·50	4·47	1·52	·44	. .	44·42

The Dutch Reformed Church is divided into four provincial synods. Also, there are the Reformed Church of South Africa and Die Nederduits Hervormide Kerk. The Anglican Church has its own constitution, important decisions requiring the concurrent assent of all orders of the Church—bishops, clergy and laity. The seat of the archbishop is at Cape Town. The province is divided into twelve dioceses. The Roman Catholic Church is organized into nine vicariates. (R. U. S.)

CONSTITUTION OF THE UNION OF SOUTH AFRICA

In accordance with the provisions of an act of the British parliament (South Africa Act, 1909), Cape Colony, Natal, the Transvaal and Orange River Colony were united under one Government in a legislative union under the British Crown. The Union of South Africa, as the new State is named, was established on May 31, 1910. Upon its formation the colonies named became provinces of the Union. In the case of the Orange River Colony its title was changed to Orange Free State Province. The colonial legislatures were abolished, provincial councils, with strictly subordinate and delegated powers, were set up, and provincial administrators (local men) replaced the various governors. (*See* SOUTH AFRICA: *History*.) The main provisions of the constitution are as follows:—

The Executive and Legislature.—The Government is vested in the king but is administered by a governor-general. He can dismiss ministers and dissolve both houses of the legislature simultaneously or the House of Assembly alone. He can appoint a deputy to act for him during absence. He is paid £10,000 a year and is advised by an executive council, whose members he nominates. The council must include the ministers of State; and departments may not exceed 11 in number. Ministers cannot hold office for more than three months unless they sit in parliament. The control of native affairs is vested in the governor-general, who also deals with Asiatics.

The Senate consists of 40 members, 8 from each province, and 8 members nominated by the governor-general. Four of these are selected for their acquaintance with "the reasonable wants and wishes" of the coloured races. The presence of both nominated and elected members in the Senate is a novel provision in British colonial legislatures. The senators chosen in 1910 hold office for ten years. After 1920 the Union parliament may make any alteration it sees fit in the constitution of the senate (up to 1928 no change had been made). A senator must be a British subject of European descent, must be 30 years old, be a voter, have lived for five years in the Union, and, if an elected member, be possessed of immovable property within the Union of the clear value of £500.

The House of Assembly consists (as originally constituted) of 121 members (now increased to 135). Of these members the Cape Province returns 51, the Transvaal 36 (now increased to 50) and Natal and Orange Free State 17 each. As population increases the total number of members may be raised to 150.

Members must, like senators, be British subjects of European descent, they must be qualified to be registered as voters and have lived for five years within the Union. A general election must take place every five years, and all polls must be taken on the same day. There must be a session every year.

The qualifications of parliamentary voters are those, which existed in the several colonies at the establishment of the Union, save that "no member of His Majesty's regular forces on full pay" can be registered as a voter. As the franchise laws in the several colonies differed, the qualifications of voters in the provinces differ also. In the Transvaal and Orange Free State provinces the franchise is restricted to white adult male British subjects. In neither province is there any property qualification, but a six months' residence before registration is required. In Natal (*q.v.*) there is a low property qualification. In that province coloured persons are not by name debarred from the franchise, but they are in practice excluded. In the Cape Province, where there is also a low property qualification, no colour bar exists and there are a large number of Kaffir voters. (*See* CAPE COLONY: *Constitution*). Parliament may alter the qualifications for the vote, but no law which would deprive coloured persons in the Cape province of the franchise can be effective "unless the bill be passed by both houses of parliament sitting together and at the third reading be agreed to by not less than two-thirds of the total number of members of both houses."

The provinces have no original authority, possessing only such powers as are delegated to them by the parliament. In certain cases the governor-general must reserve the royal assent to bills, *e.g.*, any bill abolishing the coloured vote in the Cape Province. (For proposals to alter the franchise *see* p. 60). The king is given the power to disallow any law within a year of its having received the assent of the governor-general.

With regard to bills the two houses are not in a position of equality. Bills appropriating revenue or moneys, or imposing taxation, must originate in the House of Assembly and may not be amended by the Senate. If a bill passed by the Assembly has been twice rejected by the Senate, provision is made for a joint sitting of both houses, when members vote and decide upon the measure concerned as one body. In the case of a money bill rejected by the Senate a joint sitting to decide its fate may be held in the same session in which the Senate has failed to pass the bill. Every minister of State may sit and speak in either house, but can vote only in the house of which he is a member. Re-election is not necessary on the appointment of a member as a minister of State. Members are paid £700 a year, £3 being deducted for every day's absence during the session.

The Judicature.—A Supreme Court of Judicature for South Africa was created at the establishment of the Union. The former Supreme, High and Circuit Courts of the several colonies then became provincial and local divisions of the Supreme Court of South Africa, which consists of two divisions, namely the Supreme Court and the Appellate Division. Appeals from the decisions of the provincial and local divisions of the court and from those of the High Court of Southern Rhodesia, must be made to the appellate division of the Supreme Court. Unless special leave of the privy council be obtained there can be no appeal from the decisions of the Appellate Division, save in admiralty cases. This restriction of the power of appeal to the privy council is much greater than are the restrictions upon appeals from the Commonwealth of Australia, where appeals to the privy council lie by right from the several State Supreme Courts. The difference arises from the fact that the Commonwealth is a federation of States; whereas the Union of South Africa is but one State with but one Supreme Court. One result of this unification of the courts of South Africa is that any provincial or local division of the Supreme Court in which an action is begun can order its transference to another division if that course be deemed more convenient. Moreover the judgments of each provincial division can be registered and enforced in any other division. The administration of justice throughout the Union is vested in a minister of State. As prosecutor, each province has an attorney-general appointed by the governor-general.

Among the general provisions of the Constitution the most important is that both the English and Dutch languages are official languages of the Union and are treated on a footing of equality; all records of parliament, and all notices of general public importance or interest issued by the Government of the Union must be in both languages. (Persons in the public service at the establishment of the Union cannot, however, be dispensed with because of lack of knowledge of either English or Dutch.) Other general provisions enact free trade throughout the Union, but the customs and excise, leviable under the laws existing in any of the colonies at the establishment of Union, remain in force unless parliament otherwise provides. All persons who had been naturalized in any of the colonies are naturalized throughout the Union. All rights and obligations under conventions and agreements which were binding on any of the colonies have devolved upon the Union.

The harbours of Cape Town, Port Elizabeth, East London and Durban are State owned, as are also nearly all the railways in the Union. All revenues derived from these services are paid into a separate fund. The administration of the railways, ports and harbours is entrusted to a board of not more than three commissioners (appointed by the governor-general in council) presided over by a minister of State. Each commissioner holds office for five years and may be reappointed. The board is directed to administer its service on business principles, due regard being had to agricultural and industrial development, etc., within the Union. So far as may be the total earnings are not to be more than are sufficient to meet necessary outlays.

Provincial Administration.—The subjects delegated to the councils include direct taxation within the provinces for local revenue purposes, the borrowing of money (on the sole credit of the provinces) with the consent of the ministry; agriculture (within the limits defined by parliament) and municipal institutions, divisional councils, and other local institutions. The control of elementary education was also guaranteed to the councils up to 1915, and thereafter until parliament otherwise provides.

The councils consist of not fewer than 25 members and not more than the number of members returned by the province to the House of Assembly. Constituencies are single. The qualifications for electors are the same as for parliament, and any person qualified to vote is qualified to be a member of the council. As in the Cape province coloured persons are qualified to vote, they are thus also qualified to be members of the provincial council. Any member of the provincial council who becomes a member of either House of Parliament thereupon ceases to be a member of such provincial council. Each provincial council continues for three years and is not subject to dissolution.

The executive power in each province is invested in an officer appointed by the Government and styled provincial administrator. He holds office for five years. The administrator is assisted by an executive committee of four persons elected from among its own members, or otherwise, by the provincial council on the proportional representation principle. The administrator and any other member of the executive committee, not being a member of the council, has the right to take part in the proceedings of the council, but has not the right to vote. The provincial councils have not the right to make laws, but ordinances, which must require the assent of the governor-general in council.

Law.—The basis of the common law of British South Africa is the Roman-Dutch law as it existed in Holland at the end of the 18th century. This was simply the legislation of Justinian, modified during centuries, that is, the foundation of the Code Napoléon. The authorities upon the common law in South Africa are: the Dutch commentators upon the civil law, the statute law of Holland, the decisions of the Dutch courts, and, failing these, the *corpus juris civilis* itself.

Under British influence in South Africa the law has been modified by legislation and by judicial decisions, and there now exists hardly any material difference between the law of England and of South Africa. The law of contracts, of torts, the mercantile law, the law relating to shipping and insurance are practically identical; and even the criminal law is virtually the same. The constitution of the courts is based on the English judiciary, and the rules of evidence and procedure are practically the same. All serious cases of crime are tried before a judge and jury, with the same formalities and safeguards as in England, while minor offences are dealt with by stipendiary magistrates. In criminal cases a verdict of guilty must be unanimous. In civil cases either party may demand a jury, a privilege which is seldom exercised; the verdict of the majority here prevails.

The most marked difference between the English and South African systems of law is, as might be expected, to be found in the law relating to real property. In South Africa there is a rigid and universal application of the principle of registration. The title to land is registered, in all cases; and so, with a few exceptions, is every servitude or easement, mortgage or charge upon land. There is no law of primogeniture. There is absolute freedom of testamentary disposition in the Cape province, and in some other parts of South Africa. By the Roman-Dutch law, and in the absence of any ante-nuptial contract to the contrary, there is a complete community of property between husband and wife, subject to the sole control of the husband. The courts have, however, the right to interfere in case of any flagrant abuse of this power. Ante-nuptial agreements must in all cases be publicly registered. By the common law gifts between husband and wife during marriage are void as against creditors. This rule cannot be evaded even by ante-nuptial agreement. Divorce is granted to either spouse for either adultery or malicious desertion.

(F. R. C.; X.)

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DEFENCE

Historical.—Before the Union of South Africa was accomplished in 1910, the self-governing Colonies (Cape Colony, Natal, the Transvaal and Orange Free State) maintained defence forces of which the Cape Mounted Riflemen were regulars, the remainder either volunteers or police forces, supplemented by rifle clubs and associations. Acting on the advice of Lord Methuen, commanding in chief the British troops in the country, the various colonial governments took such steps as were possible before union to secure uniformity in military training and organization. After union the question was taken up seriously by the Government in which General Louis Botha was prime minister and General Smuts the minister of defence, who introduced in 1912 and passed the first Defence Act, under which the first defence forces of the Union of South Africa were raised. A military college was at once established at Bloemfontein to train the staff officers for the new forces which came into being early in 1913. All citizens of military age were then registered, and they volunteered almost unanimously to join the new citizen forces, which were soon to prove the salvation of the country in a rebellion of which the embers were still hot when the World War broke out in August 1914. The story of South Africa's participation in that conflict is told elsewhere. Including about 28,000 coloured and native labour personnel, the Union sent about 221,500 (including over 8,700 officers) in military units to the various theatres of war, the majority serving in West, in Central and in South-west Africa, which was wrested from Germany by a South African Army about 110,000 strong under General Botha. Two other South African Generals formerly in arms against Great Britain (J. C. Smuts and Van Deventer) were successive commanders-in-chief of the operations in East Africa. The South Africans' total war casualties numbered nearly 19,000, of which 14,250 occurred in France, where over 14,050 were killed, wounded or missing and only 194 taken prisoner.

The defence forces at present consist of (a) a permanent force; (b) coast garrison force; (c) citizen force; (d) royal naval volunteer reserve and (e) any special reserve that may be established under the Defence Act.

Recruitment and Service.—Every citizen of the Union is liable from his 17th to his 60th year to render personal service in time of war, in any part of South Africa, in defence of the Union. Not more than 50 per cent undergo peace training, which every citizen is liable to undergo for 4 years, beginning in his 21st year. Volunteers are accepted to do this training between their 17th and 21st year. Those who do no such peace training must become members of rifle associations for 4 years. Wherever facilities for military training can be provided, all boys between the ages of 13 and 17 are required to undergo training as cadets unless their parents object. Members of the permanent force are trained as regulars. Training in the coast garrison force is for 18 to 24 days in a year for 4 years with re-engagements. The active citizen forces do from 22 to 25 days in the first year, from 16 to 21 days in subsequent years. From 10 to 15 days of the training in these forces must be continuous. After 4 years, members pass into the citizen force reserve, class A, and are liable to annual inspection. There is a prescribed course of annual training for compulsory members of rifle associations. The citizen force reserve class B contains all who are not in the other forces or reserves up to the age of 45, and the national reserve all other citizens below 21 and from 45 to 60 years.

Strength, Organization and Distribution.—The budget effectives in 1928 of those permanently employed in the military forces (excluding the air force given below) numbered 1,704, including 73 officers. The total military establishments include 1,471 permanent force, 268 coast garrison force, 8,128 active citizen force, 152,000 in the defence rifle associations and 44,000 cadets. The permanent force includes three batteries of artillery and a regiment of South African Mounted Riflemen, with the necessary auxiliary and administrative services. The coast defence force is divided between Cape Town and Durban. The active citizen force is grouped in units by districts for service in the field, with its reserve class A. The class B reserve is organized in 110 commandos or territorial corps. The defence forces are administered by a ministry of defence, represented by staff officers in the 15 military districts. The Cape Peninsula and Durban are defended ports.

Military Air Force.—A South African air force with a strength of 398, including 109 natives, is included in the military establishments. This force is commanded and administered by a director of air services at defence headquarters and includes a depot, flying school and service squadrons of which one has so far been established. There is also a general reserve of officers and a special reserve of pilot officers with an establishment of 24 for each flight of machines. There are about 100 prepared landing-grounds in Union territory, and steel hangars for about 80 machines at Pretoria. Unlike the other self-governing nations grouped under the British Crown, South Africans are responsible for governing vast numbers of natives, some of them formerly warlike races but now disarmed. This fact is naturally reflected in the organization of the defence forces.

See also the League of Nations *Armaments Year Book* (Geneva, 1928). (G. G. A.)

Naval Defence.—The Cape Colony from 1897 and Natal from 1902, each made small annual payments towards the upkeep of a squadron in South Africa. These payments ceased with the formation of the Union of South Africa in 1910 and during the World War the Dominion relied entirely upon the Royal Navy for its protection at sea. In 1921 the Union Government adopted the principle of forming a South African Navy for Home Defence, but progress has been slow. In 1928 the Union Government maintained a surveying sloop, and two trawlers in commission with a depot ship at Simonstown. These ships have been transferred from the Royal Navy and are manned by officers and men of the South African Naval Service. Simonstown is also the headquarters of the British Squadron on the African Station.

(S. T. H. W.)

HISTORY

Pioneers.—More, perhaps, than to any other man the discovery of the Cape of Good Hope and of South Africa as a settling ground for Europeans is due to the great Portuguese pioneer Henry the Navigator. By him a school of pilots was trained and accurate charts and maps collected which made possible the voyages of Bartholomew Diaz in 1487 and Vasco da Gama ten years later. These two great navigators made known to the world the Cape of Storms, so-named by Diaz, but rechristened the Cape of Good Hope by John II. of Portugal. This discovery inspired in Camoens one of his most celebrated passages in the *Lusiad,* where he introduces the looming Table Mountain:—

> Of such portentous bulk was this Colossus
> That I may tell thee (and not tell amiss)
> Of that of Rhodes it might supply the loss
> (One of the world's seven wonders).

The Portuguese, however, never took kindly to the southern shores of Africa in their voyages to India, especially after an affray with the Hottentots of Table bay in 1510, when one of their viceroys, Almeida, lost his life. They preferred the roadsteads they discovered on the Mozambique coast as harbours of rest and refreshment for their exhausted crews, finding the Bantus of that district more civilized and amenable. When, towards the end of Elizabeth's reign, the Dutch and English began to intrude on the Portuguese monopoly of the Indian trade, both in turn made a trial of the Cape peninsula as a half-way station where their merchantmen could break the six months' voyage to the east. In 1620 two English captains formally took possession of Table bay on behalf of King James: but this action was not ratified, and the English company found in 1651 a port of refuge in St. Helena.

DUTCH COLONIZATION

By the middle of the 17th century the Dutch East India Company had gone far ahead of their English rivals. Until the English conquest of St. Helena they had used that island as their chief stage on the way to the East; but from 1616 their ships had made a practice of putting into Table bay to get fresh water and any fresh meat that could be obtained from the natives, while a primitive form of post office had been established under an inscribed stone, where passing Indiamen collected or deposited letters. In 1648 Leendert Jansz and Nicholas Proot had been shipwrecked in Table bay with the crew of the Haarlem and for five months, till they were picked up by a returning ship, had established friendly relations with the natives, who brought them sheep, cattle and sowing vegetables, which throve amazingly. They presented a report advocating the Table valley as a vegetable garden and storehouse for the East India fleets. The company decided to establish such a station. Three ships were to take out material for building, seeds and implements, and 70 men were to form a settlement at the Cape of Good Hope.

Jan van Riebeek.—To command the expedition the directors chose Jan van Riebeek (b. 1634), a ship's surgeon, who landed on April 7, 1652. His letters and journal during his ten years' command show ability. The site chosen for the fort was near a swamp where hippopotamuses then wallowed and where Church Square, Cape Town, now stands. The Hottentots were shy of bringing in cattle for sale, and, when they had brought it, developed the habit of stealing it back again; the settlers grumbled, as new settlers do. The directors of the East India Company were troubled at the expense of the settlement, and after three years wished to reduce the number of their servants there to 50, although, as van Riebeek pointed out, the least amount of work required for the settlement to perform its functions at all could barely be done by 120; and, perhaps the hardest trial of all, any commander of a passing fleet belonging to the company superseded van Riebeek during his stay in the Bay, while foreign ships, especially French and English, were a constant source of anxiety.

Small wonder that van Riebeek himself was at times discouraged and in 1655 begged to be promoted to some more honourable post. Nevertheless, during the ten years that he remained his energy was unabated. He despatched expeditions to explore the interior; employed a yacht to good purpose in investigating the coast; encouraged a lucrative seal fishery; built a jetty to facilitate the provisioning of passing ships, and extended the company's area of cultivation as far as Rondebosch, where he built a great storehouse, Groot Schuur.

Van der Stel.—Van Riebeek left the infant colony in May 1662, after giving ample instructions to his successor Zacharias Wagenaar, who founded the present Castle on Jan. 2, 1666. Simon van der Stel, Commander and then Governor from 1679 to 1699, was the second founder of the Cape. Unlike van Riebeek, he was of good family; he loved pomp and circumstance, and elected to end his days in the country, after handing over his office to his son. Van der Stel penetrated with a hundred persons to the copper mines of Namaqualand; another party explored eastwards beyond Oudtshorn, and maritime expeditions were sent round the coast as far as the bay of Natal, which was purchased from the natives in 1689. He also extended the settlement to Stellenbosch, Drakenstein, and beyond Wellington. This extension was rendered possible by the arrival of Huguenot families fleeing from Louis XIV., and by the immigration of young girls from the Dutch Orphan Chamber and of Dutch families organized by the company's supreme Council of Seventeen.

These Dutch immigrants were more pleasing to van der Stel's intensely patriotic soul than the Huguenots, whom he disliked as aliens and for the trouble their independent and uncompromising spirit gave him. The annual fair instituted by him at Stellenbosch on the date of his own birthday was the place to see van der Stel at his best. Here he was in the beautiful settlement founded by himself, among people every one of whom was familiar to him. Here he watched them engaging in the old Dutch sports imported from the fatherland; the school children paraded before him and their elders came to drink wine and gossip with him. He himself was a notable farmer and tree-planter. He made the best wine at the Cape, planted trees round his house at Constantia, which are still one of the glories of the peninsula, and had the best crops and the best-fed cattle in the colony.

Growth of the Colony.—At first the company's idea had been simply to have a victualling station at the Cape. Nevertheless, only five years after van Riebeek's arrival, the company found it advisable to allow nine of the settlers' families to establish themselves as independent landowners. But they still were under obligation to take their turn at guarding the fort and were bound to let the company have all the produce they wanted to sell at a fixed price. One result was a continual enlargement of the boundaries of the settlement. The free burghers were always seeking better pastures farther afield. This search had the disadvantage from the company's point of view of stirring up strife with the natives. At first the Dutch only knew of two races of natives, the Bushmen, a tiny race of men in a very low stage of civilization, who lived entirely by hunting and were quite as ready to hunt the tame cattle of the farmers as more savage beasts, and the Hottentots, who were more advanced than the Bushmen; they kept cattle of their own and were able to work in copper; but they were expert cattle-thieves. Thus the settlement was often called upon to repel raids of Hottentots or Bushmen, instead of quietly raising produce for sale to passing ships.

Nevertheless, after the Peace of Nijmwegen of 1678 the company determined to try the experiment of a more vigorous colonizing policy, in the hope of thereby reducing the cost of the garrison and of developing territory which was manifestly productive. German as well as Dutch families were sent out to take up land, and also the Huguenot refugees, some 200, exiled from France by the revocation of the Edict of Nantes. There was some doubt about sending them, since their religion was not of the same form of Protestantism as that of the Dutch and Germans, and because they were not easily assimilated by the Dutch. To obviate these objections the Huguenot families were dispersed among the earlier Dutch settlements, their language and separate form of religion being discouraged by van der Stel. This policy was so successful that to-day, though such names as Malherbe, Delarey, de Villiers recall this immigration, there is nothing else to distinguish the families from the Boers. The Huguenots included the most efficient workers of France. Wine-growing especially was brought to perfection by the newcomers, notably in the vineyards of Constantia, where excellent wines are still produced.

Cessation of Immigration.—Unfortunately the company still considered that any rights the burghers enjoyed were held merely on sufferance. The burghers had an infinitesimal representation on the Council of Policy at the Cape, and for the sale of their produce they still had to give first option to the company at prices fixed by the officials. The church and schools also were entirely under the control of the officials. Already, too, complaints were heard that the Government gave the burghers insufficient protection in their disputes with the Hottentot marauders in the outlying districts. The burghers had, in addition, special grievances against Adriaan van der Stel, the governor who succeeded his father Simon in 1699, inasmuch as he and his subordinates not only appropriated the very pick of the estates, but also competed unfairly with the free members of the community in the sale of produce to the company or passing ships. Finally, in 1707, Adriaan was recalled by the company: at the same time it was decided that the recurrence of similar troubles could best be avoided by the prohibition of immigration.

Accordingly from 1707 for over a century there was no immigration to South Africa of Europeans; and indeed barely more than 50 years after the Dutch East India Company took over the Cape the supply of fresh Dutch stock, except for a few individual cases, came finally to an end. Thus the Dutch part of the population of South Africa is mainly the result of natural increase since that date. It appears that during those 50 years about 2,500 Europeans at most came into the country from overseas, of whom only a half were of Dutch nationality. On the other hand the Dutch had far the largest number of women, which accounts for the German, French and other nationalities being so rapidly absorbed into the Dutch South African nationality. Even so it is remarkable that from this small nucleus of Dutch population has developed the immense preponderance of that race to-day.

Ten years after the closing of South Africa to immigration by the Dutch East India Company a momentous decision was taken as to the best method of recruiting the labour required for the farms and other industries at the Cape. The directors sent a series of questions to be answered by the local council as to the means of improving the industrial and financial position of the Cape, the most important being whether it would be advisable to rescind the order prohibiting European immigration or to rely for labour on slaves. Hitherto the climate of the Cape peninsula had proved quite suitable for manual work by Europeans; but unfortunately in the council only one member, the captain of the garrison, de Chavonnes, raised his voice for free immigration and free labour. The arguments of the other members of the council prevailed. Slave labour was cheaper, white labourers were apt to be more troublesome and more touchy on their rights; and the council paid no heed to the contention of Chavonnes that though white artisans and labourers were more expensive they did more and better work than slaves and above all that an influx of Europeans for service would help to secure a predominantly European population in a country admirably adapted to them, whereas, once slave labour was established, white men would gradually regard it as beneath their dignity to work. So the future fate of South Africa was determined as of a country with two grades of population, the European masters disdaining to do any but the most skilled form of manual work and the hewers of wood and drawers of water composed, not merely of the natives but, since they were often inapt for the work, also of imported coolies from the East Indies or islands of the Indian ocean; a new element which further complicated the already serious racial problem.

Native Opposition.—About 1770, some Boer farmers had reached the banks of the Great Fish river, more than 400 miles to the east of Capetown. Here they found themselves up against the Xosas, the advance guard of the great Bantu race, which for centuries had been making their way down Africa from their original homes in the neighbourhood of the great interior lakes. Physically they were a magnificent race, very different from the puny Bushmen and the uncouth Hottentots. They began their migration southwards as early as the 9th century A.D., and came in spasmodic waves, pushing aside the original inhabitants. There appear to have been three main divisions of them, the more westerly invaders into Bechuanaland, the central wave of Barotse, who remained in the neighbourhood of the Zambesi, and the most formidable of all, the east coast invaders, Tembus, Pondos, Xosas and behind them the Swazis and Zulus north of Natal. By the beginning of the 18th century the Xosas had crossed the Kei river and by the last quarter of it were occupying the Amatola mountains and were found by the Boer pioneers on the further side of the Great Fish river.

Decline of the Company.—The discovery of this formidable obstacle to Boer expansion coincided with the close of the term of office (1751–71) of the last great Dutch governor, Ryk Tulbagh. His 20 years' rule is regarded as the halcyon time of the Dutch company's period, for he was a just and humane man, who repressed the official corruption which had always been one of the standing grievances of the free burghers. But in the time of his successor, Plettenberg, the grievances of the settlers were aggravated. The company itself was in a bad way and, instead of paying its officials properly, winked at their supplementing inadequate salaries by engaging in trade and spoiling the market for the free burghers; the burghers also complained that they had no representation on the Council of Policy which ordered the affairs of the community, and the frontiersmen in the eastern districts had a special grievance in the refusal of the officials to support them adequately in their troubles with the Xosas and other Bantu tribes. Finally in 1795, on the eve of the first British occupation, the farmers of the eastern districts, Swellendam and Graaff Reinet drove away the company's officials and set up a republic.

When the company's rule in South Africa came to an end in this year, after lasting for nearly a century and a half, the settlement had been extended from the tiny fort, vegetable garden and storehouse at the base of Table mountain right up to the Great Fish river on the east and over the Karoo almost as far as the Orange river to the northwest and to the Nieuwveld and Zuurberg mountains to the north. The little party of some 80 servants of the company brought out by van Riebeek had expanded to a community of about 16,000 Europeans, with control over about 17,000 slaves and an uncertain number of Bushmen and Hottentots.

The Boer is a pastoralist and hunter, and by no means inclined to agriculture: for his great herds he required tracts of country, thousands of acres in extent, and he desired to see no country from his rough homestead which he could not call his own. Strangers not of his own race he resented as alien to his ideas. Deeply religious in his simple way, the Boer head of the household read from the Scriptures and led the singing of hymns daily to his family and dependents; while almost the only social pleasure he allowed himself, was once a year when with all his household he trekked, sometimes 100 miles away, to the nearest church for Holy Communion. Objecting to interference by Government officials and regarding himself as the absolute ruler over his own dependents, at the same time he expected help from the Government when he was in difficulties with border tribes.

THE ENGLISH CONQUEST

The Cape was captured after very little fighting by a British land and sea force under Admiral Elphinstone and Generals Craig and Clarke in Sept. 1795, nominally on behalf of the prince of Orange, who had been turned out of Holland by the republican allies of France. In the death-struggle with France it was essential for England not to let this stage on the route to India fall into the hands of the enemy, and until the Peace of Amiens a hold was kept on it for strategic reasons. The government of the generals and governors who acted during the eight years of this first occupation was conciliatory and raised no serious opposition among the Boers. Fortunately there is a very interesting account of society at the Cape during most of this period in the letters written by Lady Anne Barnard, whose husband was secretary of the Government during the terms of office of Lord Macartney and Sir George Yonge. At first there was some trouble with the rebels of Swellendam and Graaff Reinet, and fighting with the Bushmen in the north and the Xosas in the east continued. But at any rate, when the Batavian republic received the country back in 1803, it was in no worse condition than it had been when the English took it over. By this time the company was dead and the Government of Holland succeeded to their charge. Mist, the first commissioner-general, and his successor Janssens introduced several economic, legal and social reforms, but did not stay long enough to see the fruits of their labour: for in 1806 the British sent another force under Admiral Popham and General Baird to wrest the Cape from Napoleon's Dutch allies. With still less fighting than at the first occupation Janssens submitted to the inevitable and once more the British entered into possession. During the rest of the war the administration, except for Lord Caledon's brief term, was kept in the hands of soldiers. Finally by the peace of 1814 England obtained the Dutch colonies of Guiana and the Cape for a payment of £6,000,000; and since then Cape Colony has remained a part of the British Empire.

Lord Charles Somerset.—The first regular British governor of the Cape was Lord Charles Somerset, who remained there from 1814 to 1826. He was autocratic. There was no representative government during his time and the only method of legislation was by proclamation. He antagonized journalists, missionaries and farmers of both races. The farmers he antagonized by a revaluation of their farms and a more strict exaction of their quitrents, and still more the Boers among them by his institution of a police force composed of natives, whom they regarded as an inferior race who should never be allowed to touch a white man. The culminating grievance with the Boers arose from the refusal of one Frederick Bezuidenhout to appear in a circuit court to answer for his treatment of a Hottentot. When the native police were sent to arrest him he resisted and was killed in the encounter; whereupon his brother, Prinsloo and other friends rose against the Government. The rebellion was easily suppressed, the other Bezuidenhout being also killed in the fighting, while of the survivors 32 were banished and five sentenced to be hanged. The execution of these five at Slachter's Nek in March 1816 was made worse by the bungling of the executioner on the scaffold.

One of the troubles on the eastern frontier had always been the paucity of settlers to resist raids by the Bantu tribes: moreover if the colony was ever to be securely under British dominion, it was important to obtain some settlers of British origin as a counterpoise to the almost wholly Boer population. Accordingly Somerset had little difficulty in persuading the ministry and parliament to grant £50,000 to assist suitable immigrants, with the result that in 1820 no fewer than 5,000 were brought out to settle in the eastern district of Albany round Grahamstown and Port Elizabeth, no attempt being made, as in the case of the Huguenot settlers, to disperse the newcomers among the original colonists and so weld all into one nation. This was the first organized settlement since the Dutch stopped immigration in 1707.

Grievances of the Dutch.—Very little more freedom was given under Somerset's successor. It is true that much needed reforms were introduced in 1828 in the administration of justice, the English criminal system being introduced, while, as in Quebec, civil procedure was left under the Roman-Dutch law. But in carrying out these reforms the Government swept away all the minor Dutch officials such as *landdrosts* and *heemraden*, substituting for them resident magistrates, who sometimes could speak no Dutch, while the old and familiar office of field-cornet was bereft of all its judicial functions. In a word almost all popular share in the government was swept away; nor was there any scope left for municipal government as an outlet for local feeling.

Most of the Boer grievances were connected in some way or other with native policy. In the first place the influence of the missionaries in regard to the treatment of natives was thoroughly distrusted by the Boers. Of the missionaries the most remarkable was the Scotsman Philip, who had much influence with several of the governors as well as with ministers and a large section of the British public at home. His policy was to segregate the natives in reserves under the supervision of Europeans who were to prevent their being tampered with by unscrupulous colonists and teach them to rise to a higher form of civilization. Philip and his brethren were also ready to defend the natives in service from oppression by hard masters. The Boers on their side objected to the policy of reserves, as that would make it more difficult to obtain servants or slaves to work for them. Next they complained of the indecision of the Government in dealing with native marauders on the borders, notably after the Kaffir war of 1834–5. Then the governor, D'Urban (*q.v.*), had established British sovereignty between the Kei and Keiskamma rivers as a precaution against further raids, but was overruled by the colonial secretary Lord Glenelg, who flouted colonial opinion by declaring that the marauders had been more sinned against than sinning. Lastly there was the grievance about slave emancipation passed by the British parliament in 1833. The Boers had causes of complaint in the inadequacy of the compensation offered; much of which, too, had to go in commissions to agents who could obtain payment only in London.

The Great Trek.—Missionaries had penetrated to Bechuanaland and Basutoland as well as to Pondoland beyond the Keiskamma river; since 1824, too, a few British traders had attempted to settle on the coast of Natal, but were not encouraged by the Government; and some Portuguese officials and half-caste soldiers clung to the coast line of Mozambique much at the mercy of the fierce Bantu tribes roaming about in their neighbourhood. Chaka the bold chief of the Zulus who had by training and an iron discipline made his fighting force the most formidable in South Africa, was holding, besides Zululand, most of Natal, having driven northward the Shangaans, who then harried the Portuguese settlements and advanced up to Lake Nyasa. A rebellious impi of the Zulus under Umsilikazi had broken off into the country north of the Orange river and then crossed the Vaal, driving the Bechuana clans almost up to the Kalahari desert. The Basutos, another small clan of the Bantus, had established themselves in the mountainous country west of Natal and there under their chief Moshesh, the greatest native statesman of South Africa, had formed one of the strongest native powers, largely by assimilating refugees from other fighting clans. Into this seething welter of warring Bantus a large number of the Boer farmers determined to launch themselves rather than abide any longer under the hated British rule. Between 1835 and 1837 some hundreds of Boers left the colony under various leaders, the most noted being Trichardt, Pretorius (*q.v.*), A. H. Potgieter, Retief and Uys. It was a veritable exodus like that of the children of Israel from Egypt, the heads of families packing all their household goods with their women and children in the great lumbering ox-waggons, beside which they drove their vast herds of cattle and sheep,—indeed we hear of one party of 113 taking no less than £60,000 worth. All started northward into the Free State, as it now is, but soon dispersed in separate detachments, some remaining on the level plateau of that state, others making their way across the Vaal and there again dividing, some to the western lowlands, others as far as the Zoutpansberg mountains in the north-east, while another large contingent crossed the Drakenberg into Natal. All went off "in the full assurance," as Retief wrote, "that the English Government will allow us to govern ourselves without its interference"; but this was just what that Government was not prepared to admit. Under the law as it then stood a man once a British subject could not divest himself of that status. But in practice the parties that settled in the Free State and the distant Transvaal were left to themselves.

Annexation of Natal.—It was otherwise with those who entered Natal. Piet Retief was the leader of the band who crossed the Drakenberg into that country, where he found Dingaan, the Zulu chief who had succeeded Chaka, in possession of most of the country but with still a few English traders and an English magistrate established at Port Natal. From Dingaan he obtained a concession of most of Natal, but when he went in friendly guise to his kraal to restore some stolen cattle, he and his unarmed companions were set upon and murdered (Feb. 1838). Dingaan then proceeded to wipe out one of the Boer laagers at Weenen; but finally, after some confused fighting, in which the English from the port helped the Boers, Pretorius, with reinforcements from the Free State, crushed Dingaan at the Blood river in December, a victory still celebrated throughout South Africa as Dingaan's Day. Thereupon a Boer republic was set up at Pietermaritzburg in Natal, which for a time held a hegemony over the republics established at Winburg in the Free State and Potchefstroom beyond the Vaal. It looked as if the hope of Retief, founder of the Natal republic, that he would be undisturbed by the English was to be fulfilled. But though the English Government showed no inclination to pursue its former subjects beyond the Orange and Vaal rivers, the case was altered when the emigrants seized the coast land and port, where British subjects had already settled; all the more when the new republic began to stir up the hornets' nest of native troubles both in Zululand and on the north-eastern border of the Cape. At length, after considerable vacillation in Downing street, English troops were sent in 1842 to garrison Port Natal. Here they were hard pressed by the Boers and would have been forced to yield, had it not been for the famous ride of Dick King to Grahamstown, whereby reinforcements were brought up just in time to save the garrison. Thereupon, in spite of another counter-order from Downing street, the governor, Napier, obtained the submission of the Boers, and three years later, in 1845, Natal was annexed as a British possession, while most of the Boers trekked back over the Drakenberg to the republic over the border.

The High Commissioner.—In 1846 the Imperial Government was constrained to recognize its responsibility for events outside the actual colonial limits by instituting the office of high commissioner, whose duty it became to deal with all British interests, not purely colonial, throughout South Africa. Normally this office was combined with that of governor of the Cape.

The chief reason for the annexation of Natal, apart from the fear of an important harbour like Durban falling into possibly unfriendly hands, was that the Boer republic was at that time not strong enough to keep the peace among the swarming hosts of Bantus with which they were surrounded. A similar reason led, in spite of Downing street's reluctance, to claims on the allegiance of the other republics north of the Orange and Vaal rivers. The only serious adversaries met at first by those who crossed the Vaal were the Matabele bands under Umsilikazi: but these bands were defeated by Potgieter in 1836 and later by the same leader on the Marico river in the following year, whereupon they fled further north and settled down in Matabeleland. Between the Orange and the Vaal the two chief native tribes were the Griquas immediately north of the Orange river and the Basutos further east. The Griquas were formidable chiefly because they were accustomed to the use of European arms and were also specially under the protection of the missionaries who had long been working among them. Both the Griquas and the Basutos complained to the high commissioner of their difficulties with the Boers, who were accused of invading their preserves. The governor and high commissioner at that date was Sir Harry Smith (*see*

SMITH, SIR H. G. W.), a restless and engaging veteran of the Peninsular War, who began extending British territory in all directions. He added British Kaffraria to the colony and extended its borders northwards to the Orange river. Then, proceeding across that river, he felt that the only way of settling the disputes of the emigrant Boers with the Griqua tribes under British protection was to proclaim the whole district between the Orange and the Vaal rivers as a dominion of the Crown under the name of the Orange River Sovereignty (Feb. 1848). Pretorius, at that time the leader of the Boers in the Winburg district, attempted resistance, but was defeated by Smith at Boomplaats in August, and Warden was left in charge of the new sovereignty. The claim on the allegiance of the emigrants beyond the Vaal, though not enforced, was not relinquished.

Acknowledgment of the Boer Republics.—But this claim over the Boers beyond the Orange and the Vaal rivers was short-lived. Smith indeed had wanted to make British authority effective beyond the Vaal as well as to the south of it, but he was overruled by Downing street, where the cold fit about colonies, reflecting a fairly general view in political circles, was predominant. Accordingly in 1851 two commissioners were sent out to deal with the situation north of the Orange river, and in Jan. 1852 signed the Sand River Convention granting "freedom to manage their own affairs" to the republicans of the Transvaal. Two years later the same liberty was given to those south of the Vaal by the convention of Bloemfontein (Feb. 1854), and the republic of the Orange Free State was instituted. In the same year representative institutions were granted to Cape Colony; in 1856 Natal, hitherto under a lieutenant-governor subordinate to the governor of the Cape, was finally separated from that colony and also granted representative institutions. So by the middle of the last century the four colonies and states which were afterwards to form the four provinces of the Union of South Africa were finally constituted; and the foundations of South Africa as an entity were laid.

Enlargement of Boundaries.—Natal, at the time of its separation from the Cape, was confined between the Tugela and Buffalo rivers to the north and the Umzimkulu river to the south. As a result of the overthrow of the Zulu power in 1880 some Boer settlers took the opportunity of carving out for themselves in 1884 a separate republic of the Vryheid and Utrecht districts, which were absorbed in the Transvaal in 1888 and then finally annexed to Natal after the South African War. The rest of Zululand was formally annexed to the British empire in 1887 and ten years later was incorporated with Natal, which at the same time obtained Tongaland with its port at Kosi bay, coveted by the Transvaal but annexed by the British Government in 1894. The Orange Free State secured new territory on the Caledon river in 1866 at the expense of the Basutos (*see* below). The Transvaal borders on the west, for a long time vague and undefined, were definitely established by 1884. But the limits of the Cape received the greatest extension. By 1847 the border had advanced very little beyond the Great Fish river, to which it had reached at the time of the English conquest. In that year Sir Harry Smith, the most energetic governor the Cape ever had, after a war to punish a raid of the Xosas into British territory, annexed the territory up to the Keiskamma and proclaimed a protectorate under the name of British Kaffraria over the country between the Keiskamma and the Kei, a settlement only finally secured after another war ending in 1853. British Kaffraria was then tenanted chiefly by the Gaika branch of the Xosas and to the north of them by Fingoes, "wanderers" from various tribes all but exterminated by the Zulus and Tembus. Beyond the Kei dwelt the Galekas, the paramount clan of the Xosas, and also the Tembus, another conquering tribe; and thence up to the Umzimkulu, the frontier of Natal, were the Pondos. In 1857, however, occurred a great weakening of the tribes east of the Keiskamma owing to the slaughter of all their cattle by Xosas at the instigation of a fanatical prophet, the Gaikas in British Kaffraria being suddenly reduced by starvation from 105,000 to 38,000; a considerable body of immigrants, including the German legion, disbanded after the Crimea, was introduced to take their place; while in 1865 British Kaffraria was annexed to the Cape. Gradual extensions of British dominion beyond the Kei were made from time to time, generally as a result of Kafir raids on the border settlers, but it was not till 1894 that the Cape Colony borders were made coterminous with Natal by the incorporation of Pondoland. To Cape Colony were added Griqualand West in 1880 and British Bechuanaland in 1895.

The Basuto Wars and Settlement.—Between the Basutos and the immigrants there was trouble over the lands near the Caledon river, the most fertile part of trans-Orangia; Moshesh also interfered with the Bantus to the north-east of Cape Colony. His first serious brush with Europeans was in 1851 when Warden attempted to bring him to account for cattle thefts in the Caledon district but was defeated at Viervoet, while in the following year Cathcart, the governor of the Cape, was also checked by Moshesh near his flat-topped mountain, Thaba Bosigo. But Moshesh was a statesman as well as a commander. He realized that native hosts could not resist a European army that meant business. In the second Basuto War of 1858 the Free State felt the weight of Moshesh's hand; and in the treaty of Aliwal North, mediated by Sir George Grey, he obtained some accession of territory to the south. Again in 1865 war broke out between the Free State and the Basutos. By this time Moshesh was 80 and had lost much of his power and cunning; his people had to yield most of the coveted land south of the Caledon river (the "Conquered territory") to the Free State.

Then, after another short war (the fourth Basuto War), the Colonial Office, yielding to the prayers of the Basutos, in 1868 annexed Basutoland to the British empire. In 1871, when the Cape was granted full responsible government Basutoland was annexed to the Colony. But the Cape "with a population of a third-rate English city spread over a great country," as Rhodes expressed it, was not then fitted for this extra responsibility, and after the fifth Basuto War, which dragged on during 1880–1 and was caused by an unfortunate decision of Sprigg's ministry to disarm the Basutos, at the Cape's own request the Imperial Government resumed control of Basutoland in 1884 and still retains it. Under imperial protection, exercised by a resident commissioner, the Basutos are self-governing, and, in accordance with Moshesh's policy, intoxicating liquor is forbidden in the country, while only a few European missionaries and traders are allowed within its borders by special license.

Discovery of Diamonds.—The discovery of diamonds near the Orange river in 1867 opened a new chapter in South African history. The diamondiferous area, roughly enclosed in an oblong with the Orange to the south, the Hart river to the west, the Vaal to the north and the Orange Free State to the east, had for long been inhabited by Griqua clans under various chieftains of whom the best known were Waterboer and Adam Kok. The Free State had already bought some lands, ill-defined, of Adam Kok, before that chief was transferred with his Griquas to the country between Basutoland and Pondoland (East Griqualand) in 1862. Nicholas Waterboer, the principal Griqua chieftain left, had put himself in the hands of an ingenious attorney, Arnot, who on his behalf claimed practically all the diamond area, to the northern part of which the Transvaal and to the southern the Orange Free State also laid claim. The Transvaal claims were submitted for arbitration to Keate, lieutenant-governor of Natal, and for want of evidence were entirely rejected; the Free State was met with opposition from Waterboer and from the diggers themselves. Finally in 1871 the colonial secretary, although after 1854 his predecessors had specifically stated that England had no interests north of the Orange, authorized the Cape governor, Sir Henry Barkly, to take over the government of the Diamond Fields on the ground that the Crown alone would be able to regulate the unruly crowd of diggers. Arbitration by an outside power, proposed by Brand, the Free State president, was refused; but in 1876 Carnarvon, the next colonial secretary, practically admitted the justice of part, at any rate, of Brand's claim by a payment of £90,000 in satisfaction to the Free State. Griqualand West, as the territory was then named, was administered through a resident until 1880, when it was incorporated with the Cape.

Annexation and Retrocession of the Transvaal: Confederation Plans.—Under Brand's wise and tactful rule the Free State had already entered on an era of quiet but sound prosperity: but it was otherwise with the Transvaal. For eight years after the recognition of its independence in 1852 it still contained four separate and discordant governments, which were only unified into one republic in 1860. Even then its constant feuds with native tribes in the north and west had reduced it almost to bankruptcy. The last straw was an unsuccessful war against Sikukuni in the north in 1876, which convinced many of the burghers that almost any issue out of their embarrassments would be acceptable. At this juncture Carnarvon, who in 1867 had piloted the Dominion of Canada Act through parliament, was meditating plans for a confederation of South Africa on similar lines. It was not the first time that the idea had been mooted. Sir George Grey (*q.v.*), governor of the Cape from 1854 to 1861, had been deeply impressed by the waste of energy and the constant causes of friction due to the separation of South Africa into four independent communities, especially in the case of native policy which called for an united front from all Europeans. His idea was frowned upon at home and when, as a necessary preliminary to such a movement for union, he responded sympathetically to a proposal from the Free State for re-incorporation with the Cape, he was disavowed. (*See* also CAPE COLONY.) Now Carnarvon reverted to the idea and the method, and sent up Shepstone, an able Natal official, to the Transvaal with instructions to agree to its annexation if he found any disposition there in that direction. Shepstone found a section of the burghers willing to evade their difficulties by this solution; so in 1877 he proclaimed the annexation of the Transvaal. But thereafter everything went awry. Instead of leaving the South Africans to work out their own salvation Carnarvon prepared a scheme himself, chose delegates to consider it and sent out Sir Bartle Frere, a most distinguished Indian official, as governor of the Cape to carry through the measure. This in itself awakened suspicion in the Cape, which had only recently obtained responsible government and was very touchy on its privileges. The Transvaal soon repented of its change of master, especially since the appearance of the promised representative institutions was delayed. As a culmination of calamity the British arms had a serious loss of prestige at the beginning of the Zulu War of 1879, when Chelmsford was routed at Isandhlwana and the Prince Imperial's life was sacrificed through unpardonable bungling, disasters hardly retrieved by the subsequent defeat of the Zulus at Ulundi. In the following year came a change of ministry in England. Unfortunately Gladstone's cabinet was divided on the question of restoring to the Transvaal its independence, and did not make the offer of independence under the suzerainty of the Crown until the garrison of Potchefstroom had been forced to surrender to a Boer commando and Colley's force had been wiped out at Majuba in 1881. After this disaster and the retrocession of the Transvaal, which had the appearance of being a surrender to force, British prestige was at its lowest ebb in South Africa and no more was heard of Carnarvon's scheme. By the convention of 1881 the suzerainty of the queen over the Transvaal was safeguarded, but in 1884 Kruger persuaded Lord Derby to drop the term in a new convention, and the only remnants left of British influence over the South African Republic were certain stipulations for civil and trade rights and an agreement that no treaties should be made with other States, except the Free State, without the approval of the British Government.

South-west Africa and Bechuanaland.—A scramble for Africa had now begun and Great Britain thus found herself with a rival power at her very gates. Namaqualand and Damaraland across the lower reaches of the Orange river, although the sphere of the Rhenish Missionary Society's activities, had long been regarded as within the Cape's sphere of political interest, and in 1878 Carnarvon had sanctioned the occupation of Walfisch bay, the best port on the coast. But in spite of an actual invitation from Bismarck, owing partly to the dilatoriness of the Cape ministry, partly to the hesitation of Downing street, the opportunity of annexing the whole territory was foregone, and in 1884 it was taken over by Germany. Almost at the same time the Transvaal began to show an inclination to encroach beyond her borders and from the other side to seize the narrow strip of Bechuanaland territory bounded by the Kalahari desert along which the missionaries, Moffat, Livingstone and the rest, had penetrated into the interior; indeed, the only route left for expansion from the Cape northwards. Largely owing to the persistence of Cecil Rhodes (*q.v.*), then beginning his career in the Cape parliament, Cape politicians realized the danger in time. The missionary Mackenzie and Rhodes himself were sent up in turn to deal with the intruding Boers, who had actually set up the republics of Stellaland and Goshen over territory clearly outside the Transvaal by the terms of the recent convention, and finally 5,000 men were sent from England to assert British rights and proclaim a protectorate over Bechuanaland. This display of force was effective with Kruger and the "missionaries' road" was saved.

Rhodesia.—Rhodes had already formed a definite scheme for the utilization of this road. Already in his diamond-digging days he had learned from hunters and missionaries of the rich gold-bearing and pastoral land sparsely occupied by the Matabele since they had been driven north by the early Boer trekkers into the Transvaal. By 1888 he had secured a concession from the Matabele chief Lobengula to search and dig for gold in his domain, and in the following year obtained a royal charter incorporating the British South Africa Company to exploit the concession. In 1890 the pioneer expedition to take possession of the rights thus acquired was sent up to Mashonaland, the country east of Matabeleland, but subject to Lobengula's control; and the first settlement was founded at Salisbury. An attack in 1893 by some of Lobengula's braves on the settlement at Victoria further south was the occasion for the Matabele War, in which Lobengula was driven a fugitive from his capital Buluwayo, which was at once appropriated by the company as one of its principal stations. Again in 1896 the Matabeles rose against the English and this time were joined by the Mashonas, the race they had subjected when they invaded the country from the Transvaal. Rhodes himself, who had resigned his office of prime minister of the Cape after "the raid" (*see* p. 58), took part in the operations; and by his courage and diplomatic skill in dealing with the chiefs in their stronghold in the Matoppos secured a satisfactory settlement.

Rhodes and Kruger.—After Majuba prospect of co-operation between British and Dutch was retarded. In 1879, partly as a protest against the annexation of the Transvaal, du Toit had founded the Afrikander Bond, with the avowed object of removing the British power and influence entirely from South Africa; its main branch was at the Cape, but branches were also formed in the two republics. Fortunately the Bond soon lost influence in the republics, while in the Cape it lost much of its anti-British savour when the great leader and organizer of the Dutch, J. H. Hofmeyr, captured the organization in 1882 with the far less provocative objects of encouraging the use of the Dutch language and training his fellow-countrymen to take an interest in Cape and also South African politics. In these objects he found a strong ally in Cecil Rhodes, who, having founded the great de Beers mining company at Kimberley, first appeared in the Cape parliament in the same year, 1880. Rhodes in his musings at the diamond diggings had elaborated a vision of a united South Africa under the British Crown with a people welded together harmoniously from the two elements, Dutch and English. With such a people he hoped to extend British influence throughout the interior of Africa, and as his plans progressed, to effect a junction with the hand stretched out by other British adventurers in East Africa, Uganda and Egypt. In the aim of uniting the races and states of South Africa, at any rate, he was at one with Hofmeyr, and with his support he attained the post of prime minister at the Cape in the same year that he launched the pioneer expedition into Matabeleland. Never have the Dutch and English worked so well together at the Cape as during his sympathetic ministry. But he found an apparently insurmountable obstacle to his larger plans in the antagonism of the Transvaal.

The Transvaal was then ruled almost absolutely by President Kruger, who as a boy of ten had accompanied his parents in the

Great Trek from Cape Colony and had never lost the distrust of the English then inculcated into him and only intensified by his dealings with them between 1877 and 1884. Thenceforward one of the chief aims of his policy was to keep his people as far as possible uncontaminated by association with the English or any of their governments. But by an irony of fate this proved the last thing he was able to achieve. In order to be independent of the Natal and Cape ports he had a railway from the Portuguese port at Delagoa bay built by 1894, and in the same year secured the neighbouring native State of Swaziland as a step toward a port of his own at Kosi bay. But Kosi bay was annexed by England, and the Delagoa bay railway could not compete effectively with the railways from the colonial ports. Again in his attempts to secure support from Germany he obtained little beyond friendly gestures, as he found after the Raid and during the South African War. But his worst blow had been the discovery of gold in almost unbelievable quantities on the Witwatersrand in 1886, whereupon the hated English, with Frenchmen, Germans, Jews and others, Rhodes himself among the first, came flocking into the Transvaal to exploit the Eldorado. Though Kruger could not prevent this influx, he at least made it as uncomfortable as he could for the invaders. In spite of the fact that the population of the Rand, almost all foreigners and mostly English, numbered some 80,000, four times as great as that of the Boer citizens, and that it contributed nineteen-twentieths of the public revenue, it was not allowed any voice in the affairs of the State, nor even in the municipal affairs of Johannesburg itself. Moreover their industry was systematically fleeced by the friends of Kruger, many of them Hollanders and Germans, to whom he gave monopolies in dynamite, an essential material in mining, in liquor, whereby they were enabled to debauch the native workers on the mines, and in the transport of coal required for the mining machinery. Indeed the Johannesburgers were appropriately called *uitlanders*. Once, indeed, in 1895, in his anxiety to do injury to anything connected with Britain, Kruger went too far, when he attempted to injure the Cape export trade into the Transvaal and the Cape railways that were competing with his Delagoa bay line, by not only making the rates over the few miles of line in the Transvaal prohibitive, but also closing the drifts to prevent the carriage of goods by waggon from the Vaal. This was a distinct breach of the 1884 Convention and the colonial secretary, Chamberlain, agreed to support the Cape ministry's protest by force, if necessary; whereupon Kruger gave way.

The Jameson Raid.—Rhodes thus determined to encourage and finance a revolution in Johannesburg, and used his position as prime minister and also as head of the chartered company to organize an armed raid into the Transvaal. The raid was to be effected with Chartered Company troopers under the command of Rhodes's great friend Jameson, then administrator of Rhodesia, and there was no difficulty in collecting such a force with adequate secrecy. But there was no suitable jumping off ground for the raid except in a strip of the Bechuanaland protectorate under the control of the Imperial Government. Accordingly, on the plea that it was necessary to have this strip for the projected railway from Kimberley to Rhodesia, Rhodes secured the strip from the colonial office in time for the raid. On Dec. 29, 1895, Jameson rode in with his troopers from Pitsani near Mafeking: but the Johannesburgers were not ready and gave him no support; four days later Jameson surrendered to the Boer commandos called up to repel him.

After the raid Rhodes had to resign his offices and was condemned for his part in it by committees of the Cape and imperial parliaments. But the grievances of the *uitlanders* still remained unredressed and were the occasion for a controversy conducted with growing exasperation on both sides. A direct negotiation between Milner, the new high commissioner and governor of the Cape, and Kruger at Bloemfontein in June 1899 led to the refusal of Kruger of an effective franchise and on Oct. 9 Kruger's Government issued an ultimatum. The course of the South African War is described in the article under that heading.

Reconstruction.—By the treaty of Vereeniging of May 1902 the Boer delegates from both republics agreed to give up their independence; they were promised cash and a loan to repair the ravages of war and full responsible government at any rate before the franchise was given to the natives. Immediately afterwards Botha and other leaders went to Europe to try and obtain better terms from Chamberlain and also to raise a fund on the continent for the Boer peoples; but had little success. The work of reconstruction which affected the whole of South Africa was almost entirely the work of Milner and his devoted staff of young helpers whom he had brought out from England, Milner himself being governor of both the annexed republics, with two lieutenant-governors under him. In the Cape the chief problem was how to deal with the Dutch rebels who in the later stages of the war had joined or openly helped the Boer raiding forces. At one time, indeed, the rebels had appeared to be so serious a danger that it was proposed to suspend temporarily the Cape constitution; but wiser counsels prevailed, and after the peace the rebels were let off lightly with little more than temporary disfranchisement as a penalty. Natal was given the two neighbouring districts of Vryheid and Utrecht, which gave it a firmer control over Zululand. But the great problem was with the old republics. Most of the farms had been destroyed in the course of the long war, while the Boer women and children had been cared for by the British in concentration camps away from their homes. The fighting forces, prisoners of war, women and children had all to be sorted out and taken to their own places; houses had to be built and seed, agricultural instruments and cattle to be supplied; and the schooling which had been provided for the children had to follow them up to their homes. At the earliest moment Crown colony government with a nominated legislative council was established in both colonies; but as the leading Boers would not accept nomination the arrangement was unsatisfactory. Not the least of Milner's preoccupations was to devise a temporary system which should facilitate transition to a hoped for confederation of all the four colonies. Thus for the two colonies of which he was governor he established a common railway system and debt service and a joint constabulary: as high commissioner responsible for all intercolonial affairs he appointed a commission to investigate the whole native problem of South Africa; and in all intercolonial conferences about customs and railway rates agreements he consistently showed a willingness to yield points on behalf of the inland colonies for the sake of harmonious cooperation.

THE UNION OF SOUTH AFRICA

Grey, Carnarvon and even Milner himself had all thought that union would most easily come by a preliminary merging of one or more of the various constituents of South Africa with a more dominant colony: this too had perhaps been Kruger's idea. But the actual method of approach was not found until all the four colonies could meet together as independent entities and on absolutely equal terms. This condition was secured far sooner than almost anyone could have expected by Campbell Bannerman's courage and faith in granting full responsible government to the two new colonies within five years of the peace of Vereeniging. The confusion of four separate governments for a total European population of less than a million and a quarter were obvious. These and other considerations were brought out in a lucid and convincing memorandum largely prepared by Lionel Curtis and his friends and adopted by the new high commissioner, Lord Selborne, who then issued it with a covering letter in Jan. 1907 at the request of Jameson, then prime minister of the Cape. The memorandum was actually published just before the two new colonies obtained responsible government, in January and June 1907 respectively: but, as soon as the new governments had found time to take stock of South African affairs, they heartily agreed with the Cape and Natal in welcoming a national convention to formulate a plan of union. This convention, which met successively at Durban and Capetown and was attended by delegates not only from the four self-governing colonies but also from Rhodesia, lasted from Oct. 1908 to the following February and elaborated the constitution of the Union in very much the same shape as it was finally adopted by votes in the parliaments of all the colonies except Natal, which accepted it by a referendum to all the voters. Passed by the imperial parliament by an act of 1909, the Union of South Africa was established on May 31, 1910, under the auspices of a new governor general and high commissioner, Lord Gladstone, son of the great statesman who had formerly restored its independence to the Transvaal and himself a member of the Government which had so promptly granted self-government to the new colonies after the war.

Certain characteristics of the Union constitution, due to the special circumstances of South Africa, are noteworthy. Much friction was avoided at the earliest sittings of the convention by the decision to make Dutch, equally with English, an official language. In the last sittings the question of the capital threatened to split the delegates irretrievably; but finally the difficulty of reconciling rival claims was overcome by the ingenious device of making Pretoria the seat of government, Bloemfontein the seat of the judiciary and Capetown the meeting place of parliament, an arrangement which has at least the merit of causing legislators and ministers to travel about the Union more than they would otherwise. It was found impossible to devise a uniform scheme of franchise or non-franchise for the natives; so the more liberal system of the Cape in making no distinction of colour, but only of education, was retained and safe-guarded there, while the other colonies kept their own exclusive system. Provision was made for Rhodesia's future admission to the Union on terms to be approved by the privy council, and also for enabling the Union to take over the native protectorates of Basutoland, Bechuanaland and Swaziland, on special terms laid down in a schedule and drawn up in consultation with the high commissioner, but only after obtaining the consent of the Imperial Government, which had special obligations to these territories.

The form of constitution adopted was as far removed as possible from that of the Australian Commonwealth, the latest confederation of British colonies before the Union of South Africa. There the aim had been to retain as much of the separate states' particularism as was consistent with any form of confederation. But in South Africa the constitution, as it came from the convention, formulated what was practically a unitary state for the whole of South Africa, with a truly sovereign parliament (subject of course to the purely nominal overriding power of the Imperial parliament), though with certain municipal rights left to the provinces, *i.e.*, the former self-governing colonies.

Botha's Ministry.—On Lord Gladstone fell the duty of choosing the first prime minister of the Union Government. It was a difficult choice, as he had none of the guidance available normally to constitutional rulers from the trend of parliamentary opinion. A suggestion had been made that a junction between Jameson and Botha as representing the two main nationalities and parties in South Africa might effectively start the new venture on harmonious lines; but Botha found the idea impracticable. Then the choice lay between Merriman, the grand old man, as he might have been called, of South African politics and Botha, both actual prime ministers of the two leading provinces of the Union, the Cape and the Transvaal. Merriman himself and the Cape generally, as the senior colony, thought he was entitled to it: but Gladstone chose Botha, a choice which was amply justified by the event. Botha was successful in securing representatives of all four colonies in his ministry, in which besides himself the other outstanding figure was his *fidus Achates* General Jan Smuts (*q.v.*). It was indeed a party ministry, and at first it was chiefly supported by the Boers with insignificant exceptions.

The supreme aim of General Botha was conciliation between the two European races, which he hoped in time to weld into one Afrikander race; he also was determined to abide loyally by the spirit of Vereeniging and, from policy as well as sentiment, attached importance to the imperial connection. On the other hand there were many Boers, of whom the chief representative in the cabinet was General Hertzog, who were afraid of the insidious influence of British ideas, and were determined to keep the old Boer Afrikander strain undiluted. Botha's suggestion of a contribution to the navy at the Imperial Conference of 1911, his willingness to welcome immigration from Britain and his curt declaration that if Great Britain were at war, South Africa would necessarily be involved in it: all these indications awakened the alarm of Hertzog and his adherents; and he gave expression to this alarm in two public utterances that entirely ran counter to Botha's conciliatory policy. Since Hertzog would not resign, Botha himself resigned and on being entrusted with the formation of a new ministry in Dec. 1912 excluded Hertzog. In the following year when the whole subject of policy was brought up at a general meeting of the South African party, while Botha secured the approval of the majority of those present, an appreciable minority, in agreement with Hertzog's views and led by de Wet, seceded. Thus Botha was more and more driven into cooperation with the progressive or unionist and mainly British party and lost much support from the backveld Boers.

Education.—With two races and two languages, education has been a controversial subject. The Boers naturally wished their children to be taught in their own language, at any rate in the early stages; but against that were two obstacles, one that it was difficult to find enough good teachers who were also bilingual for schools where the races were mixed, the other that there was some difficulty in deciding between true Dutch and the *Afrikaans* form of it. Before the Union Smuts had introduced a fairly satisfactory compromise in the Transvaal, making the medium of instruction the home language up to the 3rd standard and English as the medium in all except two subjects thereafter; but Hertzog in the Free State had made the mother tongue the medium up to the 4th standard and insisted on more Dutch in the higher standards. After the Union, parliament exercised its over-riding right of final decision even in educational questions by setting up a committee to report on the language question, as a result of which a compromise was adopted between the Transvaal and Free State arrangements. This report was more or less adopted by the four provinces. Primary education is now compulsory and free for all European children in the Union.

Native Policy.—One of the most important reasons for union and one of the most difficult problems to adjust was the elaboration of a consistent native policy uniform for the whole of South Africa. The importance and urgency of the problem is evident from the mere fact that in 1911 out of a total population in the Union of 5,973,394 no fewer than 4,019,006, *i.e.*, 67·3%, were natives, as compared with only 1,276,242, *i.e.*, 21·4%, Europeans, the remainder of the population being made up of 11·3% Asiatics and mixed races. Each of the four colonies had had a different system of administration for this large population of natives. In the Cape ever since 1854 there had been nominal equality between Europeans and educated natives, who enjoyed the privilege of the franchise; and a clause in the constitution specially safeguards this native franchise at the Cape against precipitate abolition by a majority from the other provinces. But since Rhodes's introduction of the Glen Grey Act in 1895 the policy of entrusting natives of the Transkeian territories, where there were hardly any European settlers, with a large measure of responsibility for their own affairs, encouraging them to adopt individual tenure of their lands, and at the same time depriving them of the franchise for the Cape parliament, had been greatly extended. In Natal, though theoretically the natives had the same rights to the franchise as in the Cape, in practice only a handful exercised it: the serious rebellion in Zululand in 1906 had brought home to Natal the weakness of its native administration and recently the care of the natives had been entrusted to an expert commission almost independent of parliament. In the Transvaal and the Orange Free State the natives were still under the same régime as in the old republics, obliged to hold identification passes, subject to heavy hut-taxes, unable to hold land of their own and mostly confined to ill-defined reserves or to squatting on farmers' lands with much the same status as villeins; in the mining areas of the Transvaal there were also specially stringent pass provisions and enactments as to enlistment and employment of natives. This discordance of policy was recognized as a danger, all the more as with education and a growing tendency among natives to get employment in various parts of the Union and compare notes with one another, those more drastically repressed were beginning to demand the more favourable treatment accorded to others. Above all the feeling that they were being crowded out by a minority of Europeans from their just requirements in land was causing discontent. A commission appointed by Lord Milner before the Union had already made a comprehensive report on the whole native policy, and many commissions have since been constituted to investigate detailed aspects of the problem. But hitherto the difficulties have been too great to formulate a satisfactory and comprehensive policy for the whole Union. Some reforms however have been introduced. In 1911 a Native Labour Regulation Act was passed to apply to labour districts, similar to the Transvaal mining areas, throughout South Africa, and in some respects making better provision for the welfare of the natives. In 1913 the Natives Land Act merely provided that natives and Europeans should not encroach on one another's lands, but foreshadowed a measure providing that more land should be made available for natives. So far, however, in spite of commissions and committees, the difficulties in giving material expression to this good intention have not been overcome. Useful legislation, however, has been passed in the Native (Urban Areas) Act of 1923 which makes for uniformity in the housing, etc., of natives in locations within urban limits, and still more by the act of 1925, which at last enacts one consistent system for the taxation of natives throughout the Union, while a great step forward was taken by Smuts in 1920 in securing more sympathetic and harmonious relations with the natives by the institution of a special Native Affairs Commission devoted to their interests and the revival of regular conferences with representative bodies of natives.

These measures, owing to the difficulty of finding a generally acceptable solution of the whole problem, have necessarily been of a piecemeal nature. The one serious attempt to deal with native policy as a whole has been put forward in General Hertzog's declaration of policy in 1925. He proposed to abolish the Cape franchise for natives and to substitute for it a system applicable to the whole Union, whereby the natives of South Africa should elect seven Europeans to represent them in the House of Assembly; secondly that additional land should be provided for the sole use of natives and that the system of native councils to decide on their own local affairs, which has been so successful in the Transkei, should be largely extended. The whole tendency of these proposals is, it is evident, to raise even higher the barrier between Europeans and natives, on the avowed principle that the only method of retaining a white South Africa is by preventing either natives or Europeans from trenching on one another's preserves. In 1925, largely in deference to the labour section of his supporters, Hertzog introduced the first instalment of his programme with the bill legalizing a "colour bar," whereby in certain districts natives, and Asiatics too, were to be absolutely prohibited from engaging in any skilled or semi-skilled employment where they might compete with Europeans and be confined to unskilled labour. This bill provoked intense opposition from the natives as also from Smuts's South African party and especially from those members used to the more liberal methods of the Cape: so bitter was the controversy that it was rejected by the Senate in 1925 and only passed into law in 1926 after a joint sitting of both houses. So far the other proposals in Hertzog's scheme, which have also evoked deep suspicion in the natives, have not been passed into law.

Asiatics.—In the Cape province the Asiatic, or Malay community as it was called, dating originally from the days of Dutch rule, has in time fitted itself harmoniously into the rest of the community: and a charming picture it is that Lady Duff Gordon gives in her *Letters from the Cape* (1927) of this community as she saw it in the early sixties. But difficulties have arisen from Asiatics at first (since 1860) imported under indenture from India to cultivate the Natal sugar plantations. There was at first nothing to prevent these Indians, after finishing their indentures, from settling in the country with their families; and they not only did so but began spreading as small traders or market-gardeners into the Transvaal and the Free State. Soon all three colonies began to object to the settlement of this third great race in South Africa, already enough troubled with problems arising from the juxtaposition of Europeans and the sons of Ham. Smuts himself as minister of the Transvaal had already had much trouble with them and their redoubtable leader Gandhi on the very eve of Union. From the outset of the Union Government the trouble recurred in an aggravated form. The question did not merely affect South Africa, for the Indian Government took a deep interest in the complaints of its citizens and the Imperial Government was much concerned at the difficulties experienced by members of one part of the empire in another. But South Africa was determined that no more Indians should be allowed to come into the country and become residents and that those already there should be restricted in their movements. After much disturbance and negotiation with India, the Immigrants' Act of 1913 was passed, which without directly mentioning Indians, stopped their immigration and retained the objectionable £3 tax on those left in the country; this act, however, after further agitation and negotiation with Gandhi, was modified to his satisfaction by the abolition of the tax and other slight concessions. Until 1919 this arrangement held, when the Indians already domiciled in the Transvaal found themselves suddenly deprived of their right to hold property and trade by a Gold law of 1908; while in 1924 the Natal Indians lost the Natal franchise they had hitherto enjoyed, and a Class Areas bill was introduced empowering the government to segregate Asiatics in reserved areas. Once more excitement flared up in the Indian community and in India itself: finally an arrangement was made with representatives from India whereby Indian rights were respected and a distinguished Indian was permanently stationed in South Africa to look after his fellow-countrymen's interests.

Labour Questions and Strikes.—One of the most notable developments since the Union has been the rise of a strong white labour party, with its strength centred chiefly on the Rand. Its programme resembles that of the Australian labour party with its emphasis on the maintenance of a high standard of wages and conditions of labour for all skilled and semi-skilled European workmen and the rigid exclusion of all but these from participation in such work. White labour had many grievances on the Rand and elsewhere that called for redress: trade unions were insufficiently recognized by mine managers; and the havoc of miners' phthisis, owing to inadequate precautions, was alarming. The first outburst occurred in 1913 when a strike occurred on the Rand owing to a dispute between a manager and some miners: for a time Johannesburg was at the mercy of the strikers until Botha and Smuts were forced to call in imperial troops, as the new citizen force was not yet organized. After some casualties a truce was patched up whereby the unions were recognized and remedies for other grievances were promised. But in the following year the trouble broke out afresh with redoubled violence. Owing to a dispute in the Natal coal-fields a general strike was proclaimed which affected not only the Rand but also the government railways. But this time Smuts was ready with his new citizen force. Sixty thousand men were hurried on to the Rand, martial law was proclaimed and within a week all the labour leaders in the Union had been arrested and ten of the chief agitators summarily deported without trial. Smuts's excuse for this high-handed action was "that the Government could not run the ordinary risks of the law-courts"; but he was severely criticized for it not only in England but also in South Africa, where the Government's indemnity bill was hotly debated and was followed by a labour majority in the elections for the Transvaal Provincial Council. Once more in 1922, when Smuts was prime minister he had to suppress a strike on the Rand, partly due to labour troubles, partly to republican agitation, which, owing to its violence, was called the reign of red terror and was not overcome till 10,000 agitators had been arrested. These ruthless, however necessary, repressions naturally led to the persistent opposition of the labour party to Smuts personally and eventually to its junction in 1923 with the Nationalists under Hertzog. Nevertheless both Botha and Smuts during their ministries, which lasted from 1910 to 1924, introduced several improvements in the conditions of labour, such as acts directed against the scourge of phthisis in 1911 and 1919, acts for the security of workmen's wages and for compensation against accidents, and a scheme for arbitration and conciliation in labour disputes, measures which have been further elaborated by the Hertzog Government. Since the Union also the whole railway system has been unified and the vexatious differential railway rates and customs between the different colonies abolished.

The War and the Rebellion.—When the World War broke out in Aug. 1914 many of the Boers wished to stand out of it altogether, but Botha and Smuts were determined to abide by the empire. They relieved the home forces by offering to dispense entirely with imperial troops and be responsible for South African defence, and further agreed to conquer German South-west Africa. But before doing the last they had to meet a serious rebellion among some of their own people, who wanted entirely to disassociate the country from Britain's concerns. Beyers, the commander of the Defence Force resigned and with de Wet and others collected a force to resist the Government; the commander of the border force went over to the Germans. In this crisis Botha, sorely against his will, decided it was his duty to take the field against his own rebellious Boers; but he and Smuts decided that their suppression must be entirely the work of Boers, for if troops of English origin were employed fresh racial bitterness would surely ensue. Beyers and later de Wet, the two chief rebel leaders were defeated with comparative ease in Oct. and Nov. 1914, and the bitterness aroused was considerably assuaged by the very moderate punishments inflicted on the rebels.

Botha was then able to turn his attention to his task of capturing South-west Africa. The waterless country rather than the comparatively small numbers of the German troops proved the most formidable enemy in the campaign which lasted from March to July 1915, when the German forces surrendered themselves and their colony unconditionally to Botha. The easy victory was due to fine organization for which Botha and Smuts were responsible.

After this success, South Africa as a whole took no direct part in the war, but no fewer than 50,000 South Africans fought in German East Africa, where Smuts was in command during 1916, while about half as many went overseas to Europe, gaining great honour for themselves and their country in such engagements as Delville Wood and Givenchy; in addition nearly 100,000 Bantus volunteered for work behind the lines in labour battalions. Smuts himself left the East African command only to take a seat in the Imperial cabinet during the rest of the war, while he and still more Botha were notable figures at the Versailles conference, where they signed the Treaty as equal representatives of South Africa with the other allies and dominions.

South-west Africa.—One provision of the treaty attributed to South Africa as a mandatory of the League of Nations the administration of South-west Africa. At first the administration was placed under the arbitrary rule of an administrator, G. R. Hofmeyr, assisted by a nominated council of which half the members were Germans. In 1922 the attention of the Mandates Commission of the League of Nations was directed to the methods of the administration in suppressing a revolt of the Hottentot tribe of Bondelswarts, whereby 100 men, women and children were killed, and some strictures were passed on the administrator's policy in the matter. Otherwise the territory has prospered; although about half the 15,000 Germans in the territory at the time of its occupation returned to Germany, some 10,000 South Africans have taken their place and the administration has done much by railway, roads and irrigation to increase the country's prosperity, while a long-standing boundary dispute with the Portuguese Government of Angola was amicably settled in 1926. But before this a demand had come from the European inhabitants for some voice in the administration. Partly elective municipal institutions were granted in 1922, but for a more extended electoral system it was necessary to regularize the position of the Germans, who were still technically aliens. Under an agreement negotiated with Berlin by Smuts in 1923, the Germans automatically received British citizenship, unless they elected specifically not to accept it, and in 1925 a regular system of partly representative executive, legislative and advisory councils was established. The territory may ultimately be incorporated in the Union.

Rhodesia, Swaziland and Bechuanaland Protectorate.—A section of the South Africans—and notably General Smuts—was desirous, when in 1922 the British South Africa Co.'s régime in Rhodesia came to an end, to incorporate that country in the Union. The issue was left to the vote of the settlers in Rhodesia, who, in spite of the very favourable terms offered them by Smuts, preferred to have an independent and responsible Government of their own. To this incorporation the Imperial Government would have offered no objection; but it was different with a proposal mooted in 1924 for the incorporation of Swaziland and Bechuanaland, over which the Imperial Government exercised a protectorate. Here the white settlers are few compared with the natives, on whose behalf the Imperial Government has undertaken special responsibilities, and, as the natives do not appear to be anxious for the change, it is not likely to be effected in the near future.

The Hertzog Ministry and the Flag Question.—Botha, the first prime minister of the Union, died in Aug. 1919. On General Smuts, his devoted follower, naturally fell his mantle. He had aroused suspicion among the Dutch by his participation in imperial affairs and the lukewarmness attributed to him in supporting the Dutch point of view when it conflicted with that of the British; by his conduct in combating the various strikes on the Rand he had made a bitter enemy of the growing labour party led by Col. Creswell. In 1920, after a general election he found himself in a minority in the house, and, after one more effort to heal the breach with Hertzog and his Nationalists, he saw there was nothing for it but a junction with the Unionists, who had given general support to Botha and himself since 1914. In 1921 he formed a coalition ministry with them and in the ensuing general election improved his position in the house. At the same time the Nationalists, an entirely Dutch party, and the Labour party, predominantly English, were tending towards an alliance which was practically consummated in 1923. The alarm felt by the Labour leaders at the talk of Hertzog's supporters of a desire to cut adrift from the empire was overcome by assurances from Hertzog. The parties found much in common in their native policies, the Labour party being determined to limit the Kafirs to purely unskilled work, and the Nationalists for somewhat different reasons being anxious to keep them frankly in subjection to the Europeans. The most hopeful result of these two alliances, Labour-Nationalist and South African-Unionist, was that parties were not divided on national lines, but each an admixture of Boers and English.

Smuts once more went to the country in 1924, after a defeat at a by-election, and found himself in a minority of 27. Hertzog then formed a ministry of Nationalist and Labour elements and introduced the native and labour legislation already described. But the measure which stirred the country to its depths and at one time threatened to split the ministerial coalition was the Flag Bill of 1926. To take the place of the Union Jack the Nationalists demanded a new flag for the Union, which should express something of the history of the Afrikander nation and especially the traditions of the old republics. This was only reasonable, but unfortunately in the flag originally suggested practically every symbol of the imperial connection had been eliminated. All those of English blood, including many of the Labour party, were at once up in arms and the controversy was so acute that a decision was wisely postponed for that year. Shortly afterwards followed the imperial conference at which the new and almost independent status of the dominions was defined in a document of which Hertzog, who had helped to draft it, said that it "lays a deep and enduring foundation for national cooperation by members of the British Commonwealth of Nations." But on his return the flag controversy was revived, Natal threatened to secede and opinion was even more enflamed than before, when, by one of those suddenly inspired compromises, by which, before now, South Africans have averted a calamitous breach, the bitterness of the struggle was assuaged, and a place found in the new national flag for the Union Jack to symbolize the strong sentiment for the empire felt by a large section of South Africans.

Characteristics.—The South African census perhaps wisely does not attempt, directly at any rate, to distinguish between the two principal European races in the country. But there is no doubt that those of Dutch origin exceed in numbers those of

English descent. Besides numbers the Boers have two great sources of strength, in their being mainly those attached to the soil as farmers or pastoralists, and also because their sole attachment, the only country to which they look, is South Africa itself. Those of English descent, even when they have made South Africa their only home and look to descendants to live on in that home, have almost invariably a further attachment to the mother-country.

South African literature is dealt with below. In art the greatest achievement of the South Africans is to be sought in architecture, especially that of the old Dutch farmhouses still to be found at the Cape, beautifully adapted to the climate and the needs of the inhabitants—buildings to some extent imitated, but developed for more modern conditions, by the genius of Herbert Baker, the architect of the best modern public and private buildings.

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History: H. C. V. Liebbrandt, *Précis of the Archives of the Cape of Good Hope*, 10 vols. (1896–1906): these vols., each under separate title, contain documents dating from Van Riebeek's Journal (1651–62) to 1806; Sir E. Hertslet, *Map of Africa by Treaty*, 3 vols. (1896); Sir C. Lucas, *History of South Africa to the Jameson Raid* (1899); G. McCall Theal, *History and Ethnography of Africa, S. of the Zambesi, 1505–1795*, 3 vols. (1907–10); *History of South Africa since 1795*, 5 vols. (1908–10); *Records of the Cape Colony 1793–1827*, 36 vols. (1897–1905); *Records of South Eastern Africa*, 9 vols. (1898–1903); F. R. Cana, *South Africa from the Great Trek to Union* (1909); Sir G. Cory, *The Rise of South Africa to 1857*, 4 vols. (1910–26; is not yet finished), a carefully edited and well-documented history, of which vol. i. (to 1820) is the best; A. Wyatt Tilby, *South Africa 1486–1914* (1914); G. W. Eybers, *Select constitutional documents illustrating South African history 1795–1910* (1918); *Van Riebeek Society Publications* (1918–26), original reports, journals, etc., of early Cape times; A. P. Newton, *Select Documents re Unification of South Africa*, 2 vols. (1924); *Official year book of the Union of South Africa*, published periodically at Pretoria.

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Miscellaneous: John Pinkerton (ed.), *Voyages and Travels*, vol. xv. (Thunberg's account of the Cape of Good Hope, 1814); Olive Schreiner, *Story of an African Farm* (1883); Lord Bryce, *Impressions of South Africa* (1897); Lady Anne Barnard, *South Africa a Century Ago* (1901); E. H. Crouch (ed.) *Treasury of South African Poetry* (Capetown, 1907); S. G. Millin, *The South Africans* (1926).

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SOUTH AFRICAN LITERATURE. The earliest of the books written in or about South Africa were naturally devoted to description of the country and its inhabitants.

The best of those in English is *Travels in the Interior of Southern Africa* (1822) by William John Burchell. Among many later works David Livingstone's record of his early explorations entitled *Missionary Travels and Researches in South Africa* (1857) is of outstanding importance. South African literature proper must be divided into that written in English and that written in Afrikaans.

ENGLISH

The first poet with any claim to be called South African is Thomas Pringle (1789–1834), who spent six years in the country as librarian and journalist. Among his poems the best known are *Afar in the Desert* (1828), which was highly praised by Coleridge; *The Lion Hunt*, and *The Bechuana Boy*. It was some time before any other notable work in verse appeared. A recent anthology, *The Centenary Book of South African Verse* (1925), edited by Francis Carey Slater, contains poems by 68 writers, most of whom are still living. Slater's own poetry is saturated with the feeling of the country to which he belongs. Among his works are *The Sunburnt South* (1908), and *The Karroo and other Poems* (1924). Arthur Shearly Cripps, for many years a missionary in Mashonaland, has written poetry in which the influence of Oxford is blended in a surprisingly beautiful way with that of the country to which he devoted the best part of his life. His poems include *Pilgrimage of Grace* (1912), *Lake and War* (1917); and he has also written stories of life in those remote parts, including *Faerylands Forlorn* (1910), *Cinderella in the South* (1918) and *Lion Man* (1928). Cullen Gouldsbury, for several years a native commissioner in Rhodesia, showed poetical gifts of a high order in his *Songs out of Exile* (1912) and *From the Outposts* (1914). Mary Rosalie Boyd, in her poem *The Veld*, which won the Capetown Bardic Chair in 1921, has finely expressed the fascination exercised by South Africa upon those who come to make it their home. Charles Murray, formerly chief of the Public Works Department, has written some excellent poetry, mainly in a Scots dialect. *Hamewith* (1909), *A Sough of War* (1917) and *In the Country Places* (1920) are among his volumes. Arthur Vine Hall has published his collected poems under the title *Poems of a South African* (1926). Roy Campbell, one of the youngest of South Africa's poets, made a startling appearance with *The Flaming Terrapin* (1924). Among his later poems *Tristan da Cunha* gives promise of more mature work with an increasing feeling of historical atmosphere.

The most famous novel yet produced in South Africa is Olive Schreiner's *Story of an African Farm* (1883), which with all its faults has the stamp of genius. Some of Rider Haggard's most thrilling stories, such as *King Solomon's Mines*, *Jess* and *Swallow*, belong to South African literature, for they arose directly out of his residence in that country. William Charles Scully, a magistrate in the Cape Colony, has written stories based on a first hand knowledge of native life. *The White Hecatomb* (1897) and *A Vendetta of the Desert* (1898) are among his works. *Margaret Harding* (1911) by Percival Gibbon, and *God's Step Children* (1924) by Sarah Gertrude Millin, deal with the difficult problems arising out of the contact of the white races with the black. Pauline Smith, a young writer born in the district of Oudtshoorn, has published some short stories under the title of *The Little Karoo* (1925), which are marked by a fine sympathy and sincerity.

In history and biography some valuable work has been done. The letters of Lady Anne Barnard belong in a sense to both categories. Though not published till 1901 (*South Africa a Century Ago*) they give a vivid picture of life at the Cape about 1800. An interesting account of the writer is given in Dorothea Fairbridge's *Lady Anne Barnard at the Cape of Good Hope* (1924), which includes much previously unpublished material. Among many later workers the name of George McCall Theal (1837–1919) stands out conspicuously for the untiring industry which he gave to investigating the original records upon which the work of future historians must be based. Sir George Cory's *Rise of South Africa* (1910 *seq.*) deals mainly with the development of the eastern part of Cape Colony, and gives the results of many years of patient research. Another work of outstanding importance is *Lord de Villiers and his Times* (1925), by Eric A. Walker, professor of history in the University of Capetown, who has also written a valuable *History of South Africa* (1928). An extensive literature has gathered round the name of Cecil John Rhodes, including lives by Sir Lewis Michell and Sir Thomas Fuller. Ian Colvin's *Life of Jameson* (1922) and Earl Buxton's *General Botha* (1924) are also of importance. Frederick Charles Kolbe (Monsignor Kolbe), a poet and critic of distinction, has written a delightful autobiography entitled *Up the Slopes of Mount Zion* (1924). *Education in South Africa 1652 to 1922,* by Ernst G. Malherbe, is a useful survey of an important subject. Among many works dealing with the difficult and complex problems involved in the relations between the Europeans and the natives may be mentioned *Black and White in South-East Africa* (1911) by Maurice Evans; *The Education of the South African Native* (1917) by C. T. Loram; and *The History of Native Policy in South Africa from 1830 to the Present Day* (1924) by Edgar H. Brookes. The views of the natives themselves have found expression in *The Black Problem* by D. D. Tengo Jabavu, and in other works. *A History of Christian Missions in South Africa* (1911) and *Thrice through the Dark Continent* (1917), a record of missionary travel by Prof. J du Plessis, deal with another aspect of the same subject.

See Mendelssohn, *South African Bibliography* (1910). (H. C. N.)

AFRIKAANS

Afrikaans is the name given to the language spoken and written by the descendants of Dutch, French and German colonists who settled in South Africa prior to the British occupation of 1806. Formerly the language was also known as "Cape Dutch" or "the Taal" (Dutch for "language"). Afrikaans has developed from the seventeenth century dialects of the province of Holland; but though it still agrees very closely with these dialects and with literary Netherlandish Dutch in sounds, syntax, vocabulary and idiom, it shows a striking simplification in its flexional system, having become even more analytic in its structure than English. Isolation from Holland, the almost total absence of conserving influences like schools and literature, the novel surroundings and changed occupations, and the incorporation of numbers of French Huguenots and German immigrants account for the rapid development of a form of speech grammatically as distinct from the Dutch of Holland as Shakespeare's English is from that of King Alfred. There is considerable evidence to prove that Afrikaans had reached its modern form not much later than 1750.

Till quite recently, however, the language employed in writing was modelled on that used in Holland, and particularly on that found in the seventeenth century version of the Bible. Apart from one or two stray rhymes in old newspaper files, a few documents by unschooled writers, and a word-list of 1844, we find no written Afrikaans before 1860. In that year the magistrate of Cradock, Louis Henri Meurant, anonymously published a political dialogue in what was almost pure Afrikaans. Meurant's example proved infectious, and Afrikaans articles began to appear in several newspapers. In 1870 followed the well-known adaptation of Burns' "Tam o' Shanter" ("Klaas Geswint en sy Perd") by F. W. Reitz, afterwards Chief Justice and later President of the Orange Free State. In 1872 a movement in favour of Afrikaans as a written language was initiated by A. Pannevis, with whom C. P. Hoogenhout soon afterwards became associated. In 1875 a society, "Die Genootskap van Regte Afrikaners," was founded at the Paarl with the avowed object of working for an Afrikaans Bible and an Afrikaans written language. After a considerable amount of success with a newspaper (*Die Afrikaanse Patriot,* 1876–1904), a monthly magazine (*Ons Klyntji,* 1896–1905), and a number of other publications, the movement collapsed, largely owing to the fact that its leader, the Rev. S. J. du Toit, began to entertain political views which were not shared by the bulk of the Afrikaans-speaking population. The activities of the "Genootskap" and of the Rev. du Toit cover the greater part of the first period of written Afrikaans (1860–1900). Most of the publications of this period being primarily intended as propaganda among an almost purely rural population were written in very simple language and issued in cheap pamphlet form. A few of them are today still read (*e.g.,* J. Lion Cachet's didactic stories *Die Sewe Duiwels,* S. J. du Toit's historical novel *Die Koningin van Skeba,* and a number of poems like the above-mentioned adaptation of "Tam o' Shanter"); but the vast majority of these have sunk into oblivion. Another author, also entirely forgotten today, is Melt J. Brink, who worked independently of the "Genootskap" and who published a series of humorous farces in an artificial language, a mixture of Afrikaans and Netherlandish Dutch.

The New Generation.—After the Boer War of 1899–1902 the Afrikaans movement was taken up by a new generation, and a second period of activity commenced. A system of orthography more conservative than that of the Rev. S. J. du Toit made the transition from Netherlandish Dutch to Afrikaans much easier, while the publication of the historical novel *Johannes van Wyk* by J. H. H. de Waal (1906) and of poetry of considerable literary merit like *Die Vlakte* by J. F. E. Celliers (1906), *By die Monument* by Totius (1908), and *Oom Gert Vertel en ander Gedigte* by C. Louis Leipoldt (1911), furnished a most powerful argument. Propaganda work was actively carried on in the newspaper press and especially in the monthly magazines *De Goede Hoop* (founded 1903), *Die Brandwag* (1910–1922), *Ons Moedertaal* (1914–1915) and *Die Huisgenoot* (founded 1916). The result was that Afrikaans was introduced in 1914 into the schools; and in 1919 university professorships in this language were instituted at Stellenbosch and Bloemfontein. By the year 1924 all the Dutch Church denominations had adopted Afrikaans as an official language, and an Afrikaans version of the Bible is now being prepared. In 1918 the Union legislature sanctioned the use of Afrikaans as one of the official languages for all purposes except for bills, acts, and other Parliamentary documents, in which Netherlandish Dutch had still to be used. In 1925 this restriction was removed, and since that date Afrikaans has enjoyed full official sanction. An Afrikaans literature, distinctively South African in colour and sentiment, has arisen. Poetry of outstanding merit has been written by J. F. E. Celliers, Totius (J. D. du Toit), C. Louis Leipoldt, C. J. Langenhoven, and A. G. Visser. Most of the poetry is lyrical, but there are a few successful examples in the narrative style (*e.g.,* Leipoldt's *Oom Gert Vertel*).

In prose a great deal has been published. *Uit Oerwoud en Vlakte,* by Sangiro (A. A. Pienaar), depicts in a highly artistic manner the tragedy of animal life in the forests of East Africa and has been translated into English under the title of *The Adventures of a Lion Family.* Novels or short stories have been written by J. H. H. de Waal, D. F. Malherbe, C. J. Langenhoven, Leon Maré, J. van Bruggen and E. de Roubaix—to mention only a few of the best known names. Especially the works of Langenhoven exhibit qualities of style and composition that have made a wide appeal to the Afrikaans-reading public, while those of van Bruggen reflect a psychological insight and literary power of a high order. To dramatic literature some notable contributions have been made by J. F. E. Celliers, J. F. W. Grosskopf, C. J. Langenhoven, H. A. Fagan, C. Louis Leipoldt, and others.

In biography G. Preller's *Piet Retief,* N. J. van der Merwe's *Marthinus Theunis Steyn,* J. P. la Grange Lombard's *Paul Kruger* and J. D. Kestell's *Christiaan de Wet* are the best known works.

The most comprehensive Afrikaans grammars are: Botha and Burger, *Grammar of Afrikaans;* and Bouman and Pienaar, *Afrikaanse Spraakkuns.* For the history of the language *see* the article by J. J. Smith in *Official Yearbook of the Union of South Africa 1919–1925;* D. C. Hesseling, *Het Afrikaans* (Leiden, 1923); D. B. Bosman, *Oor die Ontstaan van Afrikaans* (Amsterdam, 1923); and S. P. E. Boshoff, *Volk en Taal van Suid-Afrika* (Pretoria, 1921). The history of the literature is treated by L. van Niekerk, *De Eerste Afrikaanse Taalbeweging en Letterkundige Voortbrengselen* (Cape Town, 1920); E. C. Pienaar, *Taal en Poësie van die Twede Afrikaanse Taalbeweging* (Cape Town, 1926); and P. C. Schoonees, *Die Prosa van die Twede Afrikaanse Beweging* (Pretoria, 1927). (J. J. S.)

SOUTH AFRICAN WAR, 1899-1902. The South African War may be divided into three distinct periods. The first comprises the Boer invasion, terminating with the relief of Ladysmith on Feb. 28. The second ended in Oct. 1900 with the flight of President Kruger. The third consisted of guerrilla warfare on the part of the Boers, met by the blockhouses and punitive columns of the British, which operations were in force until May 31, 1902, when peace was ratified at Pretoria.

Operations in Natal.—The war opened with the investment of Mafeking by a Transvaal force under P. A. Cronje and the envelopment of Kimberley by Free State commandos under Gen. Wessels. But these were minor operations. The main Boer effort was made in Natal, where their forces were commanded by P. J. Joubert, while Lieut.-Gen. Sir George White was the British commander-in-chief. The northern part of Natal presented two faces of a triangle to the two enemies, the short base being formed by the Tugela river. Close to the head of the triangle at Dundee and Glencoe was posted a small British force under Maj.-Gen. Sir W. Penn Symons. Against this force there advanced a Boer force under Lukas Meyer from the east, and, more slowly, the foremost portion of the main Boer army from the north, while at the same time other Transvaalers descended upon the railway between Glencoe and Ladysmith, and the Free Staters from the passes of the Drakensberg advanced towards Ladysmith, the British centre of operations at which the reinforcements sent from India gathered. On Oct. 20 the Dundee brigade vigorously and successfully attacked Talana hill, and drove back Lukas Meyer, but Symons was mortally wounded, and 226 officers and men were killed and wounded. Half the mounted men lost their way in attempting to pass the enemy's flank and were taken, and the brigade, threatened to its left rear by Joubert's advance and by the force that had seized the railway, only escaped by retreating upon Ladysmith, where it arrived in an exhausted state on Oct. 26. Meanwhile Sir George White had discovered the Boer force on the railway, and, though anxious on account of the advance of the Free Staters, on the 21st, stimulated by the news of Talana, he sent out a force of all arms under Gen. French to drive the Boers from Elandslaagte and so to clear Symons's line of retreat. This was accomplished by French and his subordinate, Col. Ian Hamilton, in the action of Elandslaagte on Oct. 21 (British losses, 258). But on the 22nd the Free Staters' advance caused the victorious force to be recalled to Ladysmith, and the third action north of that town, Rietfontein (24th), was only a demonstration to cover the retirement of the Dundee force. By Oct. 29, all the British forces at the front and their reinforcements had fallen in on Ladysmith, which the Transvaalers on the north and east and the Free Staters on the west side began to invest. Before the junction of the two allied wings was complete Sir George White attempted by a general attack to break up their line. The result of this decision was the battle of Lombard's Kop, outside Ladysmith, in which the whole of the available British force was engaged. The engagement was disastrous to the British, who had undertaken far too comprehensive an attack, and the Natal Field Force was obliged to fall back upon Ladysmith with the loss of 1,500 men, including a large number of prisoners belonging to the left column, who were cut off at Nicholson's Nek and forced to surrender by a mixed force of Transvaalers and Free Staters under Christian de Wet. Two days later Ladysmith was isolated, but not before French had escaped south by train, and the naval authorities had been induced to send into the town a naval brigade with large guns, able to answer Joubert's artillery.

Buller's Arrival.—Gen. Sir Redvers Buller, who had been appointed to the supreme command in South Africa as soon as it was perceived that war was imminent—his force being one army corps in three divisions, the divisional generals being Lord Methuen, Sir W. Gatacre and Sir C. F. Clery—arrived in Cape Town, ahead of his troops, on the day following Lombard's Kop. The situation which presented itself was delicate in the extreme. In Natal practically the whole of the available defence force was swallowed up by the steady success of the invasion; on the western frontier two British towns were isolated and besieged; and Boer commandos were on the point of invading Cape Colony, where the Dutch population seemed on the verge of rebellion. The army corps was about to arrive, practically as a whole unit, in South Africa; but it was evident that the exigencies of the situation, and the widely divided areas of invasion, would at least defer the execution of the plan which had been formed for an invasion of the Orange Free State from Cape Colony. The first duty was to effect the relief of the British forces which had been rendered immobile, and another duty imposed by political circumstances was to relieve Kimberley (where Cecil Rhodes was), while the prospect of rebellion forbade the complete denudation of the central part of the colony. Thus Buller had no choice but to disintegrate the army corps. Clery and some brigades were sent to Natal; Gatacre with less than a brigade, instead of a division, was despatched to Queenstown, Cape Colony; while Lord Methuen, with a division, was sent off to relieve Kimberley. As November wore on, the situation did not improve. Cape Colony was invaded; while in Natal a flying column of Boers, pushing down from the Tugela, for a short time isolated the newly-arrived force under Gen. Hildyard, which opposed Joubert's advance on Pietermaritzburg at Estcourt. The situation in Natal seemed so serious that on Nov. 22 Buller left Cape Town and sailed for Durban.

Failures of Methuen and Gatacre.—In the meantime Methuen had begun his march to the relief of Kimberley. He encountered resistance at Belmont on the 23rd, but drove the Boers out of their strong positions. Two days later he won another action at Enslin. Still persevering he moved on to the Modder, where he was seriously opposed by De la Rey and Cronje, the latter having posted down from Mafeking with 2,000 men and arrived on the previous night. The Boers, who held a river line, kept the British attack at bay all day, but eventually fell back, relinquishing the position after dark, as their right had been turned by Pole-Carew's brigade. It was a long and wearing fight, in which the British lost 485 killed and wounded, and what was more serious, Methuen (himself wounded) found that his force had exhausted its forward momentum, and that he would have to collect supplies and reinforcements on the Modder before fighting his next battle. The extent of the operations and the gravity of the situation now began to be felt in England; every available man was called up from the reserves, and the War Office made what at the time seemed adequate provision for the waste which it was seen would occur. On Nov. 30 the mobilization of a sixth division was ordered, offers of colonial aid were accepted, and every facility was provided for local recruiting. On Dec. 10 Gatacre essayed a night march and attack upon the enemy's position at Stormberg, and, misled by his guides in unknown ground, was himself surprised and forced to return with a loss of 719. On the following day Methuen delivered an attack upon Cronje's position between the Upper Modder river and the Kimberley road, a line of kopjes called Spytfontein and Magersfontein. In a night attack on Magersfontein hill the Highland Brigade was caught under heavy fire while still in assembly formation, and lost its general, Wauchope, and 750 men, and in the battle by day which followed, the total losses amounting to about 950. Buller had collected at Chieveley in Natal a mounted brigade and four infantry brigades.

Buller's Failure. Lord Roberts Sent Out.—On Dec. 15 Buller made his effort and failed. Behind the Tugela at Colenso (*q.v.*) were Louis Botha's forces covering the siege of Ladysmith, and, imperfectly acquainted with the lie of the ground, Buller sent a force to turn Botha's left, in conjunction with a frontal attack. But the flank attack became entangled in mass in a loop of the river and suffered heavily, and two batteries that formed part of the frontal attack came into action within a few hundred yards of unsuspected Boer trenches, with the result that ten guns were lost, with some 1,100 men. Buller then suggested to White the surrender of Ladysmith, believing this to be inevitable and desiring to cover White's responsibility in that event with his own authority; but White replied that he did not propose to surrender, and the cabinet at home, aware of Buller's despondency, appointed Field Marshal Lord Roberts to the supreme command, with Maj.-Gen. Lord Kitchener as his chief of staff. As the formation of a seventh division practically drained the Mother-Country of trained men, a scheme for the employment of citizen soldiers was formulated, resulting in the despatch of Imperial Yeomanry and Volunteer contingents, which proved one of the most striking features of the South African campaign. Pending the arrival of Roberts and reinforcements, the situation in South Africa remained at a deadlock: the three besieged towns—Mafeking, Kimberley and Ladysmith—merely held their own. In northern Cape Colony, French, with two cavalry brigades, kept at arm's length a superior force of the enemy in the vicinity of Colesberg. On Jan. 6 the Boers in Natal tried to storm Ladysmith. The garrison, though weakened by privation and sickness, made a stubborn resistance, and repulsed the attack at Caesar's Camp and Wagon

Hill with severe loss to the enemy, itself having 500 casualties.

Roberts arrived in Cape Town on Jan. 10, 1900. His first duty was to create a field army out of units in Cape Colony. Buller essayed a second attempt to cross the Tugela, by turning the Boer left. But the upshot of several days' fighting was the retreat of the British. They had penetrated the enemy's right centre by the seizure of Spion Kop (*q.v.*), but the force there became the target for the concentrated attacks of the Boers, and, after suffering heavily, was withdrawn (Jan. 24, 1900).

By Feb. 1 Roberts had matured his plans; on the 3rd he ordered a demonstration against the right of the Boer position at Spytfontein-Magersfontein to cover the withdrawal of French's cavalry from before Colesberg, and the concentration of his army at Modder river, disregarding another set-back in Natal to Buller, who had against his advice made a third attempt to relieve Ladysmith and failed to make good the purchase which he secured across the Tugela (Vaal Krantz).

Roberts's Advance.—Roberts's plan was first to concentrate to his left, taking every measure to induce the Boers to believe that the original scheme of invasion by the centre would now be resumed, and in this purpose he succeeded so well that his field army with the necessary transport for a cross-country march was assembled between the Orange and the Modder without serious mishap. Cronje at the new centre of gravity was not reinforced, all available Boers drawing down towards Colesberg. The concentration effected, Cronje still believed that the relief of Kimberley was the object of the gathering behind Modder river, and therefore held on to his Magersfontein kopje. The relief of Kimberley was indeed urgent, for dissensions between Rhodes and the military authorities had become acute. But to this part of the task only the cavalry division assembled under French was assigned. The army itself was to force Cronje into the open and then advance on Bloemfontein from the west. Roberts began his operations on Feb. 11. French started from Ramdam (near Graspan) eastward on that day, intending to make a wide sweep round Cronje's immobile army. Skirmishing with De Wet in the first stages of their ride, the cavalry brigades crossed the Modder at Klip Drift on the 13th. Cronje sent only detachments to oppose them, but these detachments were broken through by a sword-in-hand charge of the whole division, and Kimberley was relieved on the 15th. The infantry, meeting with great difficulties in its crossing of the Riet at Waterval owing to the country and its own unwieldy transport, followed one and one-half to two days later. But Cronje had now realized his danger, and slipped away westward behind French and in front of the leading infantry at Klip Drift. These were deflected by Kitchener westward to follow up the Boer rearguard, and after some delay the remainder of the infantry, at first fronting northwards, swerved westward likewise, while French from Kimberley, with such of his men as he could mount on serviceable horses, headed off Cronje in the northwest. The result, after one premature and costly assault on Cronje's lines had been made by Kitchener, was the surrender of 4,000 Boers at Paardeberg (*q.v.*) with their leader on Feb. 29, the anniversary of Majuba. At the same moment came in news at last of the relief of Ladysmith.

Relief of Ladysmith.—It was part of Roberts's purpose to relieve the pressure in Natal by his own operations. Buller began his fourth advance on Feb. 14, and though this was checked the foothold gained was not abandoned, and a fifth and last attempt (Pieter's Hill [*q.v.*]) was successful. Ladysmith (*q.v.*) was relieved on Feb. 28. It had fared worst of all the beleaguered garrisons, and its 22,000 inhabitants were almost at their last gasp when relief came. The casualties from shell-fire had been few, but those from sickness were very heavy. Buller's operations, too, had cost at Colenso, 1,100 men, at Spion Kop 1,700, at Vaalkrantz 400, and now in the last long-drawn effort 1,600 more—over 5,000 in all. But the tide of war had changed. The Natal invaders fell back to the mountains which enclose the north of the colony; Oliver and Schoeman retired from Cape Colony; and the presidents of the republics hinted at *status quo* before the war. These proposals were rejected by Lord Salisbury.

Capture of Bloemfontein.—The surrender of Cronje and the relief of Ladysmith for the time being paralysed the Boer resistance. Two half-hearted attempts were made early in March, at Poplar Grove and Driefontein, to stem Roberts's advance upon Bloemfontein, President Kruger himself arriving on the scene to give confidence to his burghers. But on March 13, 1900, Roberts's army marched into the Free State capital, this in spite of the fact that much transport collected at Ramdam had been cut off by De Wet.

It was only on March 29 that the new railway communication recommenced to feed the army. In the meantime rebellion had broken out in the Prieska district of Cape Colony, but was promptly quelled by Kitchener. The enforced halt at Bloemfontein was unfortunate; it not only resulted in a bad outbreak of enteric, but it gave the Boers time to recuperate, and by the beginning of April they again took the initiative. The death of their commandant-general, Piet Joubert, on March 28, seemed to mark a change in the fortunes of the Republican army. Christian De Wet, who had first come into prominence as the captor of Roberts's convoy at Waterval, and was now operating east and south-west of Bloemfontein in order to counteract the influence of Roberts's numerous flying columns which rode hither and thither offering peace to the burgher, added to his laurels by ambushing Broadwood's mounted brigade and horse artillery at Sannah's Post, just outside Bloemfontein, on March 31. Four days later he reduced a detachment at Reddersburg, and then went south and invested a mixed force at Wepener, which was relieved after ten days by Gen. Hunter's Ladysmith division.

Relief of Mafeking.—On May 11 Roberts and his army moved northwards upon the Transvaal capital, Pretoria. A flying column on May 17 relieved Mafeking, where Col. Baden-Powell had throughout shown an unconventional gaiety. The same day the Natal Field Force under Buller moved up into the Biggarsberg and occupied Dundee. On May 12 Roberts entered Kroonstad, and on May 31, occupied Johannesburg, the Orange Free State having been annexed three days earlier. On May 30 President Kruger had fled with the State archives to Waterval Boven on the Komati Poort line. The gold mines were now securely in the possession of the British, and on June 5 Roberts occupied Pretoria practically without resistance.

Diamond Hill.—The army of occupation had still to face two years of almost unprecedented partisan warfare. On June 8 Buller, who had made a long halt after the relief of Ladysmith and reorganized his army and its line of communication, forced his way over Alleman's Nek, and on the following day occupied Laing's Nek, the Natal gate to the Transvaal, while Roberts fought a widespread battle against Botha, De la Rey and Kemp at Diamond Hill, 20m. east of Pretoria. The object of this action was to push back the Boers from the neighbourhood of Pretoria, but no sooner was this done than the north-western Transvaal became active, in spite of Hunter's and Baden-Powell's advance from Mafeking through this district. As the British line of operations now extended eastward from Pretoria, the advance of these Boers to the Magaliesberg threatened their rearward communications, and as Buller had moved far more slowly than the main army there was not as yet an alternative line through Natal. Most serious of all was the pressure between Bloemfontein and the Vaal, where the Free Staters, under De Wet and other commanders, had initiated the guerrilla war as soon as Botha and the Transvaalers retired over the Vaal and ceased to defend them by regular operations. Large forces had been left behind during the advance on Johannesburg for the protection of the railway and the conquered territory, and these had now to be reinforced. Hunter and Rundle successfully herded Prinsloo with 4,000 Free Staters into the Brandwater Basin (July 29)—a very satisfactory result, but one seriously marred by the escape of De Wet, who soon afterwards raided the Western Transvaal and again escaped between converging pursuers under Kitchener, Methuen, Smith-Dorrien, Ian Hamilton and Baden-Powell.

Flight of Kruger.—Before this Roberts had initiated a movement from Pretoria to sweep down to Komati Poort on the Portuguese frontier, in which Buller, advancing across country from the south, was to co-operate. On Sept. 25 Komati Poort was occupied by Roberts's troops. From October the military operations were confined to attempts to reduce guerrilla commandos which had taken the field. Kruger, deserting his countrymen, left for Europe in a Dutch man-of-war, and Buller sailed home. The Boer leaders definitely decided upon a guerrilla policy, deliberately dispersed their field army, and then swelled and multiplied the innumerable local commandos. On Oct. 25 the ceremony of annexing the Transvaal was performed at Pretoria.

Kitchener Takes Command.—The prevailing opinion was that the war was over, and Roberts left South Africa, handing over the command to Lord Kitchener. Then followed a long period of groping for a means to cope with the development of guerrilla tactics, which for the next six months were at their zenith. The railway communications were constantly damaged, isolated posts and convoys captured, and the raiders always seemed able to avoid contact with the columns sent in pursuit. De Wet, after escaping from Brandwater Basin, was hunted north-westward, and crossed into the Transvaal, where, joining the local guerrilla bands, he surrounded an infantry brigade at Fredrikstad. But, unable to reduce it, and threatened on all sides, he turned back. On Nov. 6 he was severely handled and his guns and wagons captured at Bothaville. But this misadventure only stimulated him. His emissaries roused the Free Staters west of Bloemfontein, and disaffection broke out in Cape Colony to an alarming degree, while, as forerunners of the promised invasion, scattered bodies of Free Staters crossed the Orange river to swell the rebellion. From Bothaville De Wet made for Thaba Nchu, where the Bloemfontein garrison held a cordon of posts. He passed through this and on to Bethulie, capturing Dewetsdorp and 500 men *en route*. Pursued closely and finding the rivers in flood De Wet hid some of his men under Kritzinger near the Orange and himself doubled back, traversing again the line of posts east of Bloemfontein. Kritzinger, Hertzog and bodies of Cape rebels raided Cape Colony as soon as they were able to cross the Orange, and Hertzog penetrated so far that he exchanged shots on the Atlantic coast with a British warship. All that the British forces could do was to localize the raids and to prevent the spread of rebellion. Botha meanwhile held his own in the northern Transvaal, attacked the railway posts on the Middelburg railway and captured Helvetia. De la Rey operated successfully and scathelessly in the western Transvaal, in concert with Beyers. Kitchener called for more men, and on Dec. 22 the War Office announced that 30,000 more mounted men would be despatched to the seat of war.

Concentration Policy.—With the opening of 1901 Kitchener tried new schemes. He withdrew all his detached garrisons except in the most important centres, and set himself to make his railway communications secure. He determined to make the area of operations a waste, and instituted the concentration camps, into which he intended to bring the whole of the noncombatant inhabitants of the two republics.

Although there were no great disasters, the new policy was not prolific in success. The enemy invariably dispersed before superior forces, and the removal of the women and children from the farms did not have the effect of disheartening the burghers as had been anticipated—it rather mended their vitality by relieving them of responsibility for their families' welfare.

On Feb. 10 De Wet, with five guns and 3,000 men, carried out his promised invasion of Cape Colony. Passing the Bloemfontein-Thaba Nchu cordon a third time, he crossed the Orange to join Hertzog and rouse the Cape Dutch. But this invasion failed. By judicious use of the railway Kitchener concentrated sufficient troops in the Colony to cope with the attempt, and, after being hunted for 18 days, De Wet escaped into the Orange River Colony with the loss of all his guns, munitions and half his force. In the northern Transvaal a force under Sir Bindon Blood cleared the country, but could not prevent Viljoen from escaping eastward to join Botha. Botha's activity in the south-east caused Kitchener to despatch thither a large force under French. This swept the country up to the Swaziland border, but Botha escaped. On March 3, after various raids, De la Rey, the lion of the western Transvaal, essayed an attack upon Lichtenburg, in which he was heavily repulsed. Signs of weakness were now apparent, and as a result Louis Botha, acting with the authority of Schalk Burger, the representative of President Kruger, opened negotiations with Kitchener. A meeting took place at Middelburg, Transvaal, on Feb. 28. These negotiations, however, broke down mainly over the treatment to be awarded to Cape rebels.

Blockhouse Policy.—Kitchener now resolved upon chains of blockhouses like those protecting the railways. In April Plumer occupied Pietersburg, the last remaining seat of government open to the enemy. In July, Botha applied for permission to communicate with Kruger. This was allowed, but, Kruger advised a continuance of the struggle. In the meantime, the concentration camps were becoming filled to overflowing, and a steady stream of captures were reducing the Boer resistance.

In August a proclamation was promulgated formally threatening the Boer leaders who did not surrender with permanent banishment from South Africa, but this proclamation had very little effect. Desultory fighting continued till the close of the year. Affairs again took an unsatisfactory turn in Cape Colony, and on Oct. 8 the whole colony was placed under martial law. The British began a succession of night marches and raids which practically blotted out the resistance in the eastern Transvaal. The year closed on a low note, however, as De Wet on Christmas Eve captured a large force of Yeomanry at Tweefontein.

The "Drives."—In 1902 the blockhouse system was finished. But the enemy still had about 25,000 men in the field. The mobile columns, of which there were over 60 in the field, could be pushed out along whatever blockhouse line they touched. In January, Viljoen was captured in the Leydenburg district. Early in February Lord Kitchener commenced his first drive, and it was so successful that it was evident that the key to the situation had been found. First the country east of the line Bloemfontein-Vereeniging was swept four times over, then the method was employed in the Transvaal, east and west, and finally against the Cape rebels. There were a few reverses, of which De la Rey's successful rush upon Paris's column and the capture of Lord Methuen were the most important, but when some initial mistakes in the composition of the driving lines, which robbed the earlier drives of part of their effect, were made good, the system worked like a machine. The Boers were at last convinced of the futility of any attempt to prolong the struggle, and on March 23 the representatives of the Boer Governments came into Pretoria. Six weeks were spent in negotiation, and then a meeting of delegates, under the presidency of Gen. Kemp, was held at Vereeniging.

Peace of Vereeniging.—As a result of this conference articles of peace were signed at Pretoria on May 31; their essential points were: (1) Surrender of all burghers in the field, with all arms and munitions of war; (2) all burghers duly declaring themselves subjects of King Edward VII. to be repatriated; (3) no burghers who should surrender to be deprived of either their liberty or property; (4) no proceedings to be taken against burghers for any legitimate acts of war during the period of hostilities; (5) the Dutch language to be taught in public schools on the request of parents, and to be allowed in courts of law; (6) sporting rifles to be allowed upon the taking out of licences; (7) the military administration to be superseded by civil administration as soon as possible, the civil administration to lead up to self-government; (8) the question of the native franchise not to be considered until after the introduction of self-government; (9) landed property not to be subjected to any special tax to defray the cost of the war; (10) a commission to be formed to facilitate the repatriation of the burghers, a grant of £3,000,000 being given as compensation for the destruction of farms.

In the whole war the British lost 5,774 killed and 22,829 wounded, while the Boers lost about 4,000 killed. The number of Boer prisoners in the hands of the British at the end of the war was about 40,000. (L. J.; C. F. A.; X.)

SOUTH AMBOY, a city of New Jersey, U.S.A., on the Raritan river, opposite Perth Amboy, with which it is connected by the fine Victory bridge (opened 1926). Pop. (1920) 7,897 (83% native white). South Amboy has terra-cotta works and was laid out in 1835, becoming a city in 1908.

SOUTH AMERICA, the southern of the two American continents of the Western Hemisphere, situated between 34° and 82° W. long., and 13° N. and 55° S. lat. It is roughly triangular in shape and in the north-west is joined to the continent of North America (*q.v.*) by the Isthmus of Panama. South America is the 4th largest of the continents having an approximate area of 7,570,000 sq.m., or about 14% of the land surface of the globe. Its estimated population in 1928 was 74,500,000, or 9·8 per sq.m. South America lies much farther east in the Atlantic Ocean than North America, the meridional line of New York city cutting it so as to leave 95% of the southern continent lying closer to the Old World. *See* also AMERICA.

PHYSIOGRAPHY

The Coasts.—The South American continent rises abruptly from the ocean floor along nearly all of its coast but the steepness of the continental margin is more marked on the western side than on the eastern. On the west coast between 5° S. lat. and 35° S. lat. the continental shelf is extremely narrow and is bordered by abysmal faults (the 3,000-fathom line lies less than 60 m. from the coast-line at Iquique). In this section, and in fact throughout their whole length north of Valparaiso, the Andes, in spite of their great height above the sea, are only the upper portions of mountains whose bases are thousands of feet below the surface of the Pacific ocean. South of Valparaiso the continental shelf broadens, but it is nowhere of great width and at the entrance to the Strait of Magellan again narrows so that the 1,500 fathom line is within 150 m. of the coast-line. In general the Pacific coast follows the direction of the Andes. The whole west coast north of the Patagonian archipelago is but little articulated and is completely lacking in good natural harbours. The harbours of Guayaquil and Buenaventura would be exceptions to this rule if it were not that the rivers which empty into them carry so much silt that only constant dredging or carefully engineered dykes to direct the flow and deposit of the silt would make them possible for steamers of deep draught.

From 41° S. lat. to Cape Horn the coastal zone is a broad chain of islands which were probably formed by recent subsidence of a mountainous strip and the consequent invasion of its valleys by the sea. The islands, some of which are very large, are only the higher portions of these mountains that have remained above the sea, while Smyth channel, the Strait of Magellan, and other large channels and sounds are submerged valleys. The channels, which separate the islands near the mainland and extend back like fiords into the mainland cordilleras, appear to have been greatly over-deepened by the action of the old glaciers. Even to-day great glaciers flow down from the inland ice-fields of the cordilleras to the heads of many of these fiords and, along the Beagle Channel, to the coastline of the channel itself. Many of the larger islands are steep, barren mountain masses which rise to altitudes of 4,000 ft. and in some cases bear glaciers (mostly of the hanging type, but in some cases long valley glaciers that reach to the sea) on their protected north and north-east slopes.

North of 41° S. lat. the coast belt between the Andes and the ocean averages about 40 m. in width. Its character varies greatly. In southern and central Chile it is occupied by high coast ranges. From 30° S. lat. to the mouth of the Guayas river it is a sandy arid belt broken by a discontinuous line of coast ranges. Across this arid belt flow streams from the Andes which water narrow, fertile valleys. Few of these streams, however, are perennial; many never reach the sea, and others reach it only in time of flood. North of the mouth of the Guayas river the coastal belt is covered with tropical vegetation.

The east coast is in strong contrast with the west. Between Cape San Roque and São Paulo the coast to some extent follows the orientation of the eastern border of the Brazilian plateau. On this part of the coast are some of the most beautiful harbours in the world, notably those of Rio de Janeiro, Santos, and Victoria. These harbours are submerged coastal valleys but the subsidence which produced them was limited in extent and probably did not affect the whole east coast. In fact in north-eastern Brazil uplift movements have added to the coast a belt of marine deposits. The estuary of the Rio de La Plata is the most marked indentation of the whole South American coast. It is the outlet for the combined waters of the Uruguay and Paraguay river systems. South of the La Plata in the Patagonian region many great transverse valleys open to the Atlantic but the recession of the glaciers of the Patagonian Andes, which during the Ice Age were an abundant source of supply, has greatly diminished the streams in many of these valleys. Others, since the recession of the glaciers and the re-opening of old drainage channels through the Andes to the Pacific, are completely dry.

The east coast of South America has few islands and these, except Trinidad, off the coast of Venezuela, and the islands at the mouth of the Amazon, are mostly small. Trinidad (area 1,755 sq.m.) is separated from the continent by the Gulf of Paria but along its northern edge is a range of mountains averaging about 3,000 ft. high which is geologically a continuation of the Cumana range of Venezuela. On the south side of this island is the famous asphalt lake—the largest known deposit of its kind. West and north of Trinidad and lying farther off the coast are several small islands of historical interest and considerable commercial importance: Tobago, Margarita, Blanquilla, and the Curaçao group. The main island of the Fernando de Noronha group of volcanic islands 230 m. off Cape São Roque has an area of only 12 sq.m. Although separated from the mainland by a channel 13,000 ft. deep, it really stands upon the submerged corner of the continent. The Falkland islands in lat. 51° S. also stand upon the submerged edge of the continent. Their fauna and flora indicate that they were once a part of the mainland from which they are now separated by shallow water. On the west coast north of the Patagonian archipelagos are the Juan Fernandez islands west of Valparaiso, the famous guano islands close to the mainland of Peru, the Galapagos islands on the equator, and the islands of the delta of the Guayas river near Guayaquil.

Land Relief.—The continent of South America is divided, from west to east, into three longitudinal zones—the cordilleras of the Andes, the lowland belt, and the plateaux of Guiana and Brazil—the last being interrupted at 35° S. lat. by the narrowing of the continent and the opening of the lowland belt to the Atlantic coast.

The Andes, north of their Patagonian section, have been, until recently, described as a series of more or less parallel but distinct ranges. It is now known that, except in the two widest sections (the Central Andes of Bolivia, where they consist of two ranges bordering the high *altiplano*, and the Andes of Colombia, where they finger out into three distinct ranges), they form a broad plateau, carved far over toward its western border by tributaries of the great river systems of the Atlantic slope and surmounted by narrow ridges and isolated mountains (many of them volcanoes of various ages) which include some of the highest peaks in the world. (For further details *see* article on the ANDES.)

The South America lowlands, so-called, include the *llanos* of the Orinoco, the Amazon plains, the *Chaco*, and the *Pampa*, and form a more or less continuous belt reaching from the mouth of the Orinoco to the northern border of Patagonia north of the Rio Negro. Patagonia, however, may also be properly included in the lowland belt. There is no sharp line of division between it and the *Pampa;* much of its surface has a steppe-like character, and its soil-cover is alluvial like that of the rest of the lowland belt. This alluvial cover, throughout the lowland belt, is mainly of Andean origin supplemented locally by elements derived from isolated mountain masses that here and there break the general level. In the regions of heavy rainfall the alluvial soils are almost entirely distributed by water. In the *Chaco*, where the rainfall is distinctly seasonal in character and the network of streams from the Andes does not reach far into the lowlands, the transportation of alluvial deposits is assisted by the winds during the dry season. On the *Pampa* it is almost entirely transported by the winds. The cover of rounded pebbles characteristic of large sections of Patagonia is believed to be of glacial origin distributed from the fronts of the old glaciers by water before the streams had been confined to definite beds and since that time by action of the winds. Throughout the lowland belt are evidences of imperfect stability, of movements of uplift and subsidence that have given rise to new local cycles of erosion and alluviation.

Geologists now recognize a close relationship between the highlands of Guiana and those of eastern Brazil. Both are composed of a shield of ancient crystalline granites and gneisses and of old folded schists and quartzites on platforms of sandstone, and belong to an old continental mass recently raised by vertical movements to its present elevation. At the edge of the Brazilian plateau falls still occur even on the largest rivers, some of which, like the São Francisco, flow on the surface of the plateau, while others, as in the southern part of Goyaz and Minas Geraes, have eroded deep gorges there. The interior is occupied by high monotonous surfaces at various levels and in a more or less perfect state of peneplanation. In the Guianas, however, and in the Serra do Mar of Brazil the mountains have the convex-dome shape characteristic of crystalline mountains under the action of intense tropical rainfall. The mountains of the Serra do Mar are extremely picturesque. At many points they rise directly from the seashore to an elevation of 2,000 ft., forming in places bare granite walls. In other places they are covered with luxuriant tropical vegetation. Their highest point (7,323 ft.) is in the Serra dos Orgãos near Rio de Janeiro.

Rivers and Lakes.—The most important river systems of South America—the Amazon, Orinoco, and the Paraná-La Plata system—have the greater part of their drainage basins in the lowland belt. The chief headwater tributaries of the Amazon and the Orinoco have their sources on the Andean plateau where they have cut deep valleys. The principal sources of the Paraná-La Plata system are in the Brazilian plateau, although the Pilcomayo and Bermejo (right bank tributaries of the Paraguay) rise in the Andes of southern Bolivia and northern Argentina. These three river systems together drain an area of about 3,700,000 sq.m. During the rainy season all of them overflow their banks and flood large sections of the central lowland belt. The Amazon is the largest river in the world. The main stream is navigable for ocean steamers as far as Iquitos, while many of its tributaries are navigable for steam launches almost to the foot of the Andes. In the time of high water the main stream of the Orinoco is navigable for 1,000 m. or more. Other important rivers are the Magdalena in Colombia, the Essequibo in British Guiana, and the São Francisco in Brazil. The Magdalena is navigable, in two sections separated by the rapids at Honda, for river steamers as far as Girardot, the river port of Bogotá. The São Francisco which rises in the highlands of Minas Geraes is navigable nearly to the falls of Paulo Affonso, 140 m. from its mouth, and also above the falls.

Most of the lakes of South America are mountain lakes in the Andes or along its base. Of the Andean lakes, Titicaca and Junín are the largest. (*See* ANDES.) The glacial lakes along the eastern base of the Andes in southern Argentine and those of the Llanquihue district of southern Chile are described in the articles on the Andes, Argentina, Chile, and Patagonia. There are many lakes scattered over the flood plains of the great rivers but these are mostly phases of river development. Along the east coast there are occasional lakes, like the Lagoa dos Patos of southern Brazil, of brackish water, produced by depression of the coast and the closing of the mouths of estuaries formed thereby or by barrier beaches thrown up by the sea. Lake Maracaibo is a large narrow-necked bay like that of Rio de Janeiro rather than a true lake.

GEOLOGY

The most extensive old land areas (Pre-Cambrian) of South America are found in the plateaux of Guiana and Brazil where the ancient crystalline granites and gneisses have been laid bare over large areas. The *Brasilides,* so-called, are a series of Pre-Cambrian and Pre-Devonian folds of which traces are found on the western border of the Brazilian plateau and as far south as the Sierras in the Argentine provinces of Cordoba and La Rioja. These old land areas formed the larger units in a chain of islands of which the old rocks of the Falkland islands are a part. On their shores were laid down the sedimentary beds of the Cambrian seas. At the close of the Cambrian period these Pre-Cambrian islands with their Cambrian sediments were uplifted and many of them united to form continental masses of considerable extent. During the Silurian period, however, seas still covered a large area including the present basin of the Paraguay river and a large part of the present basin of the São Francisco and extending northward between the axis of the Andes and the Matto Grosso highlands and eastward by way of the region now occupied by the lower Amazon valley.

During the Devonian period further uplift and the consequent disappearance of the Silurian seas from the basin of the São Francisco increased the area of the continental mass; but in early Carboniferous times the sea still covered a narrow strip through the lower part of the Amazon valley and part of what is now the Andes south of the Equator. During the Permian the basin of the Paraguay and the south-east coast of Brazil were covered with lagoons and swamps in which here and there coal beds were laid down. Continental Permian deposits have been found at a number of places in the southern part of the Brazilian plateau, in northern Argentine, and in the Falkland islands. Analogies between Permian fauna and flora of South America and South Africa are accepted as evidence of a Permian continental mass, known as *Gondwana,* connecting South America with South Africa and India, the western limits of which are formed by the Argentine pre-cordillera between San Juan and Jachal where the Permian layers are strongly folded. These folded Permian layers are continued south-eastward by the sierras of the Argentine province of Buenos Aires and are known to geologists as *Gondwanides.* South of them, between the Negro and Chubut rivers, is the Patagonian massif, which consists, like the *Brasilides,* of very old rocks and may have been connected with an ancient Antarctic continent. Against this massif and between it and the Andes, and antedating the latter, is a series of Cretaceous folds known as *Patagonides.* At the close of the Devonian there was widespread volcanic activity that covered with lavas large areas in what is now Paraguay and Brazil.

The importance of Jurassic and Cretaceous marine deposits in the Andes is evidence that, during the Mesozoic period, the region now occupied by the Andes was a great geosyncline occupied by the sea between two continental masses, one of which has since subsided to form the Pacific ocean. This geosyncline connected at the north end with a sea that reached from the region of the present West Indies to the present Mediterranean and persisted through the Mesozoic and into the early part of the Tertiary. The South America-South Africa land mass (*Gondwana*) continued from the Carboniferous to the Cretaceous and may have persisted into the Tertiary. There is no evidence on the present coast of Brazil of invasion by the sea between the Devonian and the Cretaceous, while the first invasion of the east coast of Patagonia and, consequently, the formation of the South Atlantic ocean dates from the Upper Cretaceous. The folding of the Andes also began in the Upper Cretaceous and continued into the Tertiary, although how far into the Tertiary is not known.

Great changes took place in the Tertiary period. The continent rose considerably higher than its present elevation and the continental land mass was, consequently, much larger than at present, including such coastal islands as the Abrolhos islands on the east coast of Brazil and the Falklands. It is possible, also, that, during this period, South America had land connection with New Zealand and Australia by way of the Antarctic continent or through the south Pacific ocean. The formation of the Isthmus of Panama with the resulting migration of North American faunal species to South America also dates from the Tertiary period; but its formation could not have taken place until the Pliocene, since the analogies between the marine fauna beds of Navidad (Chile), which date to the end of the Miocene, and European fauna of the same date can only be explained by the existence of free communication between Europe and the west coast of South America by way of the Tertiary Mediterranean up to the end of the Miocene. The elevation of the Andes during the Tertiary period was due only in part to the elevation of the continent as a whole. It was in large part assisted by the folding of the rocks and the outpouring of lavas and the accumulation of other volcanic materials in the neighbourhood of the vents. Nor was this volcanic activity confined to the Andean region. It extended into Venezuela and the islands along the north coast, the Patagonian plains, the highlands of the Paraná basin, and as far east as the islands of Fernando de Noronha. Toward the end of the Tertiary subsidence again occurred and the sea entered the Amazon, Orinoco, Cauca, and Magdalena valleys and the Maracaibo basin, and again made an island or groups of islands of the Guiana highlands.

In recent times, volcanic activity has greatly diminished over the continent and has ceased entirely in its eastern and north-eastern section. Throughout the southern part of the continent there is evidence of several periods of glacial development and recession during the Ice Age. Ice covered the whole of the Patagonian plateau as well as the western side of the Andes but the continental glaciation did not extend as far north on the east side of the Andes as on the west. Throughout the Andean zone there is evidence that the present glaciers are only remnants of much larger glaciers. There were no glaciers in the eastern or Brazilian section of the continent.

CLIMATE

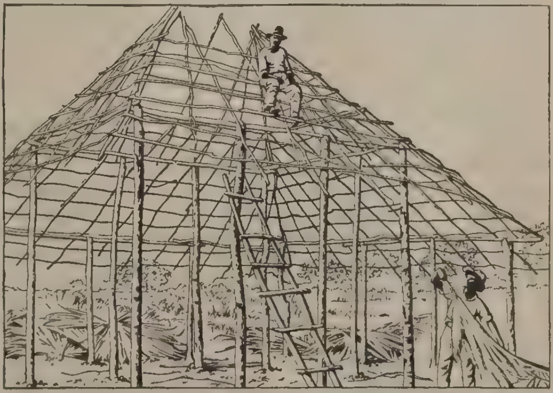
South America is the only one of the southern continents which extends far into the temperate latitudes; but, unlike the land masses of the northern hemisphere, it tapers toward the pole and, therefore, does not experience the extremes of temperature of the northern continents. The winters in the temperate latitudes are much warmer and the summers cooler than in North America or Asia. At no time of the year are there freezing temperatures at sea-level. The continent is broadest in the equatorial section and has the widest expanse of truly tropical weather of any of the continents; but, because of the width of the zone covered by the Andes, it has also the greatest area of temperate and sub-Arctic climate in tropical latitudes. Off the west coast from Cape Horn to the Equator the isotherms bend sharply toward the north. North of 40° S. lat. this is due to the cooling effect of the Humboldt Current. The east coast as far as the La Plata estuary is washed by the warm south equatorial current which the projection of the continent at Cape San Roque divides into two branches. There it meets the cool waters of the Falkland Current flowing north from Cape Horn.

Except in the south the winds blow parallel to the Andes on the west coast. They bring heavy rainfall to Ecuador and Colombia. South of this section, however, to 30° S. lat., the western side of the Andes and the coast are very dry on account of the Humboldt Current and the colder upwelling waters between it and the coast, and what little rain does fall there falls in the coolest months. South of 35° S. lat. there is much rain all the year but the maximum is in autumn and winter. This is the region of the Roaring Forties which in summer extend as far north as central Chile so that the Santiago region has mild rainy winters and rainless summers. In general the Andes offer a barrier to surface air circulation from both sides; but, south of 40° S. lat. they are relatively low, and the west winds are able to cross them, their ascent bringing heavy rainfall to the Chilean side while their descent causes the sparse rainfall of Patagonia. On the north coast of Colombia and the coasts of Venezuela and the Guianas the north-east trades blow all the year, strongest and steadiest in January and weakest during July when the rainy season occurs. The Equatorial zone has a double rainfall maximum from the north coast to about 10° S. lat.; but, except on the Equator, there is really one long rainy season with two especially heavy maxima. In all seasons the east coast, from Cape San Roque to the Tropic of Capricorn, has easterly winds varying from south-east in July to east and north-east in January. Between the tropic and the La Plata estuary the coast is on the west side of the south Atlantic anticyclone all the year and has, therefore, warm rainy winds.

SETTLEMENT

Discovery.—The continent of South America was first visited by Europeans in 1498 when Columbus, on his third voyage, touched near the mouth of the Orinoco. Others soon followed and by 1509 the east coast had been followed as far as the Rio de La Plata. In 1513 Balboa discovered the Pacific ocean at the Isthmus of Panama; in 1520 Magellan navigated the strait that bears his name; in 1527 Pizarro landed on the coast of Peru at Tumbez, and, in the same year, Cabot ascended the La Plata and Paraná rivers as far as the mouth of the Bermejo; in 1533 Cartagena was founded and the native town of Quito peacefully occupied; in 1535 Pizarro founded Lima and, in the same year Almagro invaded Chile and Mendoza established a settlement at Buenos Aires; in 1537 Jiménez de Quesada made his way from Santa Marta up the Magdalena river to Bogotá, the capital of the Chibchas; and in 1541 Valdivia founded Santiago de Chile and Orellana travelled from eastern Ecuador to the Atlantic by the Napo and Amazon rivers. It is claimed that the bay of Rio de Janeiro was discovered by the Portuguese in 1502. Affonso de Souza visited it in 1531 but went on to São Vicente near Santos to establish his colony. The first settlement on the bay was made some years later by French Huguenots.

Aboriginal Inhabitants.—At the time of the discovery of South America the aboriginal inhabitants differed greatly among themselves in customs, language and state of civilization. Those of the temperate regions of the Andes had reached a high state of culture. Wherever the Europeans have invaded in any considerable numbers the aborigines have been profoundly affected. The importation of slaves from Africa has, likewise, had an important effect on the natives of the coastal regions of Brazil and the countries of the north coast. Indians of pure blood still, however, form a large portion of the population, while those of mixed white and Indian blood constitute its chief element except in Argentina, Uruguay and southern Brazil. In Brazil and the countries of the north coast there has been, also, considerable intermixing of Indians, negroes and whites. In the interior, where the whites have penetrated but little, the aborigines are still in very much their original savage state. In some localities, as on the Argentine *pampa* and in Uruguay, where there has been much recent colonization from Europe, the Indians have practically disappeared. In the Andean countries, where they had reached their highest state of culture at the time of the discovery, they still form the major part of the population and the native Quechua and Aymará tongues are still widely spoken. The countries having the largest Indian population at present are Bolivia, with an estimated 60–70% of Indians and the remainder mixed Indian and white; Ecuador, with about 50% Indians and 45% mixed; Peru with a small white population and the remainder Indian and mixed, together with a considerable number of negroes, Japanese and Chinese among the poorer classes in the cities; Paraguay, with a population mainly Indian; Colombia, with about 15% pure Indians and the remainder chiefly of mixed blood; and Venezuela, with few pure whites, a large majority of mixed blood, and a considerable number of negroes.

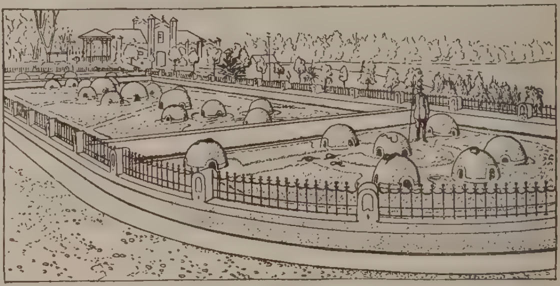

NATIVES IN RURAL VENEZUELA BUILDING A HOUSE

Settlement and Industrial Development.—Early colonization began and developed for a long period on a completely different basis in South America than in North America. Colonists in North America were seeking new homes and, therefore, settled in regions which duplicated as closely as possible the climatic and agricultural conditions that they had known in Europe. The early colonists went to South America, on the contrary, to exploit such natural resources as Europe lacked. Gold and silver were the first attractions, and the Andean regions, where the mining of these metals was already in an advanced state of development by the natives, were the centres of the first intensive invasion. The centres of mineral exploitation in the Andes were soon widespread. At an early date gold was being washed in Darien, the Ecuadorean Oriente, the valleys of the Cordillera de Carabaya in Peru, and the Araucanian section of Chile. The mining of silver also attracted large numbers. The silver mines of Potosí and Cerro de Pasco were particularly famous, those at Potosí alone being estimated as having yielded in all over a billion and a half dollars' worth of silver. In the eastern part of the continent the exploitation of mineral deposits began much later than in the Andes. Gold was discovered on the Brazilian plateau in 1693, and, in a few years, Minas Geraes, as the gold-mining region was called, came to be the chief gold-producing region of the world. The mines there reached their greatest productiveness between 1752 and 1761, when the annual yield was worth about six million dollars. The actual work of mining in the Andes was done mainly by native labour, in Brazil by native labour and imported negroes.

Mining still remains the chief industry of Chile, Bolivia and Peru; but copper has taken the place of gold and silver in Peru, tin and copper in Bolivia, and nitrates and copper in Chile. Nitrates rank first in value among the mineral products and copper second. Considerable gold and silver are still produced, largely in connection with copper mining. The chief mineral product of Colombia is still gold and Colombia is now the leading gold-producing country of South America; but her annual thirty-five million dollar coffee crop is seven times as valuable as her annual production of gold. Colombia leads the world in the production of platinum but the annual value of her platinum production is less than that of her bananas. Brazil, which, from the first discovery of diamonds in the gold districts about 1729 to the discovery of the South African fields, was the leading diamond producing country of the world, now probably produces less than one million dollars' worth annually, while her coffee crop in normal years is valued at upwards of two hundred million dollars. In fact the whole annual South American production of precious metals and precious stones probably does not exceed twenty-five million dollars, or less than that of a single copper mine at Chuquicamata, Chile. In the Maracaibo basin and the lower Magdalena valley, on the Peruvian coast at Talara, and in the Comodoro Rivadavia region of Argentina, the production of petroleum is rapidly increasing.

Agriculture in the hands of the Spanish colonists, or, as was more commonly the case, agriculture superintended by the Spanish but carried on by native labour on Spanish-owned estates seized from the natives, to which the Indians were bound by a system derived from the communal organization of the Incas, developed first around the mining centres which supplied their market. In fact the whole life of the Andean region came to be, and still is, centred in the mining industry. Farmers and traders found in the mining centres their markets not only for foodstuffs but for pack animals as well. The Andean towns and cities were, and are today, centres of service and supply for the mining districts. In addition, the transportation of minerals from the mines and supplies to them necessitated that a considerable portion of the population should be engaged in packing over the difficult trails not only to and from the towns of the plateau but to the coast as well. Next in importance to the mines in attracting colonists to South America were the tropical agricultural products. Sugar cane was for long the principal crop, followed later by cotton, indigo, cacao and coffee. The tropical crop colonies developed first in the Brazilian states of Bahia, Pernambuco and Maranhão, and spread later to the Guianas and northern Venezuela and Colombia. Today only a small part of the world's supply of cotton and sugar comes from South America, mainly from Brazil. Argentina and Peru. Brazil, Ecuador and Venezuela still produce about one-third of the world's crop of cacao. Coffee now not only is the leading tropical export of South America but the chief agricultural export of the whole continent, the greater part coming from Brazil but an important amount from Colombia and Venezuela. The export second in importance now is wheat, mainly from Argentina which is also the world's leading producer and exporter of flaxseed.

The grazing industry dates from the early days of colonization. The three chief grazing districts of colonial times were the northern Brazil district which supplied Bahia and Pernambuco, the south central Brazil district which supplied Minas Geraes and Rio de Janeiro, and the Argentine *pampa,* which supplied the mining centres of Bolivia and Peru. Exports from the cattle-growing regions consisted until fairly recently almost entirely of hides, as is still the case with Chile, Colombia, Venezuela, the Andean countries, and the interior of Brazil. Only Argentina and Uruguay are even to-day large exporters of beef, although southern Brazil ships a considerable amount. The first meat exported from Argentina was jerked beef and even in 1876, it consisted chiefly of mutton. The shipping of frozen beef began some time later but it was not until 1901 that chilled beef was shipped in quantities. Now Argentina exports more beef than any other country in the world. Sheep are still numerous in Uruguay and on the *pampa,* but they have been greatly decreased by the spread of cattle-raising and the cultivation of the land for cereals and alfalfa. In Patagonia and in Tierra del Fuego the sheep industry has had a remarkable development. In the exportation of wool Argentina, with three to four hundred million pounds of wool shipped annually, is second only to Australia.

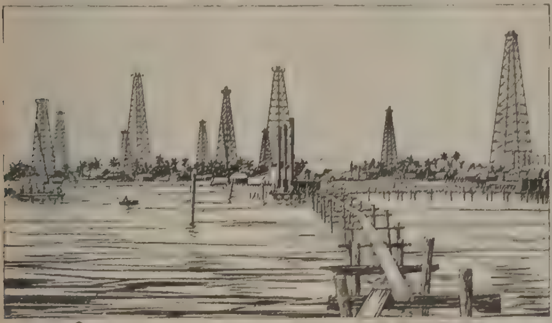


BY COURTESY OF THE PUBLISHERS PHOTO SERVICE

A SNAKE FARM NEAR SAO PAULO, BRAZIL

The exploitation of the forests in South America, as elsewhere, has had little to do with the establishment of permanent colonies, although it has at times seriously depleted those already established. In the 18th century the sugar-mills of Maranhão were deserted for the exploitation of cacao found in the neighbouring forests. In the 19th century men left the cacao plantations to search for rubber. In general only the most precious forest products have been exploited for exportation, such as logwood, rosewood, woods rich in tannin, quebracho, rubber and the vegetable ivory nut. In the east slope forests of the Andes of Bolivia, Peru and Ecuador, the collecting of cinchona bark, from which quinine is extracted, was an important industry from the middle of the 18th to the latter part of the 19th century and was at one time one of the chief resources of Bolivia. The introduction of the tree into Java, Ceylon and India has now, however, completely destroyed the industry in South America. The collecting of maté (Paraguayan tea) is still an important industry in Paraguay. Some Paraná pine is cut in Brazil for exportation to Uruguay and Argentina and saw-mills on the Strait of Magellan are engaged in manufacturing lumber from the forests of the west coast of Patagonia for the Argentine trade; but, in general, the exploitation of forests for lumber is profitable only in the vicinity of important towns. In the early days of the railroads much wood was consumed by locomotives but it is largely, though not entirely, supplanted now by coal and petroleum. Along the routes of the river steamers there is still a large demand for wood for fuel. The main routes for the transportation of lumber and other forest products are the rivers of the Atlantic side of the Andes and river ports are the chief centres of the industry—Itaquy on the Uruguay (centre of the maté industry), Posadas, Iquitos and Manãos.

One result of the wide dispersion of the early colonies in South America was the development of long transportation routes. The most famous of these was that from the Rio de La Plata settlements to Lima by way of the mining centres of Bolivia and southern Peru. Its function was not only that of the route by which cattle from the *pampa* were driven to the mining centres but also to serve as a link in the line of communication and supply between Spain and the Rio de La Plata settlements since, by decree of the Court of the Indies, direct communication between Europe and the Spanish settlements of the east coast was forbidden. There was also in colonial times much traffic on the large rivers of the Amazon and Paraná systems but these rivers were of little importance in transcontinental traffic because of the difficult ascent of the Andes from the heads of navigation. Everywhere, more or less local, but still, in many cases, long and arduous pack routes were developed between the productive areas, whether mineral or agricultural, and the local markets or the coast ports. In the Andes the mules became the chief beast of burden. On the lowlands east of the Andes where wheeled traffic was possible the ox hitched to great carts was used. Even to-day only the Argentine *pampa*, with about 25,000 miles of track, and the coffee region of Brazil, with about 20,000 miles centring at Rio de Janeiro and Santos, have a real network of railways. Elsewhere the pack train is still an essential feature in transportation. In the west coast and Andean countries, except in Chile where a longitudinal railway has been built for strategic reasons, the railways are chiefly short lines from the mining centres to the nearest ports. The exchange of commodities between the South American countries is limited and is served chiefly by water routes. Only two railway routes cross the continent—the transandine route from Buenos Aires to Valparaiso opened in 1909, and the route from Buenos Aires to Mollendo by way of La Paz (all rail except for the Lake Titicaca section), the last link of which was completed in 1926. Motor road mileage is still limited although good progress is being made.


OIL FIELDS OF LA ROSA, TOUCHING LAKE MARACAIBO

The direction of the maritime trade of South America has been greatly affected by the World War and the completion of the Panama Canal. Whereas in 1913 the total tonnage of the traffic between South America and Europe was about five times that between South America and the United States, it has now been reduced to about four times as much. Traffic is still much better balanced between the east coast of South America and Europe than between the east coast and the United States, many ships returning to the United States in ballast. The United States now has, however, more than half the traffic with the west coast. The total annual foreign trade of South America is still small (about three thousand million dollars) and half of it is carried on [illegible] Argentina alone. Not only do none of the South American countries produce any of the manufactured articles that are in[illegible] trade, but they do not supply to any appreciable [illegible] manufactured articles for home consumption. There is, as in all pioneer countries, a considerable amount of home manufacturing carried on—weaving, furniture making, and the like—and some manufacturing in the larger cities, but the total of the latter does not equal that of a fair-sized city in the United States. As a result there are few large cities in South America, Buenos Aires with about 2,000,000 people and Rio de Janeiro with about 1,000,000 being the only ones of world importance.

Political Divisions and Population.—The original Spanish colonies revolted from Spain toward the end of the first quarter of the 19th century and formed themselves into ten independent republics, the boundaries of which were based on the limits of the original colonial divisions. Brazil separated from Portugal as an independent monarchy in 1822, but did not establish herself as a republic until 1889. Only three European colonies remain on the continent—British and French Guiana, and Surinam (Dutch Guiana). Many disputes were involved in the establishing of the international boundaries on account of the vague language of the Royal decrees which established the original colonial divisions and the hazy knowledge of the topography of the continent upon which they were based. These have gradually been settled until only three of importance remain—the Peru-Ecuador dispute over the territory between the Amazon and Putumayo rivers, the Bolivia-Paraguay dispute, and the Tacna-Arica dispute.

Previous to the separation of the colonies from the mother country, the colonists, except for the negroes introduced into Brazil and the north coast colonies, were almost entirely Spanish and Portuguese. Since that time there has been little emigration from other European countries to the west and north coast countries except to Chile, where there has been a considerable immigration of Germans. In fact there has been little immigration of any kind into the west countries and little into those of the north coast except for the introduction of coolies from India and the East Indies to British and Dutch Guiana, respectively. On the east coast, however, there has been a large immigration from Europe. The 1914 census of the Argentine Republic gave a foreign-born population of 929,863 Italians, 93,634 Russians, 82,970 Spaniards, 79,491 French and 26,995 Germans. Brazil had, according to the census of 1920, a foreign-born population of 558,405 Italians, 433,575 Portuguese, 219,142 Spaniards and 52,870 Germans. The population of Uruguay is about 25% foreign-born, mostly Italians and Spaniards. Six of the South American republics have taken a census in this century—Uruguay (1908), Argentina (1914), Colombia (1918), Brazil, Chile and Venezuela (1920). Of the European colonies the British had a census taken in 1921 and the French in 1926. No census of Surinam has ever been taken. Population estimates for 1928 give the following figures: Argentine Republic, 10,500,000; Bolivia, 3,500,000; Brazil, 37,000,000; Chile, 4,000,000; Colombia, 6,500,000; Ecuador, 1,500,000; Paraguay, 800,000; Peru, 5,500,000; Uruguay, 1,700,000; Venezuela, 3,000,000; French Guiana, 48,000; British Guiana, 300,000; and Surinam, 140,000.

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ARCHAEOLOGY

No form of script existed in this continent; no system of recorded dates, as among the Maya, and no pictographical historical records, as among the Aztec, are found. Our reconstruction of the early history of the southern continent is based on the application of traditions, collected in the sixteenth century, to the results of the spade; and for large areas tradition is entirely lacking, and archaeological exploration is scanty. All the higher manifestations of culture are confined to the Andean highlands and the Pacific coast, roughly between Quito in Ecuador and northern Chile and Argentina, embracing, therefore, both Peru and Bolivia. But this culture had not penetrated the densely forested eastern slopes of the Andes, where the scattered population lived under extremely primitive conditions. Tradition is abundant in connection with the Inca of Peru, but the rise of the Inca to power only began about A.D. 1100 and tradition has very little to tell concerning the, in certain respects superior, "civilization" which had flowered and faded before Inca times, but which provided the basis of Inca culture. The Inca may thus be regarded as similar to the Aztec of Mexico, whose cultural life was based on Maya inspiration, but Inca rule was founded on ideas and ideals which differed widely from those of the Aztec. Our conception of this earlier period is founded almost entirely on archaeological research in the field, and it is a regrettable fact that so much excavation in South America has been undertaken by treasure-hunters who had no idea of the importance of the proper documentation of specimens. Excavation on scientific lines has only been carried out in limited areas, principally by Uhle, and later by Tello.

History.—The earliest manifestations of advanced culture in South America appear to have arisen more or less simultaneously in three widely separated geographical regions, the centres of which were, respectively: Tiahuanaco (at the southern end of Lake Titicaca in Bolivia, some 13,000 ft. above sea-level); Nasca on the coast in southern Peru; and Truxillo, also on the coast, in northern Peru. The early remains of these areas are known usually as Tiahuanaco, Proto-Nasca, and Proto-Chimu, but though they show certain very definite individual characteristics, there is an underlying similarity, which is most apparent in the case of Tiahuanaco and Proto-Nasca. Sequence-dating seems to suggest that these three centres flourished between the second century B.C. and the second century A.D., and were therefore more or less contemporaneous with the Early Maya of Central America. Archaeological evidence, as far as it is available, seems to indicate that the Tiahuanaco people gradually extended their influence northward throughout the highlands, possibly as far as Ecuador, and eventually dominated the coast as far north as Lima.

These three cultural centres suffered a collapse, and roughly between A.D. 800 and 1100 there was a "dark age" of degeneration which prevailed over the whole of the region. Then followed a "renaissance." On the coast Truxillo reappears as a cultural centre (the Chimu period). Further south the province of Yca revived the old Proto-Nasca art (the Nasca period), and in the highlands, the Inca succeeded to the heritage of the Tiahuanaco folk, and not only repeated but surpassed their predecessors in the development of an "empire" which eventually extended over coast and highland from Quito to the river Maule.

Records and traditions of the coastal population are almost entirely lacking, and the traditional history of events there is derived from Inca sources. Unfortunately the accounts preserved are not in agreement on all points, and it is not easy to reconcile discrepancies. For instance, one of the most important documents relating to Inca civilization is the account of Garcilasso de la Vega, son of a lady of the ruling Inca house by one of the conquerors, who had been brought up in his mother's family, and had exceptional opportunities for collecting the ancient traditions. But his natural sympathies led him to stress the virtues of the Inca regime to the point of exaggeration. On the other hand, the "official" history of Sarmiento was written rather with the idea of showing the Inca in the light of oppressors and the Spaniards as liberators. Between these two extremes lies the puzzling account of Montesinos.

While other accounts of Inca history give a list of twelve or thirteen rulers, Montesinos, who gives about one hundred, had access to the vanished work of Blas Valera, and it is more than probable that Montesinos' list includes both the chiefs of the Inca clan before they rose to power in Cuzco, and the rulers of the previous Tiahuanaco "empire."

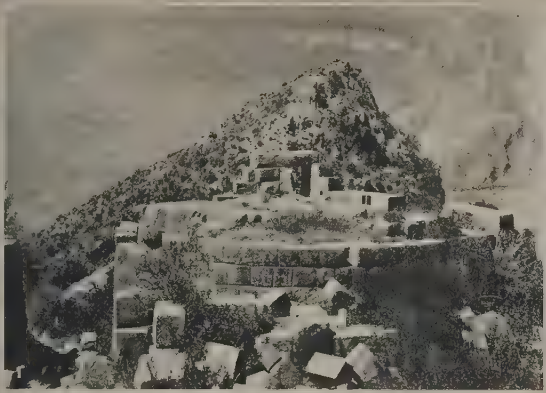
In general terms, the history of the rise of the Inca to power would seem to be as follows. Their history begins with a frankly mythological account of a migration from the south to Cuzco, under the leadership of Manco Ccapac. For years the Inca, living the same life as other Andean tribes, consolidated their power in the Cuzco Valley, and then began to make their influence felt among the surrounding tribes. A career of conquest, undertaken partly as a religious crusade, eventually raised the tribe to the position of a ruling caste, whose sovereign was regarded as a god on earth. The history of this dim period is discussed fully in Joyce's book (*see* bibliography).

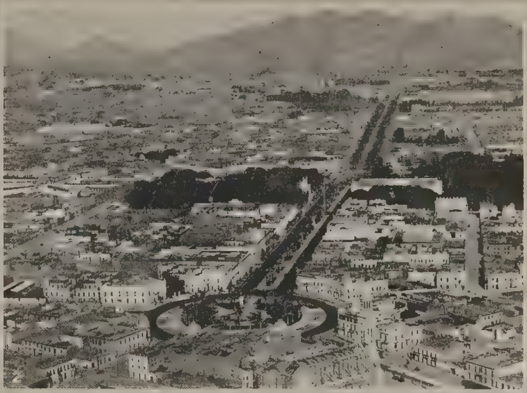
The first historical Inca (bearing the "royal" title of *Sapa Inca*) was Sinchi Rocca, by most authorities recorded as the "son" of Manco Ccapac, but, in Montesinos' list, separated from him by a long series of tribal rulers. His date may be set at about A.D. 1100. The list of Inca rulers in "historical" times (concerning which the early chroniclers are not quite in agreement) seems to have been as follows:

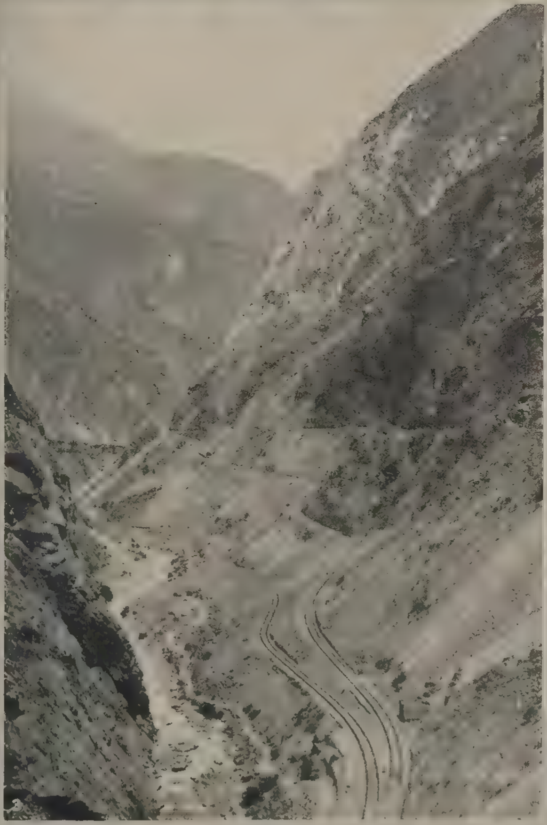
1. Sinchi Rocca.
2. Lloque Yupanqui.
3. Mayta Ccapac.
4. Ccapac Yupanqui.
5. Rocca.
6. Yahuarhuaccac.
7. Uiracocha.
8. Pachacuti.
9. Tupac Yupanqui.
10. Huayna Ccapac.
11. Huascar.
12. Atahualpa (usurper).

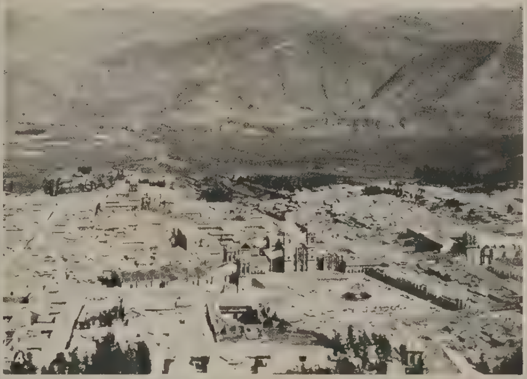
Under Sinchi Rocca, Cuzco was embellished with many stone-buildings, and the famous sun-temple, the Curicancha, was enlarged. It seems probable that Inca power began to make itself felt outside the Valley in a southerly direction (amongst the Colla peoples), and was consolidated by his successor. Mayta Ccapac continued the policy of expansion towards the south, and the activities of these rulers led to the annexation of a large region, extending as far as Lake Titicaca, in the reign of Ccapac Yupanqui. The next two reigns appear to have been devoted to the settlement of newly-acquired territory, but in the time of Uiracocha a crisis arose which decided the fate of the cultured peoples of South America. West and north-west of the Inca domain, the Chanca people, living under similar conditions, had built up a powerful confederation. A clash was inevitable, and the struggle was desperate; but the Inca, supported by their newly-acquired tributaries from the Collao, emerged victorious. As a result, a large expanse of territory was added to the Inca sphere, inhabited by cognate peoples, practising similar customs and religious observances, and therefore amenable to the new conditions. The annexation of the Chanca district opened the way to the coast, the conquest of which, for climatic and religious regions, was a long and laborious process. The reign of Pachacuti seems to have been devoted to a reorganization of the Inca system in view of its new colonial responsibilities. But under Tupac Yupanqui and Huayna Ccapac, the two great "conquerors" of the Inca dynasty, Inca domination was imposed throughout the highland region from Tucuman in Argentina to Quito in Ecuador. The conquest of the Nasca and Chimu peoples of the coast was a longer and more laborious process. Here religious difficulties arose owing to the unwillingness of the coastal folk to accept sun-worship, and they were reduced to submission only after a long series of campaigns which entailed the establishment of permanent forts and the cutting off of the water-supply which they obtained, by means of aqueducts, from the mountains, but by A.D. 1400 the coastal region fell under Inca influence.

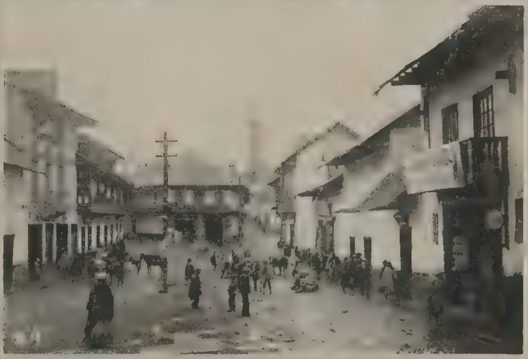
Pizarro was able to succeed in Peru by the fact that he arrived just at the moment of a political "split." Huascar, the legitimate ruler, had been seized and imprisoned by Atahualpa, who claimed to be the son of Huayna Ccapac by a daughter of the ruler of Quito. According to the rules of succession, Atahualpa had no claim to the rulership, but he had the support of Ecuador. Atahualpa held Huascar captive, and assumed the divine authority. Pizarro, by a manoeuvre which was little less than an act of











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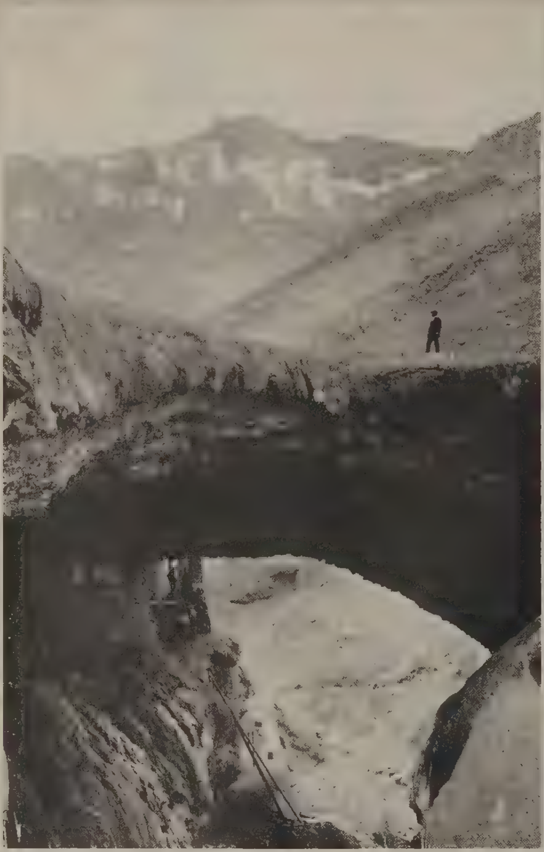
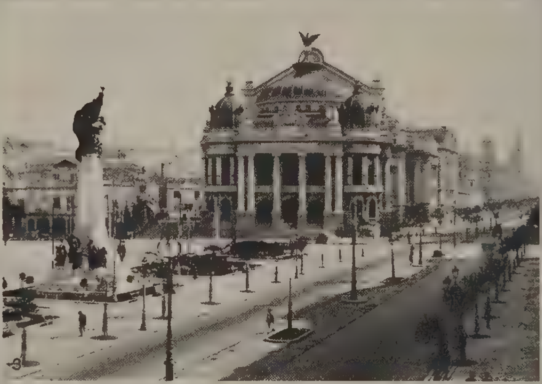
VIEWS OF SOUTH AMERICA

1. Remains of the Astronomical Tower, sometimes called Inti-huaicu, cut from the living rock on a mountain in Ecuador. It is believed this tower was used by the ancient inhabitants as a type of giant sun dial. An image of the sun is carved on the flat surface. Distinct marks are found on the spots where shadows cast by sun reach on June 21, and Dec. 22
2. Looking down on Lima, Peru, from an aeroplane, with the Plaza Bolognese shown in the foreground
3. A switchback, an arrangement of zigzag tracks for lessening the grade up a hill, in the Andes mountains. Eighteen switchbacks are in use on the Central Railway of Peru
4. General view of the city of Cuzco. The photograph was taken from the brow of Sacsahuaman
5. Looking down the principal thoroughfare in Cerro de Pasco, Peru. Elevation of this city 14,500 feet. City is surrounded by large copper mines

SOUTH AMERICA





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SOUTH AMERICAN SCENES

1. "Puente del Inca" (The Inca's Bridge), a natural stone causeway over a chasm in the Andes mountains.
2. Birds-eye view of La Paz, Bolivia. Illimani, one of the two highest mountains in Bolivia with an altitude exceeding 21,000 ft., is seen in the background
3. National Theatre at Rio de Janeiro built at a cost of over $5,000,000. Modeled after the Grand Theatre of Paris, France
4. Looking out at the harbour of Valparaiso, Chile, from the heights behind the city. Ships of all nations are anchored in this sheltered port
5. Highway winding through the rugged Andes mountains of Venezuela. The government of Venezuela has constructed hundreds of miles of excellent roads

treachery, captured Atahualpa, who, meanwhile, contrived the murder of Huascar. The result was that the Peruvian "empire," of which the administration centred in the ruler, regarded as a god-on-earth, fell like a ripe fruit into the hands of the Spanish invader. For chronology *see* chronological table, CENTRAL AMERICA, *Archaeology*.

Architecture.—The dawn of Peruvian and Bolivian culture produced great builders. But while the Tiahuanaco folk built in stone, the coastal peoples built in clay. The region of Tiahuanaco itself is a marvel of megalithic masonry; scattered blocks carved with a precision almost incredible as the work of a people ignorant of iron, obviously the ruins of some great architectural scheme. Megalithic building was characteristic of this early age in the high country, and the pre-Inca buildings in Cuzco (notably the triple rampart of the Sacsahuayman hill) and the Fortress of Ollantaitambo (to mention two of the most celebrated early architectural sites), belong to this cultural period. A peculiar feature of the early megalithic masonry is exhibited in the fact that the large blocks were keyed in to their neighbours by means of re-entrant angles. Consequently each block was sculptured to fit a definite position in the architectural scheme. And the masonry of this "polygonal" character was erected on a scale which, as proved by the surviving examples, represents one of the finest achievements of uncivilized man.

But the polygonal method is wasteful from the point of view of labour; and the Inca developed the method of building by means of comparatively small regular blocks, cut to pattern. The principles of systematic bonding and accurate fitting were inherited from their predecessors, and, to take a single example, the apsoidal end of the great temple to the Sun at Cuzco (the Curicancha), which forms the foundation of the present Cathedral, is a famous masterpiece of early architecture.

Contemporary accounts indicate that the roofs, even of the most important buildings, were constructed of thatching supported by beams. Exterior ornamentation was limited in the main to the breaking of plain surfaces by series of niches, but many, perhaps most, of the surviving stone-built ruins of pre-Inca and Inca times achieve their effect simply by their quality of massiveness and the perfect fitting of the blocks which compose them. Both the quality and the quantity of the masonry representing the two periods in the highlands mark the inhabitants as master-masons. Apart from actual buildings, there exist throughout the area literally hundreds of miles of stone terracing, built for agricultural purposes on the slopes of the Andean valleys.

On the rainless coast conditions were different. Stone, in quantity sufficient for building, was lacking, and buildings were constructed in sun-baked clay (*adobe*). In this region are found enormous structures in the form of stepped pyramids (especially at Moche, in the Truxillo area), often supporting the remains of shrines. All served a funerary purpose, since the early population buried their dead in what was the local "church-yard."

The art of clay-architecture attained a very high level in the Chimu period, and the great ruins of Chan-chan, near Truxillo, include long series of walls ornamented with intricate modelled designs, based mainly on textile art. Later buildings on the coast reflect the Inca conquest. The severity of Inca stone-work is reproduced in the local material, sun-baked clay.

Worship and Burial.—Traditions would seem to show that the Tiahuanaco folk worshipped a supreme god, Uiracocha, associated with rain and thunder, and therefore with fertility and creation. His worship persisted in Inca times, and he was especially associated with the southern tribes of the Inca Empire. No trace of sun-worship is found at this period. On the coast, sun-worship never existed until it was forcibly introduced by the Inca in the 15th century. The religious beliefs of the Proto-Chimu and Proto-Nasca peoples are very obscure, but probably they were much the same as those of the Chimu and Nasca, who paid reverence to certain high-gods (creator-gods and oracular divinities), to the moon and the sea, and to various lesser clan-gods, mostly in animal form, who may have been regarded as ancestors, and even possibly have had a totemic significance. The worship of special clan-gods is characteristic of the whole region in the Inca period, and, no doubt, played a more important part in the life of the ordinary man than the cult of the more remote high-gods. Of the latter, two seem to have been preëminent on the coast. Here the great creating divinity was Pachacamac, counterpart of the highland Uiracocha, whose great shrine exists in ruins to-day at the site which still bears his name. Another coastal deity of great importance was the oracular god Rimac, whose temple (from which the modern Lima receives its name) was the resort of pilgrims from distant regions in the Inca period.

The whole of Peruvian religion, in Inca times, is connected with the word "Huaca," belonging to the Quichua dialect spoken by the Inca, and employed throughout their empire as the official tongue. There is no one word in English which can convey its meaning. It means "holy" in the fullest sense (and was applied to the highest and most mysterious gods). Tribal gods and clan gods were "huaca," and the meaning of the word was extended to include objects which were regarded as uncanny, or merely unusual, such as a queerly-shaped rock, or a man with a hare-lip. The tribal *huaca* of the Inca was the Sun, and their campaigns of conquest were in a sense crusades, to elevate the tribal god to a paramount position amongst the neighbouring tribes. They made no attempt to suppress local cults, but planted temples to the Sun in conquered provinces and compelled the subject tribes to conform, at least outwardly, to "state-religion." In the coast region, life was one long struggle against drought and the Sun was no benefactor. The long resistance made by the inhabitants of the coast to the Inca invasion appears to have been based on unwillingness to accept sun-worship as an "established church."

Lowest in the order of *huaca* came the personal and household fetishes, known as *conopa* on the coast, and *chanca* in the highlands, usually small stones of peculiar shape or colour, or any unfamiliar object. Many of the ruling Inca possessed personal fetishes or "familiars," called *huauqui.*

But throughout the region the cult of the dead occupied a very important place in religion. Many of the tribal and clan *huaca* were regarded as ancestors, and a similar sanctity attached to the mortal remains of human forbears. The burial rites afford an interesting parallel with those of Egypt. The Egyptian process of mummification arose from the local climatic conditions. The fact that bodies, buried in dry sand, did not decay, led to the idea that the preservation of the body was a matter of importance, and so to the evolution of special means to arrest corruption. The dry air of the highlands in Peru and Bolivia, and the arid atmosphere of the coast, provided a parallel environment and produced similar results. In either region the bodies of the dead became desiccated, and in certain instances the preservative tendencies of the climate were assisted by the evisceration of the corpse before burial. The body was usually arranged in a contracted position (unlike the Egyptian mummy) and, after being wrapped in various folds of textile or netting, deposited in a cave (highlands), or a communal grave or "church-yard" (coast). The "mummies" of the ruling Inca were preserved in the great Sun-Temple at Cuzco, where they were seen by the first Spanish invaders. These "mummies" were *huaca* of a high order, and those of important individuals were paraded at certain festivals to the dead. The word *huaca* exists today as applied to the pottery remains discovered in aboriginal burial-grounds.

Arts and Crafts.—The skill of the Peruvians in the cutting of stone is illustrated in the section on architecture. The delicate flaking characteristic of the Maya area is not found here, but the manufacture of axes, mortars and other vessels, by means of polishing, attained a very high degree of proficiency. It is probable that stone was worked with stone, though certain metals, such as gold and copper, were known from the earliest periods in the highlands. The copper was in fact a bronze, probably accidental, but was worked both by casting and hammering. In Inca times, at any rate, metal was smelted in furnaces (*huaira*) fanned by the sea-breeze which blows regularly at night on the western slopes of the Andes. Gold and silver were cast and hammered, and these metals, according to contemporary accounts, were used in combination; the Inca had gardens in which flowers were imitated in the precious metals. Metallurgical skill extended to the coast in

Chimu times, and the narrow silver vases discovered in burials of this period exhibit a perfection of technique.

For archaeology, however, it is the potter's art which is the most important, in so far as the sequence-dating of the successive cultural periods is based mainly on the various styles of ceramic art found in stratified layers at certain sites. The Peruvian potter was ignorant of the wheel, and his vases were built by the "coiling" process, at any rate in early times. Moreover, Proto-Chimu pottery is almost unique in America owing to the extreme realism of its modelling. Vases in the form of human heads and figures were modelled on lines which suggest that they were actual portraits.

In the dry atmosphere of the coast evaporation was rapid, and water was precious. A closed vessel with narrow spout was necessary for its preservation. The difficulty of pouring from a single narrow spout led to the invention of the loop-handle, which permitted the introduction of air by one branch, while the liquid issued from the other. Proto-Chimu vases, apart from their realistic modelling, are distinguished by a marvellous perfection of form. They are usually coated with a creamy slip, on which designs, in more or less conventional style, have been painted in terracotta slip. A black ware is also found, though not in large quantities. If the Proto-Chimu pottery was supreme in modelling, that of the Proto-Nasca folk was supreme in colouring. No people, living under similar primitive conditions, have ever held at their command so wide a range of tints in slip-decoration. Modelling is rare and inferior to that of the Proto-Chimu, but the qualities of paste and shape are equal.

Designs in the Tiahuanaco style, but in the colours of the coast, have been found at various sea-board sites, notably Pachacamac, and provide important evidence that the Tiahuanaco folk conquered the coast at least as far as this point. The peculiar ware of the Recuay valley, with decoration suggesting both Proto-Chimu and Tiahuanaco influences, has not yet been properly studied.

The Nasca period, which succeeded the Proto-Nasca, was not so successful as a revival. The brilliant colours of the earliest period were lost, and decoration consisted in the main of rather small-scale designs derived from textile art. The Inca, inheritors of the Tiahuanaco culture, invented certain pottery shapes, one of which, known as the "aryballus" (with flaring neck and pointed base, rather reminiscent of certain Etruscan patterns) is peculiarly characteristic. Inca ware is extremely good in quality; the coloured decoration is rich, but low in tone, and limited in range, while the patterns are mainly geometrical.

The weavers of this region displayed a proficiency almost equal to that of the potters, and it has been said that, if the art of weaving were suddenly eliminated from the Old World, it could be reconstructed from a study of ancient American textiles. This is not quite true, because no specimen of "twilled" technique has been discovered. The earliest woven fabrics appear to have been constructed on a warp which was kept extended by a band encircling the back of the weaver. The weft was put in by hand, by means of wooden needles bearing threads of different colours. The technique was that of tapestry, but there were local variations. In the area covered by the Proto-Chimu and Chimu cultures, the weft was absolutely discontinuous, with the result that slits appeared in the fabric at the points where the division between colours ran in a vertical direction (like the oriental "kelim"). For this reason most of the designs ran on diagonal lines. In the Tiahuanaco-Inca and Proto-Nasca-Nasca area, these slits were obliterated by interlocking the wefts of converging colours.

The colours of the early textiles show great range and brilliancy, and certain specimens, discovered in the burial-grounds of the Nasca region, fringed with a kind of "crochet" work, are remarkable examples of design and technique. Whether the principle of the heddle was known in early times is uncertain, but this appliance was certainly employed in the later period. In Chimu times double-faced cloths, with reciprocal patterns, were woven on a simple loom equipped with two heddles and two shed-sticks; a process involving two warps and two wefts (for further details *see* bibliography, especially Joyce's book and later works).

Social Life.—The Inca rule was a form of state-socialism, based on the idea that the sovereign was the earthly representative of the Inca tribal god, the Sun. In the course of expansion, and the meticulous organization of conquered provinces, the Inca, from a tribe, became an official caste, constituting, eventually, a huge bureaucracy. The inhabitants of the highlands acquired a mentality remarkably responsive to discipline. The expansion of Inca rule was, to the populace, merely a change of overseers.

The communistic system seems to have dated from the earliest times; under Pachacuti it was adapted to the needs of "colonial expansion." Eventually the "empire" was divided into provinces, each under the control of a hereditary *Curaca* (often a local chief, confirmed in his office owing to ready acceptance of the new regime), and a hierarchy of officials ranging from sub-chiefs to subordinate inspectors, whose supervision was limited to a few families. Intensive supervision was a condition of the peculiar form of government. All produce, agricultural, pastoral or industrial, was fundamentally state property. Trade was practically non-existent. Labour, manual, operative and official was "state-tribute," and some form of "labour" was exacted from every member of the community. Lands were apportioned for cultivation in accordance with the size of families, but the produce was essentially state property. In fact the whole of the produce of the Inca empire was pooled, and distributed according to a regular system. This system had certain merits and corresponding defects. It permitted an equal food-supply throughout the empire; the surplus of the maize-crop, for instance, in the fertile valleys, providing for the upkeep of a large herdsman population in the sterile uplands; and also for the relief of drought.

Craftsmen (weavers, potters and metal-workers), though not entirely exempt from agricultural work and *corvée* labour (involved in the construction of roads and state-buildings) were, in the main, supported by the agricultural population, who, in their turn, received a proportion of textiles and other manufactured goods. The distribution of raw material, as well as manufactured articles, was carried out on a regular system, and, to take one instance, the weavers received a regular allowance of cotton and llama (or alpaca) wool, from which they were expected to produce a certain amount of woven material. Knowledge of the carefully organized interchange of produce is based mainly on Garcilasso's account, which is probably overdrawn, but there is no doubt that the main lines are correct. The system was perhaps less perfect than appears from his description, yet there is no question of the drastic measures employed by the Inca in the organization of conquered territory. Whole sections of the population were transferred from one part of the "empire" to another. Such enforced "colonists" were known as *mitimaes*, and the practice served a double purpose, political and economic. In the first place it was a safe-guard against insurrection; in the second, it provided for the population of uninhabited areas.

Under a system of this type a rigid survey of the population was a matter of first importance, and a careful "census" was made from time to time, the records preserved on the knotted cords known as *quipus* (*qv.* and *see* Locke, *The Ancient Quipu*). It was equally important that there should be no shifting of population, except under state supervision; consequently an individual born to a certain occupation in a certain locality, could, in normal circumstances, neither change his trade, move from his village, nor even marry outside his local group. The system involved the absolute suppression of personality or enterprise, acceptable to the local psychology, but intolerable to Anglo-Saxon concepts.

Behind the state-organization, lay a clan-system, still imperfectly studied, and obviously far older than the imposed Inca regime. Local family-groups, which appear to have been true clans (known as *ayllu*), practising the cult of a common *huaca*, existed within the tribal complex of the Peruvian aborigines.

The administration of the enormous length of mountainous territory administered by the historical Inca necessitated rapidity of communication, and a service of professional "runners" was maintained, who traversed the country in relays, from rest-house to rest-house, along the roads which are still traceable from Quito to Northern Argentina. In the highlands these tracks are often in the form of stairways cut in the face of precipices.

Among the populace marriage was arranged, under supervision, within the local group. But the ruler himself was limited to certain restrictions. He was allowed to maintain a number of concubines, but, at any rate in theory, his normal consort (*Ccoya*) was his sister, who alone could bear him a successor. This seems to suggest that rank followed the female line, and that Peruvian inheritance was based on a matrilineal system. Here again, chance was on the side of the Spanish invader. Pizarro arrived just at the moment of a grave politico-religious crisis. Huayna Ccapac had died recently. His legitimate heir, by his sister, was Huascar. But a pretender, who asserted that he was the son of the late "emperor" by a daughter of the chief of the lately added province of Cuzco, had assembled a force of Ecuadorian mountaineers, and, by a *coup-de-main,* had captured Huascar. Pizarro, by means which it is difficult to describe save as sheerly treacherous, seized Atahualpa. Atahualpa gave orders for the execution of Huascar, and these orders were obeyed. The motive power behind the Inca empire therefore ceased to exist. Huascar was dead, and Atahualpa, who by force of arms might have taken his place, was a prisoner. The Inca organization was for the moment like a clock without a mainspring, though the works were otherwise unimpaired. Yet the organization was so complete that when the Spaniards by a lucky random stroke, held in their possession the person of the only possible claimant to the position of divine ruler, they were able to set the wheels going to their own advantage. Naturally there was a certain amount of opposition, but Pizarro had little to face in this respect compared with Cortez. His main difficulties lay in the dissensions which arose among the Spaniards.

Allusion may be made to the system of training which was imposed on boys of prominent Inca families in the capital Cuzco. Lads of prominent families, destined to the higher posts in administration and the army, were subjected to a severe training of a "public-school" nature (which the heir to the throne also underwent), and submitted to tests of a very severe nature. The culminating ceremony was a race from the sacred Huanacauri hill to Cuzco, after which candidates who had "passed" received certain insignia of "nobility," including the ear-ornaments which distinguished the ruling caste.

The Lower Cultures of South America.—In the north-western provinces of Argentina, amongst the Diaguite people, remains have been found which display strong influences emanating from the Tiahuanaco culture, and, subsequently from the Inca. Inca influence is also evident in northern Chile. Elsewhere material culture was at a low stage, though the beautifully flaked arrow-points of jasper and chalcedony, of the lower Chilean coast are unsurpassed in the history of stone-technique. A few rather remarkable stone-carvings have been found in the Santa Caterina province of Brazil, and a very interesting class of decorated pottery has been discovered in some quantities on the island of Marajo in the Amazon delta, which appears to have been the burial-ground of a vanished Arawak population.

Ecuador.—At the time of the Spanish conquest, practically the whole of Ecuador had fallen under the domination of the Inca; and arts, industries and social life had been organized on the Inca system. Quito had risen to almost the rank of a second capital of the Inca empire, and by troops collected in this region Atahualpa was enabled to attempt to oust Huascar from the rulership. Before the Inca conquest, a contrast, remarkably similar to that in early Peru, between the culture of the coast and highlands respectively, is indicated by the archaeological remains. The pottery of the coast, in its realistic tendencies, displays a certain similarity to that of the Proto-Chimu; while the ware of the highlands shows affinities with that of Colombia, especially in the prevalence of reservation on patterns in the ground by means of wax-painting or some analogous process. History is confined to a few surviving traditions, mostly of a mythological character; but containing certain "historical" details which may be summarized as follows. A tribe known as Cara arrived on the coast in rafts (the nature of the craft suggests a coasting voyage), under a chief termed Scyri. Later they migrated to the uplands, where they amalgamated, first with the Quitu tribe, and subsequently with the Puruha. Later the warlike Canari and the Palta became members of the nascent "empire," which at the time of the Inca conquest included practically the whole of the Ecuadorian highlands.

Bibliography.—A fairly complete archaeological bibliography of South America is given in the work of Beuchat mentioned in the last section, and in T. A. Joyce, *South American Archaeology* (1912), which deals at length with the history and culture of the early tribes. Though mentioned in the above bibliographies, especial attention may be called to the annotated translations by Sir Clements Markham of certain early chroniclers, published by the Hakluyt Society of London; viz. Garcilasso de la Vega (1871 and 1879); Molina, Salcamayhua, Avila and Ondegardo (in one volume 1873); Cieza de Leon (1864 and 1883) and Sarmiento (1907). *See* also the translation of Montesinos, in the same series, by P. A. Means (1920). But a considerable bulk of archaeological literature has been published, chiefly in the form of monographs and papers in scientific journals, since the compilation of Beuchat's and Joyce's bibliographies. These cannot be given in detail, but the most important authors are Max Uhle (for Peru and Ecuador, papers printed from time to time in those countries) and detailed summaries of the results of Uhle's excavations made by A. L. Kroeber, A. H. Gayton and W. D. Strong (University of California Publications, vols. 21 and 24). L. L. Locke, *The Ancient Quipu* (American Museum of Natural History, 1923); and E. Nordenskiöld, *The Secret of the Peruvian Quipus* and *Calculations with Years and Months in the Peruvian Quipus* (both Göteborg, 1925), describe the Ancient Peruvian method of recording by means of knotted strings, so far as elucidated. The writings of J. C. Tello (in the publication *Inca,* Lima, Peru); of J. Jijon y Camaano (published in Ecuador; notably *La Religion del Imperio de los Incas,* 1919); and respecting Chile, of R. E. Latcham and Max Uhle (published locally), all demand attention. The literature dealing with the archaeology of the West Indies is adequately covered by the bibliographies appended to the work of Beuchat (mentioned above), and to T. A. Joyce's *Central American Archaeology* (1916), the latter of which deals comprehensively with the culture of the Antilles. Since the publication of these works, two others of importance have appeared; M. R. Harrington, *Cuba before Columbus* (Museum of the American Indian, 1921); and Sven Loven, *Über die Würzeln der Tainischen Kultur* (Göteborg, 1924). The abundant footnotes in both these publications practically constitute bibliographies. Shorter papers, in scientific publications, are too numerous to mention singly. Of these journals perhaps the most important are:—The *Journal of the Royal Anthropological Institute;* the *Journal de la Société des Américanistes de Paris;* the *Zeitschrift für Ethnologie;* the *American Anthropologist; Inca* (Lima, Peru). The *Reports* of the International Congress of Americanists, in particular, present a wide range of archaeological material, though the standard of the papers printed varies considerably. Access to current literature is best obtained through the *Bibliographie Américaniste,* compiled from time to time by P. Rivet and published in the *Journal de la Société des Américanistes de Paris,* Dr. Rivet's own publications ranking amongst the most important contributions to archaeological literature. (T. A. J.)

ETHNOLOGY

Practically all the definite data available indicate that the aboriginal population of South America was derived from that of the northern continent, by successive drifts coming by way of the isthmus of Panama and possibly to a lesser extent by way of the Antillean chain from Florida. It has been urged by some that a trans-Pacific origin may, at least in part, be assumed. In spite, however, of a few striking cases of cultural parallelism, the practical difficulties involved are so great that one must regard this theory as still unproved. An occasional canoe from Oceania may, it is true, have reached the South American shores, but the racial significance of such cases would be negligible.

The older theory of the origin of the American Indians regarded them as belonging to one single racial type, designated as Mongoloid. Such variations as were recognized were thought to be merely local forms of no significance. Evidence has, however, in recent years been coming to light which tends to make this view more and more impossible. The crania found at Lagoa Santa in Brazil, at Paltalcalo and Puñin in Ecuador, in Lower California, the islands off the southern Californian coast, and among the Basket-makers of the south-west, etc., with their strikingly Melanesian and Australoid characters, have led many able anthropologists to believe that at least two fundamentally different racial elements were present in the New World. Of these the Melanesian-Australoid type is the older, as shown both archaeologically and by its marginal position. A Caucasoid and even a Negroid factor are also possibly present. The peoples of the New World are, therefore, like those of the old, almost certainly of complex racial origin.

Linguistic Stocks.—The primary classification of the American Indians is usually based on language. In the northern continent some seventy odd different linguistic stocks are officially recognized by the Bureau of American Ethnology, although the investigations of the last generation have shown that without much doubt this number should be largely reduced. For South America the linguistic data available are far less abundant and satisfactory, but taking the evidence as it stands, the latest attempt to classify the tribes of the continent on the basis of language (A. F. Chamberlain, "Linguistic Stocks of South American Indians," *American Anthropologist* [N.S.], vol. xv.), recognizes 83 linguistic stocks. Just as in North America, a considerable number of these are actually related, either to each other, or to one or other of the large stocks, such as the Arawakan, Chibchan, Cariban, Tupian, etc. These and other large stocks have spread widely, the Arawakan being perhaps the greatest wanderers, representatives being found from Bolivia to Cuba.

The linguistic stocks as recognized by Chamberlain are as follows:—

Alikalufan
Allentiacan
Andaquian
Apolistan
Araucanian
Arawakan
Ardan
Atacamenan
Aymaran
Barbacoan
Betoyan
Bororoan
Calchaquian
Cañarian
Canichanan
Carayan
Cariban
Caririan
Cayubaban
Changoan
Chapacuran
Charruan
Chavantean
Chibchan
Chiquitan
Chocoan
Cholonan
Chonoan
Coconucan
Corabecan
Cunan
Curucanecan
Enimagan
Esmeraldan
Goyatacan
Guahiban
Guaraunan
Guatoan
Guaycuruan
Itonaman
Itucalean
Jivaran
Jurian
Lecan
Lorenzan
Lulean
Mainan
Makuan
Matacan
Miranhan
Mocoan
Mosatenan
Moviman
Muran
Ocoronan
Onan
Otomacan
Otuquian
Paniquitan
Panoan
Peban
Piaroan
Puelchean
Puinavian
Puquinan
Quichuan
Salivan
Samucan
Sanavironan
Tacanan
Tapuyan (Ges)
Ticunan
Timotean
Trumaian
Tsonekan
Tupian
Uitotan
Uran
Yaghanan
Yaruran
Ypurinan
Yuncan
Yurucarean
Zaparan

(*See* also South American Languages.)

Social Organization.—Three main types of political organization may be recognized among the South American Indians. The simplest is found among the more primitive nomadic or semi-nomadic tribes such as those of the Tapuyan peoples of the Brazilian highlands, many of the smaller stocks of the Amazon-Orinoco basin and of the Chaco and Pampas region southward to Tierra del Fuego. There is no centralized authority, no true tribal chiefs; the people are organized in small local and independent units, submitting themselves only in case of war to the effective leadership of the best fighters. Above these come the majority of the tribes of the region east of the Andes, among whom, as relatively sedentary communities, the tribal unit is more clearly organized, and village and occasionally tribal chiefs have acquired a considerable measure of authority, often quasi-hereditary in character. In the Andean highlands and along the Peruvian coast the position and power of the chiefs had advanced to such an extent that in several instances, such as among the Chibchas of Colombia, the Caras of Ecuador and the Yuncas and Incas of Peru, there existed an actual monarchical type of government. In Peru, this was in some measure complicated by the elaborate communistic organization of the mass of the population, which was, however, largely imposed upon them by the ruling Inca caste.

The typical totemic clan system which characterized the social structure of large parts of North America was apparently less widely and less clearly marked in the southern continent. This may be more apparent than real, since data are less abundant.

As regards marital relationships, one finds a comparatively wide range from the usual monogamy of the more primitive tribes to the highly developed polygamy of the Chibchas and Incas, where the ruling chiefs or kings possessed harems numbering several hundreds. Secret society organizations, military and otherwise, seem to be rather less common than in North America.

Mode of Life.—Among the South American Indians one may find every gradation between the purely nomadic tribes depending wholly on fish, game and wild vegetable products, represented by the Maku or Botocudos of the forest region, the Puelche and Tehuelche of the open pampas or the Onas of Tierra del Fuego, to sedentary agriculturalists, such as the Guarani tribes of Paraguay, or the higher cultured peoples of the Andean highlands, such as the Incas, Yuncas and Chibchas of Peru and Colombia. There were, however, relatively few tribes wholly destitute of agriculture, and the Incas, with their elaborate terrace irrigation, and the Yuncas of the Peruvian coast, with highly developed irrigation and the use of fertilizers, had carried the art to a remarkable stage of perfection. While maize was the major crop along the Peruvian coast and in portions of the Andean highlands, it was less grown in the tropical forest region, where in some sections it was even unknown. In this tropical area manioc was the chief agricultural product. Two different varieties were known, the poisonous and the non-poisonous, the former being rendered harmless by a simple and ingenious process. In the colder highlands the common potato was largely grown, the sweet potato being raised in the warmer sections of the continent. The quinoa was grown in the coldest regions of the highlands, where other crops would not mature. Nearly all the South American tribes, except those of the extreme south, prepared and consumed large quantities of fermented drinks, made from maize, manioc, fruits and palm-sap. In the Andean region, from Bolivia northward and east into the borders of the forest area, the dried leaves of the coca plant were chewed, in some cases mixed with lime, and widely throughout the western portion of the Amazon-Orinoco basin, various kinds of narcotic snuffs were inhaled by means of Y- or V-shaped tubes of bone or cane. Tobacco was smoked in the form of cigars or cigarettes throughout most of the tropical forest region, but pipes were, with few exceptions, in use only in Argentina. The use of tobacco seems to have been practically unknown in Peru and Bolivia and was rare along the Pacific.

Dress ranged from the complete nakedness of some forest tribes of Brazil, through the use of kynodesmy (penis supporters) and various forms of breech-clouts, aprons and kilts of tapa, palm-fibre or cotton, to the elaborately ornamented cotton or woollen mantles, ponchos and skirts of the peoples of the Andean highlands. The Yaghan of Tierra del Fuego, despite their harsh and cold environment, wore only a sealskin hung over the windward shoulder. The most characteristic feature of personal ornament was probably the labret worn in the lower lip. This was usually either in the form of a rod-like pendant or a plug of varying diameter, and was worn (chiefly by men) over a large portion of the northern half of the continent. The ear-lobe and nasal septum were also often pierced and ornaments of bone, wood or metal worn therein. On the Ecuador coast the teeth were inlaid with gold, after the fashion prevalent in parts of Central America. Tattooing was less in use than body painting, the latter type of decoration being sometimes applied by means of pottery or wooden stamps, carved or moulded in patterns. The dwellings of the forest nomad tribes were quickly constructed temporary shelters of leaves or bark, whereas the tribes of the open pampas and Patagonian plains made use of lean-to tents of skin, of the "toldo" type, open on the side away from the wind. The houses of the sedentary population were usually wholly of wood and thatch, some circular with conical roof, some rectangular with gable roof; some very small and used by but a single family, some large and communal, accommodating from 50 to 100 persons.

The bow was the principal weapon of the region east of the Andes, but was unknown or little used in the highlands or on the Pacific coast. Distinctive of South America was the use of the blowgun with poisoned darts, this weapon being in use over a large portion of the western Amazon-Orinoco basin, and reaching the Pacific coast at one or two points in the north-west. Clubs took two main forms, the two-handed wooden broad-sword or "macana" used in the north, and the shorter, stone or metal-headed club of the Inca empire. The throwing-stick, similar in principle but differing in details from the Mexican "atlatl," was widely used in the north, and has been found in early archaeological sites as far southward as northern Chile. The nomad hunting tribes of the pampas made much use of the bolas, composed of two stones attached together by a short cord, in hunting the guanaco and the rhea or South American ostrich.

The dog was a well-nigh universal possession as a domestic animal. In the highlands of Peru and Bolivia the alpaca and llama were also domesticated, the former for its wool, the latter primarily as a beast of burden. Here also land transport was greatly facilitated by the remarkable system of roads built by the Incas, paved in places, and crossing streams by suspension bridges, and over which an elaborate courier service was maintained. Bark and dug-out canoes were widely in use, but were supplanted on the Pacific coast from northern Chile nearly to Panama, by reed or log "balsas" or rafts, often furnished with sails. In southern Chile the "dalca" or three-plank boat was in use.

Religion.—The methods of disposal of the dead comprise almost every known form. Simple inhumation was probably the commonest, the deep shaft graves of Colombia and Ecuador marking its highest development, as these in some cases attained a depth of 50 or 60 feet. In this region mounds were sometimes built over the grave. Platform burial, cave burial and urn burial were fairly commonly employed. In the Andean region various methods of preserving the body were tried, desiccation in the dry, cold air; smoking over a fire, etc. The well-known Peruvian "mummies" are, like those of the south-western United States, primarily the result only of natural desiccation. Some of the Orinoco and upper Amazon tribes who practised inhumation, were accustomed to exhume the bones after a time, burn and powder them, and then drink the powder mixed with their fermented drinks. The shaman or medicine-man was, among all except the tribes of highest culture, an outstanding figure, a curer of disease by sucking, blowing or the use of charms, a sorcerer, diviner and intermediary between man and the supernatural world. Often he was supposed to have the power of turning himself into a wild animal at will. In the higher Andean cultures the shaman developed into an elaborate priesthood.

Ritual, involving mimetic and other dances, sacrifice and prayer, presents a wide range of complexity. Mimetic dances, with or without the use of masks, were characteristic among many peoples of the western and central parts of the tropical region, and more commonly with animal and bird skins for disguises, played a large part in the ceremonies of the Incas and other folk of the Andean cultures. In Venezuela and far to the southward, the whipping-dance was widely spread, in which the participants lashed each other's legs with whips. Puberty initiation ceremonies, very often involving severe ordeals, were also found widely, all the way from Panama to Tierra del Fuego. Sacrificial offerings were developed mainly in the Andean section. In Colombia, these were most commonly of gold objects, or parrots to whom a prayer or message had been taught. Among the Incas, large numbers of llamas were offered. Human sacrifice, if we except the killing of war captives, was practised occasionally; in some cases it was restricted mainly to infants, as in parts of Colombia and north-western Argentina. Mature victims were sometimes tied to a pole and shot to death with arrows, as in middle America. In Peru and more doubtfully farther northward, the heart was sometimes torn out in the Mexican fashion. The practice of head-hunting (*q.v.*) and the preservation of head trophies was widespread from Colombia to Peru, and reached its highest development in the region of eastern Ecuador, with the curiously shrunken heads prepared by the Jivaro (*q.v.*) and other tribes of that area.

Temples and purely religious structures were also, in the main, confined to the area from Colombia to Peru. In the former region they were of perishable construction like the dwellings, although often decorated with a great wealth of gold. In Peru and about Lake Titicaca, they were massively built of cut stone.

The use of images was confined to the Andean highlands, as was incense. Among the great majority of the tribes worship and ritual were addressed to tribal deities of the simpler sort, or to totemic or ancestral spirits, or to local deities of mountain or stream. In Peru, these features were strongly marked, although overlaid by the sun-cult of the Incas imposed by them on the conquered peoples. The figures of some of the creator gods, notably of the Incan Uiracocha or Pachacamac, "the soul of the Universe" attain, however, a higher stage. A notable feature of the mythology of the highland tribes is the appearance of a fair and shining culture-hero, who disappears, promising to return at some later time. Something of the initial success of Pizarro and his followers in Peru seems to have been due to their being regarded as divine beings, fulfilling prophecy.

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SOUTH AMERICAN LANGUAGES. The languages of South America are for the most part still very imperfectly known, and the number of linguistic stocks considered independent of and unrelated to any linguistic family in the New or Old World is reckoned at 75. For many of them we have only vocabularies, often very scanty and of doubtful accuracy. Grammars are rare and nearly all compiled on the model of Latin by missionaries who did not realise that the methods of Latin are totally unsuited for describing languages with essentially different structure and syntax. Finally for most of the languages we have no ancient material. On the Pacific side the main languages are as under:

Chibcha was once spoken almost all over Colombia up to the frontier of Nicaragua and northern Costa Rica, with representatives as far as the latitude of Guayaquil in Ecuador, prior to the Inca invasion, when Chibcha speech was ousted by Kichua on the Andean Ecuadorian plateau.

Kichua.—The language of the Inca, Kichua or Runa-Simi, is still spoken by Indians on the high plateau of Ecuador and Peru, in Bolivia (Cochabamba, Chuquisaca and Potosi), in the north-west of the Argentine (Jujuy, Santiago del Estero). It is the only language in America which was an element of civilization before the Discovery, when it was the instrument of an invading culture brought by an organized conquering people. Inca imperialism forced it on the vanquished peoples, then the Catholic missionaries continued and completed the work of the overlords of Cuzco.

Aymara.—Speakers of Aymara exist in Peru in two provinces of the department of Puno, in the departments of Arequipa and Moquegua, in Bolivia. Before the spread of Kichua it was more widely diffused and the builders of the famous monuments of Tiahuanaco almost certainly spoke it.

Araukan.—This language still exists in Chile between the Pacific and the Andes, between the 27th and 43rd degrees of latitude and in the Argentine up to Buenos Ayres.

Choko was spoken on the Pacific side between eight and four degrees North and Esmeralda on the north coast of Ecuador.

On the Atlantic side at the time of the Discovery the people were at a low level of civilization and we find there several large language families and a great number of small independent groups:

Tupi-Guarani.—In the north this language was spoken in Guiana (Oyampi and Emerillon), in the west up to the slopes of the Andes and in the plains west of the Bolivian Grand Chaco (Chiriguano). Southwards it is still spoken throughout Paraguay. In the east, tribes of this speech, at the time of the Discovery, occupied the largest portion of the Brazilian coast up to the mouths of the Amazon.

Old Tupi or Abañeenga had two dialects, that of the south or Guarani, the parent of modern Guarani, as still spoken in Paraguay and adjoining territories, and the northern, Tupi, the forerunner of modern Tupi or Neeñgatu, the "lingoa geral" used in commerce and missionary work throughout the Amazon basin.

Carib.—A wider area was covered by the Carib, whose place of origin is thought to have been the region between the Upper Xingu and the Tapajoz, whence they spread northwards to the Lesser Antilles and to the southernmost point of Florida. They reached the Andes on the west and small groups entered Colombia (Motilon, Opon and Carare Indians) and Peru in the Jaen area (Patagon). On the east they found the coast at Guiana (Oyana, Rukuyen, Kaliña, Galibi, etc.).

Arawak.—The Arawak area is almost identical with that of the Caribs, and in some cases they seem to have migrated together. Their centre of dispersion was somewhere in the Venezuelan-Brazilian area, about the basins of the Orinoco and the Rio Negro. Arawaks were found in Florida and southwards in Paraguay, in Peru (Uru and Pukina) and in the east at the mouths of the Amazon (Araua). So far this form of speech is the earliest of the forms found in the Peruvian-Bolivian area, being earlier than Aymara, which was ousted by Kichua.

Pano.—Of the three geographical groups of this family, the most important is found on the south bank of the Amazon, from the Jutahy east to the Huallaga west, on both banks of the Ucayali from its mouth to parallel 10° and the right bank of its tributary, the Urubamba, in the entire basin of the Upper Jurua and the sources of the Purus. The second group covers the basin of the Inambari, while the third group holds the banks of the Mamore, the Beni and the Madre de Dios between 9° 15′ and 12° 30′ latitude and 64° 45′ to 67° 30′ longitude.

Ge.—This family probably represents one of the oldest elements in South America and extends over the whole of the southern half of the Brazilian plateau reaching Xingu on the west and the Atlantic coast on the east, whence its speakers were expelled by Tupi-Guarani in the 15th century. The classification of Ge speech has yet to be accomplished and is one of the most urgent linguistic tasks awaiting the Americanist.

Tukano.—The first or eastern of the three geographical groups of the Tukano family covers the basins of the Uaupes, Curicuriary and Apaporis. The western group occupies the entire basin of the Napo from its junction with the Amazon up to the mouth of the Aguarico, along the latter river, along the Putumayo from its source to its junction with the Yaguas, along the upper Caqueta to about the 74th degree longitude. The northern group is found at the sources of the Manacacia, a tributary of the Meta.

Katukina.—An immense area south of the Amazon between 72° 30′ and 62° 30′ longitude and between 4° and 9° latitude is occupied more or less continuously by this family.

Puinave.—Like the Ge group the speakers of the Puinave languages are among the most primitive peoples of South America and represent a very ancient element of the population. The Puinave are found in the basin of the Inirida and the nomadic Maku between the Rio Negro and the Yapura, between 69°30′ and 61° 45′ longitude.

Guaykuru.—The Guaykuru languages are spoken by a series of tribes along the banks of the Paraguay, the Parana and their tributaries and in the Chaco, *e.g.,* Mbaya-Guaykuru, Guachi, Payagua, Toba, Mokovi, Abipon.

Matako-Mataguayo.—In the lesser Chaco a compact group is formed by the following: Mataguayo, Matako, Vejoz, Choroti, Ashluslay, etc.

Unclassified Languages.—All over the western portion of South America are spread isolated languages, such as Jirajara, Timote, Yaruro, Otomak, Guahibo, Saliba, Maku, Shiriana, Auake, Kaliana, Guarauno in Venezuela or on the borders of Brazil and Venezuela; Koche, Kofane, Zaparo, Chirino, Kahuapana, Cholona, Amuesha, Tuyuneiri, Leko, Moseten, Yurakare, along the eastern slopes of the Andes and the upper tributaries of the Amazon from southern Colombia to Bolivia; Witoto, Yuri and Mura on the upper and middle Amazon; Mobima, Kayuvava, Kanichana, Itonama, Chapakura, Mashubi, Huari, Nambikuara, Karadja, Trumai, Bororo, Chiquito, Guato, Samuku, Maskoi, Enimaga and Shavante in central and southern Brazil, in eastern Bolivia and in Paraguay; Kariri in eastern Brazil; Charrua formerly spoken in Uruguay; Vilela-Chulupi, Sanaviron, Allentiak, Het and Puelche in the Chaco and in the Argentine Plain.

Australian Affinities.—Of the three southernmost languages of the continent, Alakaluf, Yahgan and Chon, only the last, now spoken by the Patagonians or Tehuelche of the Argentine Pampa, and by the Ona in Tierra del Fuego, has been identified and is found to belong in respect of vocabulary to Australian languages. The migration of Australians to America must have taken place via the Antarctic during the post-glacial optimum when the climate of those regions was sensibly more favourable than now, a period counted by geologists as not less than 6,000 years distant. (Rivet, *Bulletin de la Société de linguistique de Paris,* t. xxvi. 1–2, pp. 23–63, 1925; *Compte-rendu sommaire des séances de la Société de bio-géographie,* Paris, 3$^{\text{éme}}$ année, no. 18, séance Feb. 19, 1926.)

Although links have been established with Australia and in the north with Malayo-Polynesian Australasian (*e.g.,* the Hoka group) and with Sino-Tibetan (*e.g.,* the Na-Dene group), linguists have failed to prove any relationship between the languages of North and of South America or with those of Central America. Information is also needed about the dying languages before they have completely disappeared.

BIBLIOGRAPHY.—*Les Langues du monde,* by a group of specialists under the direction of A. Meillet and Marcel Cohen (1924); W. Schmidt, *Die Sprachenfamilien der Erdkreise* (1926).

SOUTHAMPTON, HENRY WRIOTHESLEY, 3RD EARL OF (1573–1624), one of Shakespeare's patrons, was the second son of Henry Wriothesley, 2nd earl of Southampton, and his wife Mary Browne, daughter of the 1st Viscount Montague. He was born at Cowdray House, near Midhurst, on Oct. 6, 1573, and succeeded to the title in 1581, when he became a royal ward, under the immediate care of Lord Burghley. He entered St. John's College, Cambridge, in 1585, graduating M.A. in 1589; and his name was entered at Gray's Inn before he left the university. At seventeen he was presented at court, where he made friends with the earl of Essex, and received extraordinary marks of the queen's favour. He became a munificent patron of poets. Nashe dedicated his romance of *Jack Wilton* to him, and Gervase Markham his poem on Sir Richard Grenville's last fight. His name is also associated with Barnabe Barnes's *Parthenophil and Parthenope,* and with the *Worlde of Wordes* of John Florio, who taught him Italian. But he is best known as a patron of the drama and especially of Shakespeare. *Venus and Adonis* (1593) is dedicated to Southampton in terms expressing respect, but no special intimacy; but in the dedication of *Lucrece* (1594) the tone is very different. "The love I dedicate to your lordship is without end . . . . What I have done is yours; what I have to do is yours; being part in all I have, devoted yours." Nicholas Rowe, on the authority of Sir William Davenant, stated in his *Life of Shakespeare* that Southampton on one occasion gave Shakespeare a present of £1,000 to complete a purchase.

If the sonnets were addressed to Southampton, the earlier ones urging marriage upon him must have been written before the beginning (1595) of his intrigue with Elizabeth Vernon, cousin of the Earl of Essex, which ended in 1598 with a hasty marriage that brought down Queen Elizabeth's anger on both the contracting parties, who spent some time in the Fleet prison.

Meanwhile in 1596 and 1597 Southampton had accompanied Essex on his two expeditions to Cadiz and to the Azores, in the latter of which he distinguished himself by his daring tactics. In 1598 he had a brawl at court with Ambrose Willoughby, and later in the same year he attended Sir Robert Cecil on an embassy to Paris. In 1599 he went to Ireland with Essex, who made him general of his horse, but the queen insisted that the appointment should be cancelled, and Southampton returned to London. He was deeply involved in Essex's conspiracy against the queen, and in February 1601 was sentenced to death. Cecil obtained the commutation of the penalty to imprisonment for life.

On the accession of James I. Southampton resumed his place at court and received numerous honours from the new king. On the eve of the abortive rebellion of Essex he had induced the players at the Globe theatre to revive *Richard II.*, and on his release from prison in 1603 he resumed his connection with the stage. In 1603 he entertained Queen Anne with a performance of *Love's Labour's Lost* by Burbage and his company, to which Shakespeare belonged, at Southampton House.

Southampton was an active member of the Virginia company's council. He seems to have been a born fighter, and engaged in more than one serious quarrel at court, being imprisoned for a short time in 1603. He was in more serious disgrace in 1621 for his determined opposition to Buckingham. He was a volunteer on the Protestant side in Germany in 1614, and in 1617 he proposed to fit out an expedition against the Barbary pirates. In 1624 he and his elder son enrolled themselves as volunteers for the United Provinces of the Netherlands against Spain. Immediately on landing they were attacked with fever, to which both succumbed, the father surviving, Nov. 10, 1624.

There exist numerous portraits of Southampton, in which he is depicted with dark auburn hair and blue eyes, compatible with Shakespeare's description of a "man right fair." Sir John Beaumont (1583–1627) wrote a well-known elegy in his praise, and Gervase Markham wrote of him in a tract entitled *Honour in his Perfection* (1624).

For further information *see* "Memoirs of Henry Wriothesley, the third Earl of Southampton," in Boswell's *Shakespeare* (1821), xx. 427 *sqq.*, where many of the elegies on Southampton are printed.

SOUTHAMPTON, THOMAS WRIOTHESLEY, 1ST EARL OF (1505–1550), obtained extensive lands between Southampton and Winchester at the dissolution of the monasteries. He was made one of the king's principal secretaries in 1540, was knighted in the same year, and was created Baron Wriothesley of Titchfield in 1544. Having been lord keeper of the privy seal for a few months, he became lord high chancellor in 1544, in which capacity he became notorious by his proceedings against Anne Askew. He was one of the executors of Henry VIII.'s will, and was created earl of Southampton in Feb. 1547. However, he had committed an offence in appointing four persons to relieve him of his duties as lord chancellor and he was deprived of his office in March, when he left privy council. Again in the council, Southampton helped to arrange the fall of Somerset. He died on July 30, 1550.

For the career of the 1st earl *see* Lord Campbell, *Lives of the Lord Chancellors;* E. Foss, *Judges of England.*

SOUTHAMPTON, Hampshire, England, 79 m. S.W. of London by the S.R. The town stands near the head of Southampton Water, an inlet of the English Channel which forms the estuary of the river Test; on a peninsula bounded east by the river Itchen. The county borough includes, since 1920, South Stoneham, part of North Stoneham, Swaythling, Bitterne, Sholing, Itchen and Woolston, and Weston and Newtown, giving a total area of 9,192 ac. and a population (1921) of 160,994.

There was a Roman settlement on the east bank of the Itchen. It was walled, and inscribed stones, coins, pottery, etc., have been found. Southampton (*Hantune, Suhampton*) superseded the Saxon *Hantune* and was a royal borough before 1086. The charter was given by Henry VI. in 1445, while by charter of 1447 the neighbouring district was absorbed. A charter was finally given by Charles I. in 1640. Southampton has returned two members to parliament since 1295. There are remains of the old Norman walls, strengthened by towers at intervals, such as the Arundel Tower at the north-western corner. The site of the castle, near the water, is built over. It was originally a Saxon fortress, and was partly demolished in 1650.

One old house, known as King John's Palace, is considered to be earlier than any example of the 12th century in England. The South and West town gates date from the early 14th century, while Bar Gate, as it stands, is later, and retains excellent Decorated work. Blue Anchor Gate also survives. Numerous early vaults remain below the houses within the walls. The two old churches, St. Michael's, the central tower and lofty spire of which rise from Norman arches, and Holy Rood, partly Decorated, are greatly modernized. St. Michael's contains a Norman font of black marble. The chapel of St. Julian is of transitional Norman architecture, greatly altered by restoration. It was originally attached to the hospital of God's House, founded in the time of Henry III. for eight poor persons, the existing buildings of which are modern. The chapel was allocated as a place of worship by Queen Elizabeth to certain Protestant Walloon refugees. The priory of St. Denys, an Augustinian foundation of 1124, gives its name to a suburb by the Itchen, and has left only fragmentary ruins. Netley Abbey (*q.v.*) 3 m. S.E. is a ruined Cistercian abbey.

The Gildhall, used as a court-house, is in the upper part of Bar Gate. The Tudor House is a well preserved relic, now corporation property and used as a museum. The Edward VI. grammar school was founded in 1550 and reorganized in 1875, and occupies modern buildings. Alderman Taunton's trade school was founded in 1752, and includes a technical department. The University College of Southampton, formerly housed in the Hartley Institution, removed to new buildings at Highfield in 1914.

The Port and Its Trade.—Southampton was the chief port of Winchester. It had a large import and export trade, and in the 13th century was the second wine port in England. Wool was very largely exported, and the fact that it was brought to this port to be shipped probably extended the woollen trade in the west of England. The rise of London as a port, the prohibition of the export of wool, the loss of the Winchester market after the suppression of the monasteries, and the withdrawal of the court led to a gradual decline of trade in the 16th century.

The modern importance of the port begins with the creation of a pier and harbour commission in 1803, and the erection of the Royal Victoria Pier in 1831. The prosperity of the town was enhanced by the opening of railway communication with London in 1840. The harbour is one of the finest natural harbours in the kingdom, and has the advantage of a double tide, the tide of the English channel giving it high water first by way of the Solent and two hours later by way of Spithead. In 1892 the docks, which lie at the southern end of the peninsula, became the property of the Southern Railway Company, then the London & South-Western. The present docks include the Empress open dock (18½ ac.) with a depth of 26 ft. at low water. The quays on the rivers Itchen and Test have been extended to 4,492 ft. and 4,220 ft. respectively. The depth at these quays is 28 ft. and 32 ft. respectively (low water). There are the Outer (16 ac.) and Inner (10 ac.) docks. The total extent of quays and jetties after the extension power of 1925 is approximately 21,214 feet. Besides this there is the Prince of Wales graving dock, the Trafalgar graving dock, a large floating dock some 960 ft. long and four other dry docks. The west station has been rebuilt with a view to giving further railway traffic facilities. Southampton has an air service which operates from Woolston aerodrome to the Channel Islands. The Woolston area has large shipbuilding and engineering works. Southampton is the chief port for express transatlantic passenger services, notably those of the Cunard, White Star and Canadian Pacific lines, while the West African, West Indian, South American, South African, Peninsular and Oriental, and Australian and New Zealand services also use this port, as do a number of cross-channel services under the control of the Southern Railway.

Southampton gives name to a suffragan bishopric in the diocese of Winchester. The county borough was created in 1888.

SOUTHAMPTON, a township of Long Island, New York. Pop. (1925) 15,393 (State census). It embraces several villages, including Southampton (pop. 3,952 in 1925), Quogue, West Hampton and Eastport, and is a summer resort, with many fine estates and clubs. Potatoes are grown in large quantities. Southampton was settled in 1640, from Lynn (Mass.). It became an important whaling centre, and in 1678 Governor Andros mentioned it as one of the principal trading ports of the Colony. The Shinnecock Indians long took part in the whaling industry, and many of them were lost in the wreck of the "Circassian" here on Dec. 31, 1876. The village of Southampton was incorporated in 1894.

SOUTH AUSTRALIA, a state of the Commonwealth of Australia, occupying 380,070 sq. miles (12·78%) in the central southern portion of the continent. Its southern boundary is the coast-line whose absolute length (1,540 m.) somewhat belies its geographical significance.

Physiography.—Situated athwart the junction line of the great western plateau and the great central plains of Australia, and having also special features of its own, South Australia falls into a number of different physical areas though its relief is nowhere so marked as that of the eastern States and there is relatively little land above 2,000 ft. (a) The north-west quarter is occupied by the south-western extension of the western plateau. (b) The north-eastern quarter is occupied by the Lake Eyre depression, with its horseshoe of mud and marsh-filled depressions ("Lakes" Frome, Callabonna, Blanche, Gregory, Eyre [3,700 sq. miles], Torrens) surrounding the northern Flinders Ranges. (c) Southwards from these lies an area where recent (Pliocene) cross-patterned warping and faulting, elevation and submergence have provided the most decisive features of the State:—Mount Lofty–Flinders Range, the northern part of Yorke Peninsula, the Spencer Gulf–Lake Torrens (semi-drowned) valley; the Flinders–Barrier spur or ridge, the extremities of the peninsulas, Kangaroo Island and perhaps also—though it is older—the Gawler Range. (d) South and east of this lies the Murray and south-eastern lowland plain, the western fringe of the great Murray (Tertiary sea-basin) lowland and the counterpart of the Lake Eyre basin in the north.

The coasts are alternately rocky and cliff-bound (*e.g.*, Bight, Jervis Peninsula) and again low, sandy and backed by dunes. Their general inhospitality is due partly to uplift in relatively recent geological times. Most distinguished is the granite coast from Cape Jervis to Port Elliot, and most curious the long "haff" of the Coorong. (*See* further: AUSTRALIA: *Geomorphology, Soils, Drainage.*) The Murray has some 500 miles of its lower course in South Australia. Its total fall in South Australia is only 57 ft. and its outflow to the sea, through Lake Alexandrina (*q.v.*) and over a sandy bar, is meagre.

The north-eastern corner of the State (118,000 sq. miles) forms part of the Great Artesian Basin, the water-bearing beds lying at (average) depths of 4,000–5,000 ft. in the north-east but shallowing until, along the edge of the W. Australian platform, the waters well up in a line of remarkable "mound-springs." The soft strata of the Lower Murray basin also yield plentiful supplies, often of good quality, from depths of 50–350 ft. and, towards the extreme south-east (Penola–Millicent) the underground water-table intersects the surface and has resulted in extensive swamps and coastal lagoons. Boring westwards of Oodnadatta has revealed good supplies and the results of recent prospecting in the vast western interior (northwards from the transcontinental railway line) are reported to have been encouraging. The yield of the north-east bores is, however, diminishing: one well 5,458 ft. deep yields now only 50 gallons a day.

Climate.—South Australia lies wholly within the temperate zone but the greater part of the north lies in that "No Man's Land" between northern and southern rainfall and shares the aridity or erratic régime of the continent's interior. Av. ann. temps. range from *c.* 70° F in the north-east to *c.* 56° in the extreme south, but much greater extremes are experienced in the north and in the interior generally than in the coastal parts especially towards the south-east. So with rainfall. Apart from occasional descents of northern (monsoonal) summer rains into the north and north centre of the State, the rain falls in winter and is heaviest (20–25 in.) and most reliable over the central south and south-east coastal areas. Inland (northwards) the average amounts rapidly die away and practically all the areas north of lat. 31° 50′ S.—and in the east, north of the River Murray—have less than 10 in., and the extreme interior has only *c.* 5 in. (Oodnadatta, 4·97 in.) and this extremely erratic. The wettest portions are in the extreme south-east (25–30 in.) and in southern Eyre's Peninsula; the central highlands and, to a less extent, Spencer Gulf, induce heavier precipitation and cause a long tongue of higher rainfall (20–25 in. in the S., with 40 in. in the hills east of Adelaide, to 15–10 in. in the N.) to extend far into the interior. (*See* also PORT AUGUSTA; ADELAIDE; and *inf.*)

Population, Settlement and General Economic Development.—Comparatively long settled, possessing a climate mainly temperate, with little of the sensational in her development, South Australia shows few unusual features as regards population. With an area 12·78% of that of the Commonwealth, the population (1927–28) of 575,800 represents 9·27% of that of the Commonwealth's total, nearly 57% (327,700) being metropolitan. The increase, if not at a very high rate, has been remarkably steady (1920–27: 1·66–2·68%), and due to natural causes and to immigration in about equal proportions. The average density is low (1·49 per sq. mile) and this, as well as the distribution, exhibits clearly the effect of physical and also of historical circumstances. The overwhelming majority of the people live in the belt of highlands and coastal lowlands which stretch northwards from Encounter Bay and Jervis Peninsula to the lat. of Port Augusta and rather beyond. Yorke Peninsula and south-east Eyre's Peninsula, and the Murray River valley are comparatively well-peopled; the "South-East," parts of the "Mallee" country (south of the Murray) and the north-west coastal parts of Eyre's Peninsula have a fair but relatively isolated amount of settlement. The great interior, though partly pastoral, contains very few people.

Of the total area of the State only 7% has been alienated (1927–28), some 49% is held under lease and licence (42%, 259,300 sq. miles, under pastoral lease) and 44% is unoccupied. The total production (1926–27) was valued at £41,154,000 (£73 13s. per head) to which agriculture contributed *c.* £16,635,000; manufactures, £13,100,000; pastoral industry, £6,128,000; dairying, poultry, etc., £2,928,000; mining, £1,032,000 (1927: £1,189,000). Moreover, in 1921, 12·83% of the total population was classed as "industrial," 10·60% as "primary producers," 10·59% as engaged in transport and commerce. Discernible in these figures are: (a) The overwhelming importance of the "gulf" area—lowlands and highlands—containing the capital city (manufactures, commerce) with its surrounding agricultural and dairying districts, Port Pirie (*q.v.*) with its metallurgical industry and the largest continuous areas of agricultural production. (b) The relatively sparse population and secondary position of the northern areas with their pastoral industry. (c) The relative unimportance of mining.

In the northern areas—*i.e.*, the 280,000 sq. miles lying north of *c.* lat. 31° S. (*v. sup.*)—the chief geographical determinant is the climate with its high summer temperatures, large annual and diurnal range, and its small and very erratic rainfall (*v. sup.*). These lands are, and will probably long remain, pastoral areas, capable of improvement through water-conservation, pasture cultivation and control of rabbits and dingoes, but never perhaps of more than second or third rate quality. The western half is only now being slowly occupied. Recent reconnaissance and well-sinking seem to indicate wide-spread underground (shallow) water-supplies, and stock-routes (with wells) have been established from the Musgrave Range to the central railway line at Warrina (south of Oodnadatta) and from Coward, on the same line, south-west to Wilgena on the transcontinental line. The east (Lake Eyre Basin) is better known and more developed, and contains scattered cattle and sheep stations—besides a mission-station—with their artesian wells. These lie mainly along the lines of railway and the two other main stock-routes—(Marree–Diamantina River–Birdsville, and Hawker or Farina [on central railway]—Strzelecki Creek–south-west Queensland, respectively)—which branch north-north-west and north-north-east respectively from near the head of Flinders Range and serve to bring stock from as far as Central Australia and south-west Queensland to their markets in the south. Some 80,000–90,000 cattle and 890,000 sheep are carried normally—the latter mainly in the north-east—but the density per square mile is low.

The second division includes the central highlands and part of their eastern spur (the Flinders-Barrier Range "bridge"). But between these and the eastern boundary of the State lies a strip (lats. 30–34° S.) which might, not inappropriately, be termed the "Eastern Interior," since in respect of climate (large temperature range; rainfall under 10 in.) it more resembles the northern interior and is devoted almost exclusively to pastoral pursuits (cattle and sheep). The coastal zone is the best developed portion of the State and comprises nearly all the mineral deposits so far worked, a large part of the agricultural, dairying and manufacturing areas and sites, besides the capital city and nearly all the larger towns and important parts of the State. The *mineral* output is at present relatively small. The copper areas, notably those of the Moonta-Kadina field, though they probably still contain valuable reserves, have virtually ceased production. Their annual output (1916–20) alone averaged £600,000, whereas in 1927 the total copper production of the State was valued at £12,500. The iron-ore is practically inexhaustible; the Iron Knob area northwest of Spencer Gulf, at present vigorously exploited and the ore exported from Whyalla (1927: £831,000, *see* AUSTRALIA: *Minerals,* and *Metallurgy*). The State possesses perhaps upwards of 70,000,000 tons of available coal but much of this is of soft (sub-bituminous) and rather poor quality (high sulphur content) and unfavourably situated. Valuable clays and building stones abound, and the salt and gypsum deposits are the largest and best in Australia, are easily worked and serve as a basis for industrial developments (alkali and chemical industry). Deposits of salt occur on Yorke Peninsula (Yorke Town, with port at Edithburgh), at Lake Macdonnell, near Fowler's Bay (Bight) (2,500,000 tons salt; gypsum, 70,000,000 tons), and near Port Wakefield. The high temperatures (net evaporation: 30–80 in). and semi-enclosed (high-salinity) waters of the gulfs also facilitate salt-production by evaporation. Some 18,000,000 tons of reserves of salt exist; the output (1927) was valued—salt: £178,400; gypsum: £82,000.

In the vegetation eucalypts predominate. The Mallee scrub extends as far north as about the 12 in. av. ann. rainfall line ("Goyder's Line" in South Australia), and serves roughly to differentiate the (potentially) agricultural lands from the pastoral (mulga, blue-bush, etc.) areas of the interior. "Mallee-country is wheat-country" is now almost a maxim, and the trees (roots and over-growth) yield useful fuel. Several of the lower-growing eucalypts yield valuable essential oils (av. ann. output: eucalyptus oil, 5,000–8,000 gal.; yacka gum [picric acid]: 500–1,500 tons, Kangaroo Island being important for both), and wattle (tanning) bark is also produced (5,000–8,000 tons).

Water-supply, under the existing climatic conditions, had early to be provided. The highlands (including Eyre's Peninsula) form the main catchment areas and here some 18 reservoirs, having a total capacity of nearly 17,000,000,000 gallons serve an area of over 18,500 square miles, with 5,120 miles of mains. In the Northern Interior agriculture is absent; in the extreme south it is of the Victorian type (*see* VICTORIA); on the Murray it is mainly by irrigation; here it is, on its extensive side, wheat—with some mixed (wheat-and-sheep)—farming and, in its more intensive aspects vine and fruit (including olive) culture, apiculture, poultry, etc. There are (1927–28) 2,862,000 ac. under wheat (*cf.* New South Wales: 2,990,000; Victoria: 2,900,000; Western Australia: 2,812,000 ac.) and by far the greater portion of this lies, in the area under review, in Yorke Peninsula and in the lowlands and highlands east of the gulf. Here the fairly reliable winter and spring rains, followed by a hot and dry summer, are ideal for early winter planting, and harvesting (December–January), and loam soils—lighter and more sandy in parts of Eyre's Peninsula—and the prevailingly flattish terrain permit of "extensive" farming methods and large harvests per unit manpower. Usual farms average from 200 to 240 ac. and, as elsewhere in Australia, superphosphates are largely used as fertilisers (91% of the total area cultivated in the State is manured, 147,000 tons of manure, that is to say, over 93 tons per acre, being used) and the producing areas are very dependent upon rail or port outlets. The following figures illustrate the wheat-bearing capacity of the areas under review:

	Fallowed		Unfallowed	
	Ac.	Yield	Ac.	Yield
Central . .	450,444	15·25	61,617	8·45
Lower North .	659,748	17·69	96,669	10·17
Upper North .	189,467	13·05	34,720	5·42
Western . .	184,222	12·07	439,225	8·75

Barley and oats are grown in moister areas and poorer soils, and a considerable part of the wheat and oats sown is reaped as hay (500,000 ac. in the whole State).

Dairying is carried on mainly on the plains and in the hills within reach of Adelaide where markets and export facilities exist, and the same applies to some extent to pig and poultry rearing, bacon-curing, etc. Apart from dairy herds few cattle are now found in this area, but sheep, though not of first importance, are widely kept, often as an element in a mixed-farming régime, and bred (crosses) for both meat and wool.

The southern region (Mount Lofty Range) is the home of vine, fruit, vegetable and, to a less extent, of olive culture. Vines and olives thrive on the lower western slopes (below 500 ft.) of the Adelaide hills, while further north-east and north the Angaston, Tanunda and Clare districts are noted for their excellent wines. (Olive oil production: 1926–27: 16,500 gallons.) Oranges, lemons, peaches, apricots and almonds abound on the plains or in the valleys of the hills where water, shelter and warmth are available. Northern fruits (apples, plums, pears, etc.) also abound and the rich valley-bottoms (*e.g.*, Piccadilly and Uraidla) within a 20–30 mile radius of Adelaide produce and market much small fruit (strawberries, raspberries, currants, etc.) and vegetables. One of the striking features of Adelaide is the profusion of fruit and vegetables available, ranging from tropical (bananas, etc.), through Mediterranean (including melons, etc.) to temperate types. A high standard of agricultural production has been achieved and is maintained by the work of agricultural colleges and research institutes (*e.g.*, at Roseworthy, and the Waite Institute, University of Adelaide). Such manufacturing as exists is concentrated mainly in the metropolitan area, more particularly in the outlying suburbs (*e.g.*, Hindmarsh, Kilkenny, Islington, etc.), in ports Adelaide, Pirie, Wallaroo. Many industries are carried on largely with imported fuel (coal) and even imported raw materials and owe their existence mainly to the tariff and the local market.

Few inland settlements have as many as even 2,000 inhabitants (Peterborough, 3,000; Kadina, formerly a mining town, 2,500). The harbours are rarely good—Port Lincoln, a wheat port and naval station, is an exception—but the small ports are numerous. Yorke Peninsula is notably devoid of railways, communication being maintained by coasting steamers and packet boats. Port Adelaide alone has an outer harbour visited by ocean-going vessels. Land routes within this area, apart from a fairly well-developed and growing system of roads, consist of railway lines. Adelaide is an important railway centre from which the systems run, branching, mainly northwards—following the physiographic trend-lines—but also east, crossing the Mount Lofty range rather uneconomically at its highest part.

By the River Murray Agreement, Lake Victoria (in New South Wales) was allotted to South Australia as a storage reservoir (514,000 acre-feet) as well as 9 weirs and locks to be constructed within the State. Of these the Lake Victoria works are virtually complete, 5 weirs are completed and 3 more are under construction (1928), one of the completed weirs operating to keep Lake Bonney (in South Australia) partly filled as a reservoir. The water thus becoming available in the Lower Murray district is being applied partly to irrigation and partly to water-supply for general (farming) purposes in areas beyond the irrigation area. Irrigation is generally by pumping, but, below Morgan, the flat strips and crescents of alluvium of the originally marshy trench-floor have been embanked and drained ("reclaimed lands") and here irrigation by gravity is possible. Irrigation holdings are usually limited to 50 acre leases, but larger blocks of "dry" land are available. Large quantities of sub-tropical fruits (including currants and raisins) are grown and exported (fresh, dried, preserved or pulped). Renmark is the oldest, largest and best-known settlement (total area: 23,000 ac.; pop. 4,800), and comprises large fruit-packing sheds, distilleries, etc., some of them managed co-operatively. The reclaimed lands are used mainly for the production of fodders (lucerne, etc.) and vegetables.

The Mallee scrub lands, long regarded as a desert, are now large wheat producers. Plentiful supplies of underground water are available at 15–300 ft. depth, and the rainfall (10–15 in.) and light soils suffice to produce, under modern methods, fairly reliable crops of 10–15 bu. per acre. Clearing is an initial difficulty, and large areas (*e.g.*, in the Ninety Mile Desert) defy cultivation, and the rail-haul is long and expensive. But the areas thrive and progress. In 1926–27, 269,000 ac. (fallowed lands) were sown to wheat and yielded 13·1 bu. per acre; in addition, 352,000 ac. unfallowed (7·8 bu. per ac.) and mixed (sheep and wheat) farming is succeeding the pioneering wheat-growing. The newly-constructed railways spread a wide fan across the country, tap the Murray at Waikerie, Loxton, Renmark, etc., and the north-west Victorian "Mallee" by means of the Pinnaroo line. These lines converge at Tailem Bend, a growing centre on the river below Murray Bridge. Near by, at Moorlands (15 miles to the east), is a lignite deposit (8,250,000 tons), which assist the district.

Separated from the areas described by a large stretch of rather thin (limestone and occasional sandy) soils which form lightly timbered and rather poor pastoral country, the "south-east," with its richer patches of arable lands, is fairly self-contained, rather remote from Adelaide, and climatically (lower temperatures and heavier rainfall: 20–33 in.) more akin to south-west Victoria. The poorer country is devoted to cattle and sheep. Good agricultural lands exist (*e.g.*, around Naracoorte and elsewhere); Mount Gambier in particular has volcanic soils, and the Millicent area rich recently-drained swamp flats. Mixed farming including dairying, is carried on.

STATISTICAL REVIEW

Area, Population, etc.—*Area:* 380,070 sq. miles=12·78% of area of Commonwealth, all within temperate zone; coast-line 1,540 miles. Population (estimated, Dec. 1927): 575,771=1·49 per sq. mile and *c.* 9·27% of population of Commonwealth. Metropolitan, 327,686=56·91% of total.

Production and Agriculture.—(1926–27): Total: £41,154,000=£72.13.0 per caput. Agricultural: £16,635,000; manufactures, £13,077,000; pastoral, £6,128,000; dairying, £1,882,000; poultry, £1,046,000; mining, £1,032,000. Agriculture (1926–27): *Area under cultivation:* 6,058,380 ac. Wheat, 2,768,500 ac.; barley, 256,530 ac.; oats, 152,180 ac.; hay, 496,000 ac., other fodders (lucerne, peas, etc.), 61,100 ac.; vineyards, 50,270 ac.; orchards, 31,500 ac.; fallow, 2,100,000 ac. Production: Wheat (1921–28): 22,000,000–35,559,000 bu. (7·69–14·29 bu. per ac.); barley: (av. (1920–27) *c.* 4,000,000 bu.; oats, *c.* 2,000,000 bu.; orchards, etc., apples: (av. last 5 yrs.): 674,000 bu.; oranges, 373,000 bu.; apricots, 246,000 bu. Vineyards (last 5 yrs.): wine, 11,830,000 gal.; currants, 105,700 cwt.; raisins, 121,450 cwt.

Dairying, Livestock.—Cows (1915–26): 130,000–140,000. Butter, 13–16,000,000 lb.; cheese, *c.* 3,500,000 lb.; bacon, 5,400,000 lb. Poultry (1921–27): *c.* £1,060,000. Honey, *c.* 2,000,000 lb. Horses, *c.* 250,000; cattle, 350,000–400,000; sheep 6-7,000,000; pigs, 60,000–90,000. Of the total sheep, 70% are comprised in flocks of up to 5,000 head, and 20·8% in flocks of 5,000–20,000 each. The clip averages 42–50,000,000 lb. (av. last 5 yr. 55,656,000 lb.), fleeces averaging 8·2–8·5 lb. Total value of wool (last 5 yrs.): £4,878,000; (1927–28: £5,275,000).

Trade and Commerce.—Total (overseas): £32,500,000–£33,500,000. *Exports:* (1924–25—1926–27): £17,094,000–£19,419,000 (wheat, barley, flour, £7,300,000–£8,800,000; wool, etc., £4–£5,000,000; minerals (including Broken Hill concentrates): £2,900,000–£5,200,000; hides, skins, etc.: £610,000–£800,000; wines, £92,000–£620,000; fruits, £400,000–£670,000; butter, £96,000–£171,000. Total exports to United Kingdom: (1925–26): 63·5%; (1926–27): 55·5%.

Imports: (1925–26—1926–27): £14,079,000–£15,510,000 (*c.* 56% from British countries), chiefly textiles, etc. (£2,600,000); motor vehicles (*c.* £2,000,000), fuel oils (£1,120,000), machinery and metal goods, *c.* £4,000,000.

Ports, Shipping, Railways, etc.—Total trade of Adelaide: £25–26,000,000; Port Pirie: £3,600,000–£5,600,000; Wallaroo: £1,700,000–£2,000,000; Port Lincoln: £610,000–£935,000. *Total Shipping:* (inwards: 1927): 1,444 vessels=5,123,000 tons, of which *c.* 1,250 vessels (4,425,000 tons) are British.

Social.—Education: (1927), 1,028 schools (State primary and higher); 2,637 teachers, 86,500 pupils (average attendance: 73,180); average cost: £10.3.2. Also 188 private schools with average attendance 14,175. University; income (1927): £98,300, with endowments £540,500. Technical Colleges, etc., average attendance: 10,400. Total (State) expenditure on education (1927): £1,161,000 (£2.1.0 per caput of pop.), besides expenditure on public charities (hospitals, State wards, pensions, etc.).

Finance.—Public debt (1927): £88,540,152 (£155.1.9 per caput). Revenue: £10,784,897; expenditure: £11,834,947, of which £233,768 was set aside for public debt. Savings Banks: (1927) depositors, 512,332, deposited £23,600,897 (£41.6.10 per caput of pop.), *c.* 90% of the total population being depositors. Including deposits in banks of issue the total sum on deposit in banks (all types) was £50,424,077 (£88 per caput of pop.).

See A. Grenfell Price, *South Australians and their Environment*, and various official South Australian publications.

HISTORY

Though the coast of the Northern Territory was well known to Portuguese and Spanish navigators as early as perhaps 1530, being called Great Java, it was not surveyed till 1644, when Tasman laid down the line of shore pretty accurately. The western part of the southern coast had been seen and named Nuyt's Land in 1627. But Flinders, by his discovery of the two great gulfs, Kangaroo island and Encounter bay, in 1802, was the first to reveal South Australia proper. Captain Sturt descended the Murray in 1830, and looked over the hills near Adelaide. The first to direct attention to a settlement there was Major Baron who communicated with the Colonial Office in Feb. 1831. His suggestion was to establish, at no charge to the British Government, a private company, that should settle a party on Yorke peninsula. After much discussion South Australia was by Letters Patent made a British province in 1836. It was arranged that a local government should be established when the settlement had 50,000 people. Though the first settlers were sent to Kangaroo island, all were afterwards gathered on the Adelaide plains. The colony was proclaimed under a gum tree on Dec. 28, 1836. Great delay took place in the survey of land. The South Australian Company purchased large tracts from the commissioners at 12s. per acre and sold at 20s. A general speculative spirit arrested progress. Governor Gawler went into extravagant outlay on public buildings, etc., and drew against orders upon the English Treasury. Such difficulties arose that the British rulers had to suspend the charter in 1841 and create South Australia a Crown colony. A revival of prosperity took place when the farms were tilled and poverty had taught prudence. Copper and lead mines were subsequently discovered. Kapunda in 1843, and the Burra Burra copper mine in 1845, greatly aided in the restoration of commercial credit. The gold fever in Victoria drew off numbers in 1852; but the good prices then realized for bread-stuffs gave a great impetus to farming.

A partially elective legislative council was established in 1851 and in 1856 the colony was given its own Constitution and self government. From its origin as the venture of private enterprise the State has passed through orderly stages of evolution up to the zenith of democratic government. Such alterations as have been made in the Constitution have been in the direction of a still further enlargement of the franchise. Payment of members proved to be the corollary of manhood suffrage. In 1887 a temporary act was passed for the payment of £200 a year to each member of both houses, and in 1890, the law was made permanent. Thus was rendered possible the direct representation of all classes. Soon afterwards the parliamentary Labour party came into existence. In 1894 the principle of "one man one vote" was extended to that of "one adult one vote" by the inclusion of women as voters on terms of absolute equality with men. The delegates to the Federal convention and to the Commonwealth parliament were in South Australia elected by the combined vote of men and women. Elections were formerly held in successive batches, but since 1893 they have taken place simultaneously in all districts. Electoral expenses are rigidly limited, both as to objects and amount. Although there is no general statute the referendum has often been applied. The salary of members was increased to £400 annually in 1921. (*See* AUSTRALIA.)

SOUTH BEND, a city of northern Indiana, U.S.A., county seat of St. Joseph county; 86 m. E. by S. of Chicago, at the "south bend" of the St. Joseph river, where it turns northward to Lake Michigan. It is on Federal highways 20 and 31, and is served by the Grand Trunk, the Michigan Central, the New Jersey, Indiana and Illinois, the New York Central, the Pennsylvania, and electric railways. Pop. (1920) 70,983 (19% foreign-born white); estimated locally at 102,000 in 1928. The city has an area of 16·58 sq.m., an altitude of 726 ft., and an assessed valuation (1927) of $190,781,410. It is surrounded by a farming, dairying and fruit-raising country, including the principal mint-growing district of the United States. The water-supply comes from 109 artesian wells. A hydro-electric plant on the river furnishes current for the entire region. South Bend has 400 manufacturers producing 625 different articles, including automobiles, four-wheel brakes, watches, fishing rods and artificial bait, toys, lathes, varnishes and paints. The total output for 1925 was valued at $150,616,000. Bank debits in 1926 aggregated $608,035,000. In the old court house is the museum of the Northern Indiana Historical Society. Adjoining the city is the 1,200-ac. campus of the University of Notre Dame du Lac, founded in 1842 by members of the French religious community known as the Congregation of Holy Cross (of which it is still the headquarters) and now the largest Roman Catholic educational institution in the country, with an enrolment of about 2,600. A mile to the west is St. Mary's College for women, conducted by the sisters of the order. The site of South Bend was visited by Father Marquette and La Salle when it was occupied by a Miami village. A trading post for the American Fur Company was established in 1820. In 1831, when the population was 168, a town was laid out. It was incorporated in 1835 and chartered as a city in 1865. The population was 1,652 in 1850, and it has grown steadily and substantially in every decade since.

SOUTHBRIDGE, a town of Massachusetts, U.S.A., on the Quinabaug river. Pop. (1920) 14,245 (29% foreign-born white); 15,489 in 1925 (State census). The river falls 165 ft. at this point, furnishing abundant water-power. Optical goods are its most distinctive product. In 1801 a poll parish (popularly called Honest Town) was formed from parts of Charlton, Dudley and Sturbridge; and in 1816 it was incorporated.

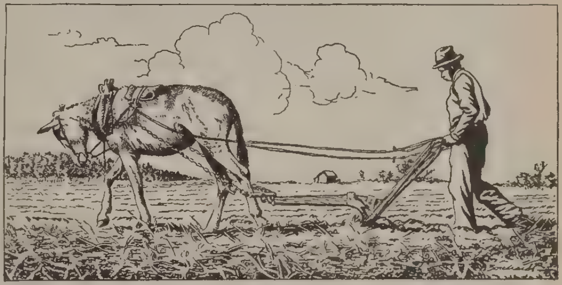
SOUTH BROWNSVILLE, a borough of Pennsylvania, U.S.A., on the Monongahela river, adjoining Brownsville and opposite West Brownsville. The three boroughs form one community. Pop. (1920) of South Brownsville 5,675; of Brownsville, 2,502; of West Brownsville, 1,902; 1928 local estimate of the combined population, 12,000.

SOUTH CAROLINA, popularly called the "Palmetto State," is an Atlantic coast State of America, and one of the original Thirteen. Its area is 30,989 sq.m., of which 494 sq.m. are water.

Physical Features.—South Carolina is mainly in the coastal plain and Piedmont plateau regions, but in the north-west it extends slightly into the Appalachian mountain region. Locally the coastal plain region is known as the low country, and the Piedmont plateau and Appalachian mountain regions are known as the up-country. The coast is low and islands increase in size and number toward the Georgia border. For about 10 m. inland the coastal plain is occupied largely by salt marshes. Then, although continuing flat, the surface rises at the rate of about 2½ ft. per mile for 40 m. or more.

Parts of the Blue Ridge rise abruptly from the foothills to 3,413 ft. in Mt. Pinnacle, 3,218 ft. in Caesar's Head, and 3,157 ft. in Table Rock. The highest point in the State is Sassafras mountain (3,548 ft.) in the Blue Ridge and on the North Carolina State line. The mean elevation of the State is about 350 feet.

The principal rivers rise in the Appalachian mountains and flow south-east into the Atlantic ocean. In the middle section, Santee river is formed by the confluence of the Wateree (known above Camden as the Catawba) and the Congaree, which is in turn formed by the Broad and the Saluda. The basin of this system embraces about half the area of the State. In the north-east the Great Pedee and its tributaries—the Little Pedee, Waccamaw and Lynches—are wholly within the coastal plain, but the main stream is a continuation below the fall line of the Yadkin river, which rises in the mountains of North Carolina. The Edisto is the principal stream in the south-east. In the Piedmont plateau there are rapids; but in the coastal plain the current becomes sluggish, and in times of high water the rivers spread over wide areas.



A "ONE-MULE" FARMER WORKING HIS FARM IN SOUTH CAROLINA

Flora.—Palmettos are confined to the coast. For some distance from the ocean there are magnolias, live oaks draped with long grey moss and reed-covered marshes. In the swamps are cypress, gum and bay trees. In most of the uplands of the coastal plain the long-leaf pine is predominant, but large water-oaks and undergrowths of several other oaks and of hickories are not uncommon. On the Piedmont plateau and in some of the more hilly sections below the fall line there is some short-leaf pine, but most of the trees in these areas are hardwoods. Deciduous oaks are most common, but beech, birch, ash, maple, black walnut, chestnut, sycamore and yellow poplar also abound. On the mountains are oaks, chestnut, laurel, white pine and hemlock. Among indigenous trees, shrubs and vines are the blackberry, grape, persimmon, plum, crab-apple, hickory, chestnut and hazel nut.

Climate.—Along the coast the climate is mild and equable. At Charleston, the mean winter temperature is 51°, the mean summer temperature 80°, the mean annual temperature 66° and the range of extremes from 104° to 7°. For the State the mean temperature is about 63°. In nearly all sections January is the coldest month and July the warmest. Aiken, near Augusta, Ga., has a very mild winter season and is a popular resort. The mean annual rainfall for the State is about 47·75 in. and its distribution is excellent. Seventeen inches fall during the summer. Snow is uncommon in the south-east but elsewhere there may be several inches. The frost-free season ranges from 245 days on the coast to 204 days on the uplands. Tornadoes occur in the west and the coast suffers from hurricanes.

Soils.—In general the soils of the Piedmont plateau are such as have been formed by the disintegration of the underlying rocks. These consist mostly of granite and gneiss, but in the north-central section there is trap-rock, and in the south-east section some slate. On the Piedmont plateau the subsoil is a reddish or yellowish clay. In the upper section of the coastal plain the soil is for the most part a loose sand, but lower down it becomes more fertile.

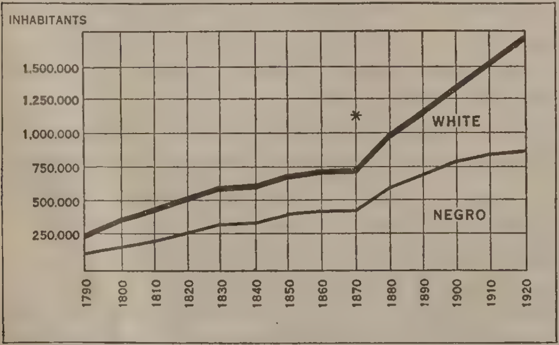
Population.—The population of South Carolina was 249,073 in 1790; 502,741 in 1820; 594,398 in 1840; 703,708 in 1860; 705,606 in 1870; 995,577 in 1880; 1,151,149 in 1890; 1,340,316 in 1900; 1,515,400 in 1910; 1,683,724 in 1920, an increase of 11·1% in the last decade, as compared with 13·1% and 16·4% in two preceding decades. The population on July 1, 1928 was estimated by the U.S. Census Bureau at 1,864,000. In only one other State, Mississippi, in 1920, did the negroes exceed the whites; in South Carolina 51·4% of the total, or 864,719 were negroes, and 48·6% were whites. There has been a steady decline in the percentage of negroes from the high point of 60·7% in 1880, until in 1928 the Census Bureau estimated them at a little less than 50%. The increase of negro population during the decade 1910–20 was only 3·3% as compared with 20·5% for the whites. In 1920 of the total population 99·2% were native-born. Density of population was 55·2 per square mile. The urban population was 17·5% of the whole, as compared with 14·8% in 1910.

Government.—South Carolina was governed from 1670 to 1719 under the provincial charter of 1665, from 1719 to 1775 under commissions and instructions from the Crown, and from 1776 under the Constitutions of 1776, 1778, 1790, 1865 and 1895. An amendment to the Constitution may be proposed in either house of the legislature. If approved by two-thirds of the members elected to each it must be submitted to the people at the next election for members of the house of representatives. If it is approved by a majority of those voting upon it and subsequently by a majority vote in each house of the general assembly chosen at that election, it becomes a part of the Constitution. A convention to revise the Constitution may be called by a two-thirds vote in each house ratified by a majority of those voting for representatives at the next election.

A voter must be 21 years old, a resident of the State two years, of the county one year, of the voting precinct four months and must obtain a certificate of registration conditioned on showing that he or she is able to read and write the Constitution or the past year paid taxes on property assessed at $300 or more. (Assessments are usually at about one-fourth value.) Illiterates were allowed before 1898 to register for life by "understanding" the Constitution. Paupers, idiots, the insane, prisoners and persons ever convicted of certain crimes, unless pardoned, are disfranchised. As the democratic nomination is equivalent to election, more important is the rule confining voting in the party primary to white Democrats and a negligible number of negroes who can prove by ten white men that they have voted Democratic from 1876, the only other qualifications being those of citizenship, age and residence as stated in the Constitution.

Constitutional amendments changed the terms of the governor and other State officers from two to four years, beginning with those elected in 1926. The governor is ineligible for re-election. He may veto "any one or more of the items or sections contained in any bill," but may be overruled by a two-thirds majority of those voting in each house. In practice the item veto has been used only regarding appropriation bills. The general assembly, meeting annually, is composed of the senate (one member from each of the 46 counties elected for four years) and the house of representatives (124 members elected for two years from the counties in proportion to population). The State elects seven congressmen.

The five supreme court judges and the 14 circuit court judges are elected by the legislature for ten and four years respectively.



GRAPH SHOWING GROWTH OF POPULATION IN SOUTH CAROLINA, 1790–1920 (*1870 CENSUS GENERALLY DEFICIENT IN THE SOUTHERN STATES)

Magistrates (justices of the peace) are appointed by the governor with senate confirmation, although the recommendation of the senator from the county or of a primary election practically determines the selection. In a few counties a county court with an elected judge disposes of a large part of the lesser civil and criminal cases elsewhere burdening the circuit courts. The probate judge in each county (elected) has also the duties of a juvenile court. The State is divided into two Federal court districts.

Local Government.—The unit of local government is the county. Counties are divided into townships, but there are no township governments, the township being hardly employed except for the assessment of taxes and the care of local roads. Although the forms of municipal government are prescribed under general statutes and enjoy certain constitutional rights, they are considerably subject to State legislative authority. They may exempt new manufactories from taxes for five years, except for school purposes, provided a majority in a popular election approve.

The county is administered by a commission, almost always popularly elected. Road or hospital commissions, etc., are frequently appointed by the governor, usually on recommendation of the county legislative delegation. The usual county officers are elected, except the auditor and treasurer, who are appointed by the governor with senate confirmation; however, the governor practically always names the successful primary election candidates without question. There being no county legislature, the State legislature is oppressed with a mass of local legislation. It enacts usually without question whatever the senator and representatives of the county concerned agree upon. These thus form in effect a county legislature. The senator, as controlling action by the senate, thus exercises an enormous extra-legal power.

Miscellaneous Laws.—Any officer negligently permitting a prisoner to be lynched forfeits his office and becomes ineligible to any office unless pardoned. The county, without regard to the conduct of the officers, is liable in damages of not under $2,000 to the heirs of the deceased. Since 1895 divorce has been constitutionally forbidden. The few divorces ever granted in South Carolina were under the act of 1872 permitting divorce for adultery or wilful desertion for two years.

Finances.—The State tax commission, created 1915, supervises all tax administration and directly administers the income, inheritance, gross receipts, public utilities, corporation and gasolene taxes. More than three-fourths of the revenues supporting the State Government are from these special taxes, less than one-fourth being from the general property tax. There thus exists in practice to a considerable degree separation of State and local revenues, the latter being derived from the general property tax, and in the case of municipalities from business licences in addition. The gasolene tax and motor vehicle licence fees are divided between State-maintained roads and local roads. Schools are assisted by the receipts of a small capitation tax.

Education.—As early as 1710 public school education was provided for indigent children. The present free-school system was established in 1868. The educational system is under the supervision of the State superintendent of education, with the assistance of a board composed of the governor, the superintendent of education and seven other persons appointed by the governor. State support and regulation of high schools were greatly increased in 1907. In 1925 there were 285 State-accredited public high schools. South Carolina maintains a dual school system: one for white and one for coloured children. The public school enrolment in 1927–28 for whites was 248,272 and for negroes 228,003; the number of white teachers was 8,687 and of coloured, 4,451. The average length of session was 171 days for white and 115 days for coloured schools. Other improvements are night schools for adults, enlarged facilities for agricultural, vocational and home economics training, State standard certification of teachers and more effective State supervision. By the 1919 law four months' school attendance is compulsory, but enforcement is lax.

Agriculture.—The products of the soil equal less than half the output of the factories. The value of the 19 principal crops in 1927 (not including truck) was $155,300,000 as against $317,741,669 for all manufactures, the value of the crops being a little above, and that of manufactures appreciably below, the average for the past six years.

The total acreage in farms in 1925 was 10,638,900, or 54·5% of the total area of the State; in 1920 the acreage was 12,426,675, or 63·7% of the total area. The number of farms showed a corresponding decrease; the total in 1920 was 192,693 as compared with 172,767 in 1925. Of the 172,767 farmers in South Carolina, 82,186 were whites and 90,581 were coloured. White owners were 41,601; coloured, 18,368; white tenants, 40,251; coloured 72,179; white managers 334; coloured 34. The percentage of tenancy was 65·1. The total farm acreage (10,638,900) in 1925 was divided as follows: crop lands, 5,035,956; pasture land, 1,637,431; woodland, 2,562,000; all other land in farms, 1,403,507. The average acreage per farm was 61·6, but crops were harvested from only 25 ac. per farm. The valuation of all farm property was $523,084,383; of the average farm, $3,028. The average per acre value of land alone was $32.62. The farm population decreased during the five years, 1920–25, from 1,074,693 to 911,885, or a total loss of 15%.

Cotton holds the first place in acreage, with about 50%; corn (maize) the second, with around 30%. The State has two great cash crops—cotton and tobacco; five grain crops—corn, wheat, oats, rye, rice; four legumes that yield both hay and grain, cowpeas, soy beans, velvet beans, peanuts; two for syrup, sorghum and sugar cane. Potatoes, both white and sweet, fruit and vegetables also add to the wealth of the State.

The principal crops with their approximate acreage, product and value as of Dec. 1927 were as follows:—

Crop	Acreage	Product	Value
Cotton . . .	2,421,000	735,000 bales	$72,030,000
Cotton seed . .	. .	448,000 tons	9,094,000
Indian corn . .	1,497,000	25,449,000 bu.	22,904,000
Wheat . . .	80,000	880,000 „	1,338,000
Oats	448,000	10,327,000 „	7,745,000
White potatoes. .	29,000	3,034,000 „	5,765,000
Sweet potatoes . .	53,000	5,300,000 „	4,240,000
Hay	446,000	358,000 tons	6,436,000
Tobacco . .	104,000	75,920,000 lb.	15,564,000
Peaches . . .	. .	615,000 bu.	922,000

The coastal region, with a mild climate and a soil responding quickly to intensive cultivation, is especially suited to commercial truck farming. The chief products, exclusive of potatoes and cane grown for syrup, are watermelons, cabbages, cucumbers, snap beans, spinach, asparagus, tomatoes and lettuce. Strawberries, dewberries, blackberries, figs and grapes add to the fruit wealth of the State.

Dairying and the live stock industry as a whole, in South Carolina, is capable of much further development. The State produces only about one-third of the creamery butter it consumes, there being, it is estimated, less than one milch cow to the farm, upon the average. The total value of all dairy products in 1924 was $5,852,427. The total value of live stock on the farms of South Carolina on Jan. 1, 1928 was estimated at $38,299,000.

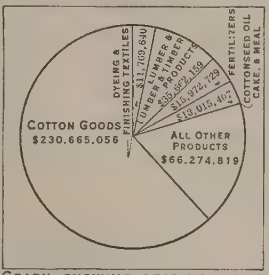
Forests.—The total stand of saw timber in South Carolina in 1920 was estimated at 25,000,000,000 bd.ft., of which 15,000,000,000 bd.ft. were in softwoods and 10,000,000,000 bd.ft. in hardwoods. The annual growth was estimated at about 250,000,000 bd. feet. The 520 sawmills operating within the State in 1925 produced 2·7% of the total lumber production of the United States. Small quantities of turpentine and rosin are produced from the slash pine forests of the coastal plain.

Fisheries.—The commercial fisheries are located in the five coastal counties—Beaufort, Colleton, Charleston, Georgetown and Horry. Approximately 30,000,000 oz. of oysters were canned in 1927 and the quantity is increasing. Chief among other products are shad, mullet, sea bass, sturgeon, shrimp and hard clams.

Minerals.—South Carolina's mining output is small, amounting in 1925 to only ·07% of the total mineral value of the United States. The principal mineral products in the order of value were clay products, stone, sand and gravel and barite.

The stone quarried in South Carolina is chiefly granite and granite-gneiss. High grade granite, the "Winnsboro Blue," is quarried in Fairfield county near Rion. Barite is mined chiefly near Gaffney, Cherokee county.

Manufactures.—The manufactures of South Carolina showed a remarkable development during the first quarter of the 20th century. In 1927 the capital invested was $316,115,480, the value of the products $317,741,669, and the average number of wage-earners 104,201. The manufacture of cotton goods is much the most important, its output constituting in value in 1925 61·8% of the State's manufactured products. The number of cotton manufacturing establishments in 1927 was 223, the number of producing spindles 5,408,713, looms 127,061, the operatives 79,772, the amount of raw cotton consumed 1,253,112 bales and the value of the output $234,251,698. Practically every grade of cotton cloth is produced. Factors contributing to the phenomenal development of the cotton textile industry in South Carolina are the abundance of cheap hydro-electric power from the Piedmont streams, a suitable climate and dependable native labour. The Piedmont section leads in the textile industry. The values of the output in the chief producing counties were, in 1927, for Spartanburg $39,560,544, for Greenville $33,419,033, for Anderson $22,679,697, for York $15,341,131, for Greenwood $14,945,723, for Union $13,724,135 and for Chester $10,522,567. Charleston and Richland counties are important for diversified manufactures.



GRAPH SHOWING LEADING MANUFACTURES OF SOUTH CAROLINA, 1925, ON BASIS OF VALUE OF PRODUCTS

During 1927 lumber and timber products equalled $15,962,747, cotton seed oil, meal and cake, $11,769,999, electric current, $11,690,293, fertilizers $8,809,816 (temporarily greatly reduced), foundry and machine-shop products $4,668,674, printing and publishing $3,483,623, flour, feed and grist $3,135,179.

Hydro-electric development has greatly aided both industrially and in bettering living conditions. The report of the U.S. Geological Survey (1926) ranks South Carolina sixth among the States of the Union in developed water-power and estimates the State's potential water-power at 632,000 h.p., while private estimates go as high as 1,000,000. The existing 58 water-power plants have a capacity of 514,428 horse-power. In 1927 63% of the power used by textile mills was hydro-electric. The Murray dam 10 m. above Columbia on Saluda river, to be completed in 1930, 208 ft. high and 7,000 ft. long (one of the largest earth dams in existence), will form a lake 50,000 ac. in area and develop 200,000 h.p. (150,000 kilowatts).

Transportation and Commerce.—The chief railway systems of South Carolina are the Southern, the Atlantic Coast Line, and the Seaboard Air Line. Steam railway mileage, Jan. 1, 1928, was 3,693, of which 365 m. were double tracked. Also, electric interurban lines operated 134 miles. An extension of the Georgia & Florida railway from Augusta, Ga., to Greenwood, S.C., 56 m., is under construction. The mileage of State highway, Jan. 1, 1929, was 5,809, of which 1,047 m. were paved and 8 m. were surfaced with bitumen and crushed stone. About 227,000 motor vehicles were registered in 1928.

Inland water communication is possible on a number of the larger navigable rivers, but is undeveloped except slightly near the coast. Charleston in 1925 had a foreign trade of 1,142,114 tons valued at $42,893,403, and a coastwise trade of 1,531,577 tons valued at $113,239,039. Georgetown had a coastwise trade of 122,400 tons valued at $3,390,883.

HISTORY

The history of South Carolina may be divided into the periods of discovery and exploration (1521–1663); proprietary rule (1663–1719); royal rule (1720–75); and Statehood (from 1776). The first Europeans to visit the coast were a party of Spaniards from Cuba in 1521. The first settlement was made by Spaniards under Aylion in 1526, but, after a few months it was abandoned. The Spaniards again settling in 1566, maintained a port on Parris island for about 20 years. In the meantime (1562) French Protestants under Jean Ribaut made an unsuccessful attempt to establish a colony on Parris island (*see* PORT ROYAL). In 1629, Charles I. granted to his attorney general, Sir Robert Heath, all the territory lying between the 31st and the 36th parallels and extending through from sea to sea, but no settlement was made, and in 1663 the same territory was granted to the earl of Clarendon (1609–74), and seven other favourites of Charles II. A second charter in 1665 extended the limits to 29° and 36° 30′. The proprietors were to legislate for the Province "by and with the advice, assent and approbation of the freemen." They were empowered, though not required, to grant religious freedom to dissenters. Circulars were issued in 1663 and 1665 offering most liberal terms to prospective colonists. In the Fundamental Constitutions adopted by the proprietary board in 1669, John Locke and Lord Ashley (1621–83) prepared for the Province an elaborate feudal system of government which would have been obsolete even in Europe. Little effort was made to enforce the more impractical portions of the Constitutions. They were, nevertheless, an element in rousing the feeling of discontent among the colonists which culminated in the overthrow of proprietary rule, and they encouraged the large plantation system which constituted the foundation of the slave-holding aristocracy.

First Permanent Settlement.—The first permanent English settlement was made in April 1670 at Albemarle Point, on the west bank of the Ashley river, but as the situation proved unfavourable the government and most of the people moved over in 1680 to the neck between the Ashley and the Cooper rivers, the site of the present city of Charleston. The area of settlement was gradually extended along the coast in both directions, but did not penetrate far into the interior. There were many English from Barbados and French Protestants, who influenced the history of the Province.

Struggles for Popular Control.—Her political history during the colonial era is the story of a struggle between popular and prerogative interests, first between the people and the lords proprietors, later between the people and the Crown. From 1670 to 1700 the principal questions at issue were the refusal of the settlers to subscribe to the numerous editions of the Fundamental Constitutions and disputes over the collection of quit-rents. Concessions were finally made which brought the Government more directly under popular control. In 1693 the commons house, elected by the people, secured the privilege of initiating legislation. The truce was followed by a controversy between churchmen and dissenters. A test act requiring members of the assembly to conform to the Church of England and to take the sacrament of the Eucharist according to the rites and usages of that church (1704) was defeated only through the intervention of the Whig House of Lords in England. By an act of Nov. 30, 1706, which remained in force until 1778, the Church of England was made the established religion. After a few years of peace and prosperity, the proprietors, acting on the advice of Chief Justice Nicholas Trott (1663–1740), adopted a reactionary policy, vetoed several popular laws and could not give aid in the desperate 1715 Indian war. In 1719 the people rebelled, overthrew the existing government and elected their leader James Moore as governor. The result of the revolution was accepted in England, and the province at once came under royal control, although the rights of the proprietors were not extinguished by purchase until 1729. Theoretically South Carolina and North Carolina constituted a single province, but, as the settlements were far apart, their governments were always separate. Until 1691 each had its own governors. From 1691 to 1712 there was usually a governor at Charleston and a deputy for the northern settlements, and after 1712 there were again separate governors. The first attempt to define the boundary was made in 1730, but the work was not completed until 1815.

The period 1725–75 was a period of great prosperity, based upon the trade in pelts (mainly deer skins) and more permanently on the rapidly expanding rice and indigo culture. The southern colonies' Indian trade centred mainly in Charleston. This, and a rich agriculture and the large commercial business to serve them, supplied the economic basis of a coast country society of notable intelligence and culture. One of the earliest theatres in America, musical culture, libraries, and the education of a large number of youths in England, gave the society around Charleston a tone and finish at that time rare in the New World.

Passing under the royal Government did not check the encroachments upon the governor and council by the commons house of assembly, which defiantly announced the powers of the British Commons as its model. By 1760 the council had almost ceased to exercise any real control over legislation. They rarely initiated or amended a bill, and never attempted to change a money bill without incurring violent denunciation from the popular house and sometimes paralyzing legislative action for years.

Movements Toward Independence.—The State was preparing for independence. Although the measures of the British Government after 1763 were not especially oppressive to the province, the people were too long accustomed to having their own way, and had, especially in the bitter dispute over the Wilkes fund (1769–75) involving the right of the commons alone to control finance, developed too fully a sense of general American and even British freedom to submit to measures which they regarded as subversive of the principles of liberty. Delegates were sent to the Stamp Act Congress (1765) and to the Continental Congresses (1774 and 1775). A council of safety appointed by an extra-legal provincial congress virtually took over the Government in June, 1775. Royal administration ended when, Sept. 15, the governor dissolved the assembly and fled.

Wars with the Spanish in 1686, 1702–04, 1740, with the Spanish and French in 1706, with pirates in 1718, with the Yemassee Indians in 1715 and the Cherokees in 1760–61, with aid only in 1760–61 from British troops, and a slave rising in 1739 had accustomed the people to arms. The State suffered severely during the Revolution both from British troops and from the presence of numerous loyalists. A British fleet attempting to capture Charleston was repulsed by Ft. Moultrie, June 28, 1776. Calm prevailed until Clinton returned in 1780 with an overwhelming force and Gen. Benjamin Lincoln surrendered the city, May 12.

Completely overrun, there followed two years of fighting involving more battles, though most of them small, than occurred in any other State. A Continental army under Gen. Greene assisted by State troops under Sumter, Marion and Pickens slowly drove the British back into Charleston and wrecked the plan of British troops from the South to join those from the North to crush Washington. The chief battles fought in the State were Ft. Moultrie (June 28, 1776), the siege of Charleston (March 12–May 12, 1780), Camden (Aug. 16, 1780), King's Mountain (Oct. 7, 1780), Cowpens (Jan. 17, 1781), Hobkirk's Hill (April 25, 1781) and Eutaw Springs (Sept. 8, 1781).

The generation following the Revolution witnessed an ambitious programme of transportation development. The Santee canal, connecting Charleston with the whole Santee-Wateree-Broad-Saluda river system, was opened in 1800. Highway building followed. The latter was dropped and the canal was ruined from railroad development. The South Carolina railroad, 133 m. from Charleston to Hamburg opposite Augusta, when completed in 1833 was the longest railroad in the world.

Strife Between Sections.—The early State period was characterized by a bitter struggle between the older low country and the newer up country, the latter settled largely by Scotch-Irish coming down the Piedmont belt from Pennsylvania, Virginia and North Carolina. In 1786 it was necessary, to allay discontent, to consent to the removal of the capital to a newly located site to be called Columbia. Although removal took place in 1790, State officers until 1865 kept offices both in Columbia and Charleston and the supreme court met in each city to hear appeals from the two sections respectively. The up country (then comprising a larger area than now thus designated), containing four-fifths of the white population and one-fifth of the wealth, in 1808, with the help of a liberal low country minority led by Joseph Alston, secured a constitutional amendment apportioning one senator to each county and representatives to each county in proportion equally to white population and wealth. This left the control of the upper house to the low country and that of the lower house to the up country. Manhood suffrage followed in 1810. The low country's fear for its slave interests was allayed as slavery, fostered by cotton culture, spread up the State.

The South Carolina college was chartered in 1801 largely to allay sectional enmity. Only the necessity of standing unitedly against anti-slavery and reconstruction agitation from the North prevented the more numerous element from forcing its democratic changes until late in the 19th century.

Nullification and Secession.—Northern anti-slavery agitation and the adoption of a tariff harmful to Southern agriculture united both factions in the passage of the Ordinance of Nullification, Nov. 24, 1832, forbidding the execution of the tariff in South Carolina. The readiness of a powerful minority to assist President Jackson, combined with a reduction of the tariff, operated to deter the majority from forcing the issue to armed conflict, but left a bitterness within the State that disappeared only after 1850 in the face of graver danger from outside.

Following the slave conspiracy of 1822 and the Northern abolitionism the slave code was severely revised (1840–44), even to forbidding the sending of a slave to freedom anywhere in the world. The years 1850–52 saw most of the people deterred from secession only from lack of the co-operation of other States. After 1828 Virginia's Southern leadership was superseded by the more uncompromising leadership of South Carolina under John C. Calhoun. South Carolina was the first State to secede, her ordinance of Dec. 20, 1860, being almost unanimously approved by her citizens. With a white population of 291,300, the State put into the field 62,838 effectives, with a total enrolment, including reserves, of 71,083, of whom 22% were killed or died in prison. Gen. W. T. Sherman's march across the State, February to March 1865, was accompanied by enormous destruction, including the burning of Columbia.

Reconstruction.—The misfortunes of war were more easily borne than the humiliation of reconstruction. Under President Johnson's guidance, the white population elected officers, who were soon ejected under the Congressional plan of reconstruction, disfranchising most whites and transferring power to the negroes, Northern adventurers ("carpetbaggers") and disreputable native whites ("scallawags"). In the spring of 1868 the State was "readmitted" to the Union under the control of these elements, and entered upon a period of eight years of crime and corruption, accompanied by arrogance on the part of the blacks that the whites found unendurable. Legislation was by bribery. Stealing extended from large blocks of State property to the price of a politician's whiskey. Two hundred trial justices were said to be unable to read. Daniel H. Chamberlain, able carpetbagger and would-be reformer of his own party (governor 1874–76) declared in 1901 that if he had been re-elected in 1876, his party, even with white assistance, could not have given government "fit to be endured." The most urgent pleas on a non-partisan basis failing to draw the least sympathy in Washington, the whites in 1876, by combined fraud, intimidation and persuasion of negroes elected Gen. Wade Hampton (1818–1902) governor by a narrow majority. President Hayes's withdrawal of troops in March 1877 marked the collapse of "radical" rule.

Political Parties.—Since 1876 practically the entire white population has been Democratic, partly from historical reasons and partly because of the conviction that union under the only national party that has defended them against negro rule in the past is necessary for the maintenance of white supremacy. The only murmuring in this connection was in 1928, when the nomination of Governor Alfred E. Smith for president put a severe strain on the party loyalty of thousands of South Carolina Democrats, though few voted against him.

The Reform Movement.—In 1878–80, under the leadership of M. W. Gary (1831–81), the old conflict between up and low country became a fight mainly between the poorer masses and the propertied classes.

The triumph under Benjamin R. Tillman (governor 1890–94; U.S. Senator 1895 to his death in 1918), prominent "farmers' movement" leader, was facilitated by acute agricultural distress. Col. A. C. Haskell's appeal to the negro against Tillman, with proviso that there should be only white officials, was generally condemned even by his own class, drew practically no negroes, and only served to embitter feeling among the whites. The farmers', or more broadly "reform," movement was marked by the establishment of Clemson Agricultural and Mechanical college (1889), the dispensary system of State liquor monopoly (abandoned because of corruption and failure to restrain intemperance) and the work of the Constitutional Convention of 1895 disfranchising so far as possible the negro. Direct primary elections, long in use in most of the counties, beginning in some in 1878, were adopted in 1896 for naming U.S. Senators, Congressmen and State officers. State politics since 1890 present a strange combination of rancorous personal politics, mass conservatism and dislike for "aristocratic" influence. Class feeling was strongly manifested in the campaigns of Coleman L. Blease (governor 1911–15). Factionalism subsiding, Blease was in 1924 elected Senator after having been badly defeated in 1918 on a platform condemning American participation in the World War. The State contributed over 70,000 men to the World War.

Agriculture and banking suffered severely in the deflation of 1920–22. Recovery has been made through more diversified and scientific farming and the expansion of manufacturing.

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SOUTHCOTT, JOANNA (1750–1814), English religious fanatic, was born at Gittisham in Devonshire. Her father was a farmer and she herself was for a considerable time a domestic servant. She was originally a Methodist, but about 1792, becoming persuaded that she possessed supernatural gifts, she wrote and dictated prophecies in rhyme, and then announced herself as the woman spoken of in Rev. xii. Coming to London at the request of William Sharp (1749–1824), the engraver, she began to "seal" the 144,000 elect at a charge varying from twelve shillings to a guinea. When over sixty she affirmed that she would be delivered of Shiloh on Oct. 19, 1814, but Shiloh failed to appear, and it was given out that she was in a trance. She died of brain disease on the 29th of the same month. Her followers are said to have numbered over 100,000, and are not yet extinct. She left a locked box with instructions for it to be opened by all the bishops together assembled at a time of national crisis. The box was finally opened in 1928 in the presence of one of the bishops, but it was found to contain nothing of interest at all.

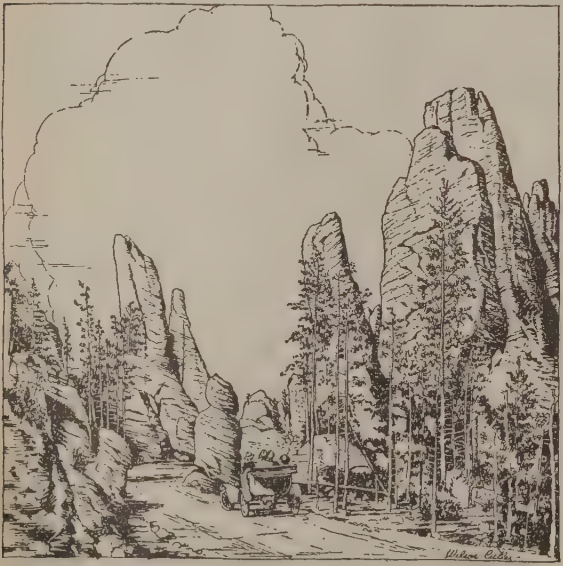
Among her sixty publications, all equally incoherent in thought and grammar, may be mentioned: *Strange Effects of Faith* (1801–1802), *Free Exposition of the Bible* (1804), *The Book of Wonders* (1813–1814), and *Prophecies announcing the Birth of the Prince of Peace* (1814). A lady named Essam left large sums of money for printing the *Sacred Writings of Joanna Southcott.*

See D. Roberts, *Observations on the Divine Mission of Joanna Southcott* (1807); R. Reece, *Correct Statement of the Circumstances attending the Death of Joanna Southcott* (1815).

SOUTH DAKOTA, the "Sunshine State," is one of the North Central States of the American Union. It is rectangular in shape with an average length (east-west) of 380 m. and an average width (north-south) of about 200 miles.

Its area is 77,615 sq.m., of which 747 sq.m. are water surface. South Dakota formed the southern half of the original Dakota Territory, organized in 1861 and named after the Dakota Indians which inhabited the land. The Territory was divided into North Dakota and South Dakota by the enabling act of Feb. 22, 1889.

Physiography.—With the exception of the Black Hills district in the south-west, the State is a broad, wide rolling plain, ranging from level river valleys in the east to irregular plateaux broken by buttes and scored by cañons in the west.



ROCK NEEDLES ON STATE HIGHWAY, BLACK HILLS, SOUTH DAKOTA

In the extreme north-east there is a range of low hills known as the Coteau des Prairies, which crosses the State in a south-south-east direction, forming the divide between the headwaters of the Minnesota river on the east and the James river on the west. The greater part of the James river valley lies in the bed of the extinct Lake Dakota, which was once a very narrow body of water. West of the James river valley lies an elevated table-land, known as the Coteau du Missouri, which marks the water-parting between the James and the Missouri rivers.

The Bad Lands.—In the south-west extreme results of erosion are seen in an accentuated form in the region between the White river and the South Fork of the Cheyenne river, known as the Bad Lands or *terres mauvaises.* This area extends from the 101st meridian up the White river for about 120 m. and varies in width from 30 to 50 miles. The most prominent features of the landscape rise from 150 to 300 ft. above the valleys; the latter and the flat tops of the mesas are sometimes covered with a scanty soil and a sparse growth of grass. The Bad Lands of the White river are noted for their wealth of animal fossils.

The Black Hills.—North-west of the Bad Lands of the White river lie the Black Hills (*q.v.*), an irregular dome-shaped uplift, about 125 m. long and 60 m. wide, lying partly in Wyoming, and with the main axis trending almost north-west and south-east. The main mass of limestone and crystalline rocks have in general a height of 4,000 or 5,000 ft. above the sea—some ridges and peaks rise higher. Cathedral park in the southern portion, Spearfish cañon in the north and the extensive fossil forest at the foot of Mattie's peak are noteworthy; while the Crystal cave, near Piedmont, and the Wind cave, near Hot Springs, are famous.

Drainage.—With the exception of the extreme north-east, the State lies within the drainage system of the Missouri, with its tributaries the Big Sioux, the James, the Grand, Moreau or Owl, Cheyenne and White rivers.

The Minnesota river has its source in the north-east, and the Big Stone lake, a body of water about 25 m. long and 3 m. wide, forms a connecting link between its headwaters and the rest of the stream. North of this lake lies Lake Traverse, 27 m. long and 3 m. wide, whose waters flow north into the Bois de Sioux river, whence they flow into the Red river (of the North). The portion of South Dakota east of the Missouri river is dotted with numerous shallow lakes, ranging from small ponds to bodies of water from 10 to 15 m. in diameter.

Forests.—The total woodland area has been estimated at 2,500 sq.m., about 3·25% of the land area, and of this amount 2,000 sq.m. are in the Black hills district. All the higher lands of this area are covered by forests consisting mainly of yellow pine, but spruce, aspen, white birch, bur oak, box-elder, red cedar, white elm and cottonwood are among the other varieties found. In the more arid regions the sagebrush and cactus make their appearance. Harney national forest lying wholly within the State, and Custer and Black Hills national forests lying partly within the State, have an area in South Dakota of 1,064,357 ac.

Climate.—Owing to the northern latitude, comparatively high altitudes and the great distance from the ocean, there are great annual variations of temperature and a small amount of rainfall. The State is coldest in the north-east where the mean annual temperature averages 42° F and warmest in the region south of the Cheyenne and west of the Missouri river where the mean annual temperature is 48°. The crop-growing season ranges from 120 days along the northern border to 150 days in the south-east. The average annual rainfall ranges from 14 in. in the north-west to 30 in. in the south-east.

Government.—South Dakota is governed under its original Constitution, adopted in 1889, with frequent amendments.

The legislative power lies in the State legislature, consisting of a house of representatives and senate, except that the people have reserved to themselves the powers of initiative and referendum. South Dakota adopted these two methods of legislative procedure in 1898 and was the first State in the United States to do so. Petitions of but 5% of the qualified voters are sufficient to secure either of these privileges. The legislature in 1927 consisted of 42 senators and 103 representatives, all elected for terms of two years.

The executive department is headed by the governor, elected for two years. The governor's veto can be overridden by a two-thirds majority in each house, and does not extend to bills passed directly by the people through their use of the initiative or referendum. The governor's judicial power is represented in his right to remit fines and grant reprieves, commutations and pardons which the courts may have imposed.

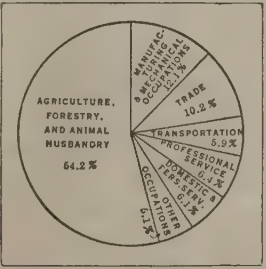
The judicial powers are vested in a supreme court, circuit courts, county courts, justices of the peace and such other courts as may be created by law for cities and incorporated towns. The supreme court has appellate jurisdiction only, and two terms, at least, must be held yearly at the seat of government. It consists of five judges chosen from districts by the qualified electors and serving terms of six years each. The State is divided into districts or circuits in each of which is a circuit court with one or more circuit judges elected for a term of four years. The number of circuits can be increased by the legislature from time to time if deemed necessary. There were in 1927 12 circuits and 21 judges. In each county is a county judge elected for a two year term.

Population.—There were 636,547 inhabitants in South Dakota, according to the Federal census of 1920, an increase over the 583,888 in 1910 of 9%. In 1925 the official State census registered a population of 681,000. In 1920 the white race represented 97·3% of the total population, the remainder being largely Indians, who numbered 16,384. There were only 832 negroes and but 142 Chinese. The Indians are chiefly of the Dakota (or Sioux) tribes, the largest group being the Oglala Sioux at the Pine Ridge agency, which numbered 7,628 in 1925. There were also 5,700 Sioux at the Rosebud agency, 3,000 Cheyenne River Sioux near the mouth of the Moreau river, 2,500 at the Sisseton agency and 2,000 at Yankton, beside smaller bands at the Crow Creek, Lower Brule and Flandreau agencies.

A large portion of the pioneer settlers of South Dakota were foreign-born. Since there has been little immigration since 1900, however, and the original pioneers are fast passing on by death, the percentage is rapidly decreasing. Foreign-born numbered 175,865 in 1910, 82,391 in 1920 and 71,399 by the State census of 1925. In the latter year natives of Norway numbered 12,237, Sweden, 9,113 and Denmark, 5,395. Of equal importance, approximately, was the German element, there being 14,988 natives of Germany and 9,589 Russians, chiefly Teutonic Mennonites.

In 1920 South Dakota averaged 8·3 inhabitants per square mile. The most densely settled portion is in the south-east where some counties average over 25 persons per square mile. East of the Missouri river towns are located every eight or ten miles along the railways and are so evenly spaced that few localities are more than 15 m. from a railroad town. South Dakota is largely an agricultural State and its high percentage of rural population (84% in 1920) is exceeded only in North Dakota and Mississippi among the States. There are no cities larger than Sioux Falls, which had a population in 1925 of 30,127.

Education.—The public elementary and secondary school system is under the control of the superintendent of public instruction. Under this official are three rural supervisors covering respective districts and a high school supervisor. There were, in 1925–26, 5,430 elementary schools, of which 4,812 were located in rural districts, 502 in cities or villages. The remaining 116 were of the consolidated type. There were also 435 high schools of which 359 were properly accredited. Of these 267 were giving the full four-year course. There was an enrolment in the elementary schools of 138,166 and in high schools of 26,390. There were 7,106 elementary teachers with an average annual salary of $906 in rural districts, $1,114 in towns and villages and $1,053 in the consolidated schools. There were 1,530 high school teachers employed at an average annual salary of $1,641.



OCCUPATIONS OF PERSONS TEN YEARS OF AGE AND OVER ENGAGED IN GAINFUL EMPLOYMENT, 1920

The State institutions of higher learning are controlled by the regents of education, five in number, appointed by the governor for terms of six years. Each institution is administered by its president. The University of South Dakota is located at Vermillion. Its faculty in 1926–27 numbered 95 and its enrolment was 1,027. The university has charge of the geological and natural history survey of the State, of the State health laboratory and the State chemical laboratory. At Brookings the South Dakota college of Agriculture and Mechanic Arts is located, with an enrolment in 1926–27 of 848 and a teaching staff of 125. Preparatory work and vocational courses have been gradually dropped so that the institution can concentrate on work of college level. The State School of Mines at Rapid City, in the Black Hills, enrolled 250 students in 1926–27. It issues numerous publications, among them *The Black Hills Engineer*. There are several independent and denominational colleges, the most important being Dakota Wesleyan university, a Methodist institution at Mitchell (1926–27 enrolment 344, faculty 26); Huron college under Presbyterian auspices at Huron (1926–27 enrolment 311, faculty 31); Yankton college, a non-sectarian school at Yankton (1926–27 enrolment 300, faculty 33) and Sioux Falls, a Baptist institution at Sioux Falls (1926–27 enrolment 125, faculty 16). The Norwegian Lutherans support Augustana college, also at Sioux Falls.

Charities and Corrections.—The State penitentiary situated at Sioux Falls had 463 inmates in July 1926. A printing department, farm garden and twine plant are operated, the latter making a net profit of $40,239 for the year 1925–26. The State hospital for the insane at Yankton had an average of 1,305 patients in 1925–26. A 1,750 ac. farm is run and the labour of the patients themselves has financed the purchase of a vacationing park on the James river where a club-house has been erected for their use. At Redfield is the school and home for the feeble minded, an institution with 427 inmates in 1925. The State training school for delinquent boys and girls is at Plankinton and had an average of 131 pupils in 1925–26. A soldiers' home is maintained at Hot Springs, in the Black Hills, open to both soldiers and their wives.

Finance.—The total wealth of South Dakota was estimated in 1922 to be $2,926,000,000. This amounted to $4,482 *per caput*, a higher average than in any other State of the United States. For assessment purposes taxable property was valued by the board of equalization in 1926 at $1,805,466,033. Of this, $1,420,768,023 was classified as real property, represented by agricultural lands valued at $1,245,703,110, city real estate valued at $165,120,365 and mineral lands to the value of $9,944,548.

For the year ending June 30, 1926 all revenue to the State Government amounted to $27,637,806, while its expenditures totalled $26,073,254. The largest items of expenditure, besides those of the general fund for administration purposes, were $4,984,267 for highways, $6,297,706 for rural credit purposes in aid of agriculture, $1,529,199 for hail insurance and $1,454,049 distributed to schools from the interest and income of the common school fund. The State in 1925 had a total debt of $62,100,000 and sinking fund assets of $45,527,000, leaving a gross debt of $17,405,000 or $25.65 *per caput*. The purposes of the debt were divided into $48,400,000 for agricultural aid, $6,000,000 soldiers' bonus, $5,700,000 highways and $2,000,000 for improvements.

There were, on June 30, 1926, 474 banks (108 of them national banks) with total resources and liabilities of $193,662,000 and capital, surplus and undivided profits of $18,987,000. Their deposits totalled $158,197,000, of which time deposits made up $85,570,000.

Agriculture and Livestock.—Agriculture is South Dakota's most important industry, and nearly 90% of its population are probably either directly engaged in it or engaged in industries directly dependent upon it. Of the total population 361,779, or 51·1%, actually lived upon farms in 1925.

The value of all crops fluctuates widely from year to year depending on crop conditions and prices. In 1924, a good year in general, it was $245,606,000, in 1925, $187,344,000, and in 1926, an extremely poor year, $118,484,000. In 1919, when prices were high, the crop value was $311,007,000. In the depression following the World War the farming industry suffered most severely. The depression is seen also in the drop in value of livestock on the farms, from $238,568,000 in 1920 to $146,222,000 in 1925, and in the decreased value of farm land from $2,231,423,000 to $1,201,015,000, or from an average of $64.42 to $37.51 per acre.

In 1926 Indian corn was the leading crop, having a total value of $46,281,000, almost twice that of its nearest competitor, cultivated and wild hay combined. As late as 1900 very little Indian corn was grown because only a few then existing varieties would mature in most parts of the State, but the development of new varieties and acclimatization has made it now dependable in almost all sections. Its production is heaviest, however, in the south-eastern counties and decreases with the distance from the south-east corner. In 1923 the crop was 145,176,000 bushels. In 1926 there were 1,361,000 ac. of cultivated hay yielding 1,364,000 tons valued at $17,732,000 and 2,315,000 ac. of wild hay yielding 926,000 tons valued at $9,723,000.

BY COURTESY OF U.S. GEOLOGICAL SURVEY
ARTESIAN WELL AT WOONSOCKET

Until recent years wheat was the largest money-producing crop of the State, and in good years it still rivals Indian corn for first place. In 1925 31,835,000 bu. valued at $40,734,000 were grown, but in 1926 a very poor crop resulted in but 10,840,000 bu. valued at $12,776,000. Wheat is relied upon more in the northern than in the southern part of the State. The oats crop valued at over $40,000,000 in 1924 decreased to $26,980,000 in the more nearly normal year of 1925. The barley crop was valued at $11,181,000 in 1925. Flax, another crop, extensively grown, especially upon new breaking, was valued at $8,552,000 in 1925. Potatoes, also very important, were grown to the value of $7,137,000 in 1925.

In the south-eastern part of South Dakota there is a large diversification of crops, and a great deal of intensive farming. These methods are spreading rapidly northward and westward over the entire State. Pigs and dairy cattle are being introduced in larger numbers, and a greater percentage of the grain is being fed to stock on the farms. Of 1,727,000 cattle in the State in Jan. 1927 (valued at $64,093,000) 534,000 were milch cows. Their value was $29,370,000. Creamery butter produced increased in value from $18,536,000 in 1918 to $29,193,000 in 1925. The number of swine increased from 1,010,000 in 1910 to 2,760,000 in 1925, in the latter year valued at $36,432,000. By Jan. 1927, they had decreased in number to 2,183,000 but increased in value to $37,111,000. They were most numerous in the south-eastern portion of the State. West of the Missouri, in the rougher country, there is a great deal of sheep-raising; the sheep grown increased in value from $3,042,000 in 1922 to $7,131,000 in 1927, when they numbered 721,000 head. Wool production in 1926 amounted to 4,712,000 lb., the average fleece being 8·1 pounds.

In 1920 69·4% of the farmers owned motor-cars, 5·7% owned motor trucks, and 59·4% were served by telephones, while 8·6% had gas or electric light in their houses. In 1925, 20·6% had tractors. The average size of a South Dakota farm decreased from 464·1 ac. in 1920 to 402·6 ac. in 1925.

Mining.—The bulk of the mineral output consists of gold and silver produced from the deep mines of the Black Hills, particularly from the famous Homestake mine in Lead City. Silver is a minor product and is only classed with gold because it is found in the same ores. Of the 1,674,720 tons treated in 1924 there was an average recovery of $3.65 in gold and $.05 in silver per ton, making the gold output $6,117,421 and the silver production $57,987. Together these metals contributed $6,175,408 of the $6,925,678 at which the total mineral output of South Dakota in 1924 was valued. In gold production South Dakota ranked fourth among the States. Altogether, the Homestake mine has produced over $200,000,000 worth of ore and paid $48,826,924 in dividends. During the World War, when there was a shortage of tungsten, South Dakota produced large quantities, totalling $1,106,740 in value for the years 1915–18 inclusive.

Manufactures.—The most important industries are those connected with the agricultural products of the State such as butter, cheese, condensed and evaporated milk ($13,325,741) and flour, feed and other grain-mill products ($3,219,709). Bread and bakery products amounted to $3,148,161 and lumber and timber products to $1,187,649. Except for concentration at Sioux Falls where products to the value of $36,166,431 were manufactured, factories were usually small and well distributed over the State.

Transportation.—There were in 1926, 3,841 m. of main line track in the railway systems of the State. Of these, the Chicago, Milwaukee, St. Paul and Pacific railway owned 1,636 m., including the only transcontinental line crossing South Dakota. The Chicago and North-Western railway has 1,119 m. of road in South Dakota.

Highways.—There were, in 1926, 116,906 m. of rural roads of which but 3,007 m. were surfaced. The State highway system included 5,924 m. of which 2,468 m. were surfaced. Expenditures upon the State highway system amounted to $5,596,000 in 1924 and $6,378,000 in 1925. Most of the important highways run from east to west. The Yellowstone trail roughly parallels the line of the Chicago, Milwaukee and St. Paul railway.

History.—It is possible that the Frenchman, Charles Le Sueur, visited South Dakota in the region around Sioux Falls as early as 1683 and that some trading with the Indians in that vicinity by French on the Minnesota river took place around 1700, but the first authentic exploration by white men, of which there is certain record, was that of the Verendrye brothers, who in 1743 came overland from the Assiniboine river in Manitoba to the Missouri in North Dakota, and wandered from there south-west probably to the Black Hills and thence east to the Missouri at the present site of Pierre. Theirs was a disappointed search for the "western ocean." In the decade of the 1780s fur traders began to enter South Dakota irregularly, coming up the Missouri river from St. Louis, down from Canada by the Red river of the north, or in from Wisconsin by the Minnesota river. In 1794 Jean Baptiste Truteau, leading a fur-trading expedition from St. Louis, caused the first building erected by white men to be built on the bank of the Missouri river, in Charles Mix county. Fur traders and trappers were, therefore, already familiar with the territory when the first scientific exploration party led by Lewis and Clark passed up the Missouri in 1804 on its way to the Rocky mountains. The whole area of the State in the meantime had been transferred from French to U.S. ownership by the Louisiana Purchase of 1803.

Following the Lewis and Clark expedition, which returned in 1806, the Missouri river became the natural highway for many expeditions trading with the upper Missouri Indians or passing westward to the mountains. Manuel Lisa, of St. Louis, ascended the river in 1807 and for many years thereafter either went himself, or sent parties to trade with the upper Indians. In 1817 Joseph La Framboise built old Ft. La Framboise near the modern site of Pierre, and around this post grew up the first settlement in South Dakota. In 1831 the first steamboat to ascend the Missouri reached the site of Pierre. It was owned and regularly used thereafter by the American Fur company, which by that time controlled the Missouri river fur trade. In 1832 Ft. Pierre was built for the same company. Except for a later period of bison-hunting, the fur trade period was about over in 1855 when the company sold this post to the U.S. Government.

Settlement.—The first attempt at permanent settlement by the agricultural pioneers was at the falls of the Sioux river in 1856 by a party from Minnesota. Other homes were established in the Sioux valley from 1857 to 1862, but all were abandoned because of fear of the Sioux Indians after the Minnesota outbreak of 1862. In the meantime, a permanent settlement was made at Yankton in 1859. In 1861 Dakota Territory was created by Congress and Yankton designated as its capital. Settlement was very slow at first, however, and even by 1870 when Iowa had 1,115,000 inhabitants, South Dakota had no more than 12,000. Sioux City, Ia., was reached by the railway in 1868 and in the same season stage lines to Yankton and Sioux Falls were established. The last two towns became the centres for early settlement in the eastern part of the State, and Sioux City was the depot and shipping point until the railway reached Yankton in 1873 and Sioux Falls in 1878.

In the meantime, a settlement of quite different character was developed in the Black Hills at the opposite end of the State. Gold was discovered in 1874 by the men of Custer's expedition, and a rush of gold hunters followed. But the region belonged to the Sioux Indians and the Government intervened to keep settlers out until an agreement could be made with the owners. Such an attempt was made at the Red Cloud agency in 1875, but when the Indians refused to cede the region, Government opposition to settlement ceased. Between Nov. 1875 and March, 1876 over 1,100 persons arrived in the hills, most of them stopping at Custer, the scene of the original discovery, which by March was a city of at least 6,000 persons. The rapid exhaustion of the placers there encouraged prospecting elsewhere with the result of rich workings being discovered in Deadwood gulch, 75 m. further north, in June 1876. Almost the entire population rushed to the new diggings where the city of Deadwood rapidly became famous. The discovery of permanent bodies of ore gave it stability, and smaller towns grew up in outlying gulches. In the autumn of 1876 Moses Manuel located the Homestake lode, which has supplied one of the world's greatest gold mines with a steady stream of ore to the present day. Around it the city of Lead has grown up. Stage lines to Deadwood were established from Laramie, Wyo., Sidney, Neb. and Bismarck, N.D., and population grew rapidly.

The "Dakota Boom."—During the years 1879–86 much of the territory of South Dakota was settled and these years are known as the years of the "Great Dakota Boom." At the end of the period all but three of the present day counties had settlements located in them, and all of the counties now east of the Missouri river had been organized. In 1878 there was but 60 m. of railway in the Territory, but by 1886 over 1,000 m. of railway were built and settlement rapidly followed each railway.

During the energetic decade ending June 30, 1889, nearly 42,000,000 ac., or almost half the area of South Dakota, were homesteaded. In 1887 no free land remained in 22 counties of southern Dakota Territory. The population had increased from 98,268 in 1880 to 263,411 in 1885, and in 1890 it was 328,808. The boom times were brought to an end chiefly by crop failures, the terrible drought of 1889 producing widespread destitution.

Admission to Statehood.—The boom resulted in a movement for statehood. There was much agitation among the inhabitants for a separation of Dakota Territory into a northern and southern State, and this was made part of the programme of the National Republican Party in 1888. When the party prevailed in the subsequent election, North and South Dakota were admitted as separate States (Nov. 2, 1889). From 1889 to 1897 South Dakota suffered a period of repeated droughts, the rainfall over large parts of the State being deficient every year. Immigration was almost at a standstill and many homesteaders left the State. Many counties in 1897, most of them west of the James river, had but half the population they boasted in 1887. Those that went were largely of American stock, the foreign immigrants being more persistent. Commencing about 1896 the rainfall increased and fairly satisfactory conditions prevailed until 1910. These were years of stabilization and increasing prosperity, the aggregate value of farm property rising at least 500% between 1895 and 1910. The increase in population in the same years was 252,913 or 76%, a large proportion of the increase being west of the James valley. Many of the Indian reservations were opened to settlement in the latter part of this decade.

The years 1910–12 were unusually dry. During the World War, values were inflated far beyond normal, only to be depressed alarmingly after the Armistice.

South Dakota is normally Republican in politics and this party controlled the State Government from 1900 to 1926. In 1926 the State elected its first Democratic governor.

BIBLIOGRAPHY.—The recent publications of the various State departments and reports of officials must be consulted for authoritative information upon governmental activities. The *South Dakota Manual*, published annually by the Public Printing Bureau contains many facts. The bulletins, circulars and reports of the South Dakota Geological and Natural History Survey, also the bulletin of the South Dakota School of Mines contain many valuable studies of the minerals and natural resources. *Bulletin* No. 11 of the South Dakota School of Mines (1917) is an exhaustive "Bibliography of the Geology and Mining Interests of the Black Hills Region." The School of Mines also publishes the *Black Hills Engineer* (1912 *seq.*). For agriculture consult the reports and bulletins of the South Dakota agricultural experiment station and the Publications of the South Dakota Department of Immigration. The most important books are: S. S. Visher, *Geography of South Dakota* (1918); D. Robinson, *History of South Dakota* (1904) and *Encyclopaedia of South Dakota* (1925); G. W. Kingsbury, *History of Dakota Territory* (1915); F. E. Peterson, *Historical Atlas of South Dakota* (1904); G. F. Will, *Archaeology of the Missouri Valley* (1924); O. W. Coursey, *Who's Who in South Dakota* (1916–25); L. K. Fox, *Who's Who Among South Dakotans* (1924–25); Peter Rosen, *Pa-ha-sa–pah; or, The Black Hills of South Dakota;* A. D. Tallent, *The Black Hills* (1923). *See* also the *Collections of the South Dakota Historical Society* (1902–26).

SOUTHEND-ON-SEA, a watering-place in Essex, England. Pop. (1921) 106,070. It was visited by Queen Caroline in 1804, and is the nearest seaside resort to London. The bathing is good, but the tide recedes rapidly for nearly a mile. The pier, which is over 1¼ m. in length, permits the approach of steamers at all tides. Westcliff-on-Sea is a western suburb. Westward again is Leigh-on-Sea (pop. 3,667); its lofty Perpendicular church tower is visible from afar. The castle was built in the 13th century, and two ruined towers remain. Southend was incorporated as a county borough in 1914.

SOUTHERNE, THOMAS (1660–1746), English dramatist, was born at Oxmantown, near Dublin, in 1660, and entered Trinity College in 1676. Two years later he was entered at the Middle Temple, London. His first play, *The Persian Prince, or the Loyal Brother* (1682), contained a flattering portrait of James II. as the "loyal brother." The poet received a commission in Princess Anne's regiment, but his military career came to an end at the Revolution. His two most successful plays were *The Fatal Marriage, or the Innocent Adultery* (1694), known later as *Isabella, or the Fatal Marriage,* and *Oroonoko,* or *The Royal Slave* (1696), the plot in each case being taken from a novel by Aphra Behn. He died on May 22, 1746.

His other plays are: *The Disappointment, or the Mother in Fashion* (1684), founded in part on the *Curioso Impertinente* in Don Quixote; *Sir Anthony Love* (1691); *The Wives' Excuse, or Cuckolds make themselves* (1692); *The Maid's Last Prayer; or Any, rather than fail* (1692); *The Fate of Capua* (1700); *The Spartan Dame* (1719), taken from Plutarch's Life of Aegis; and *Money the Mistress* (1729).

See *Plays written by Thomas Southerne, with an Account of the Life and Writings of the Author* (1774).

SOUTHERN PACIFIC COMPANY, an American transportation system, comprising, with its affiliated companies, 17,000 m. of rail lines and 3,800 m. of water lines. It serves directly a large part of the United States west of the Mississippi river (at New Orleans) through to the Pacific coast, besides steamships plying between New York city and the ports of New Orleans, Galveston and Houston. Its lines also extend into Mexico as far south as Guadalajara.

Construction of its first unit, the Central Pacific main line, completed in 1869, was the link from California across the Sierra Nevada mountains to Ogden, Utah, now 782 m. from San Francisco, which completed the first through rail line between the eastern and western shores of the North American continent. In 1883 the Sunset route was opened for traffic between New Orleans and San Francisco via El Paso and Los Angeles, distance 2,479 miles. In 1887 the Shasta route was completed, giving a rail line between San Francisco and Portland, Ore., distance 771 miles. Southern Pacific is also part of the Golden State route from Los Angeles to Chicago, its line, Los Angeles to Tucumcari, N.M., 1,146 m., being one-half the distance to Chicago.

The construction of the Central Pacific, followed by the Southern Pacific and the merged operation of both, was under the inspiration of four citizens of Sacramento: Leland Stanford, Collis P. Huntington, Mark Hopkins and Charles Crocker. Stanford, prior to his death, founded and endowed Stanford university. After the death of these men E. H. Harriman secured control and carried to conclusion projects previously planned, including the straight and level 104 m. line from Lucin to Ogden, of which 31½ m. were built across Great Salt Lake.

The invested assets of the Southern Pacific Company exceed $2,125,000,000; its capital shares of $372,400,000 par value are owned by 58,000 stockholders. Its equipment for handling traffic consists of 2,600 locomotives, 4,000 passenger cars, 87,000 freight cars, 23 ocean steamships and 24 ferry steamboats; it also has half ownership in 40,000 refrigerator cars. (W. Spr.)

SOUTHERN RAILWAY, an English railway system. It was formed by the amalgamation of the London and South Western, London Brighton and South Coast, South Eastern, and London, Chatham and Dover Railway Companies, together with the South Eastern and Chatham Railways Managing Committee and various subsidiary companies, under the Railways Act, 1921. Operation as a single concern was commenced Jan. 1, 1923, with a total mileage of 2,156. Seventy-five per cent of its traffic is passenger, its suburban business being enormous and most concentrated. It operates 700 miles of electrified track.

The Southern Railway controls eight routes to the Continent, including the most popular cross-channel service via Dover-Calais and during the year 1927 over two million passengers were conveyed across the English Channel by these routes. The company's modern fleet of passenger steamers consists of 23 vessels, including eight which are operated jointly with the French State Railways on the Newhaven-Dieppe route. The latest additions to the fleet, "Isle of Thanet," "Maid of Kent" and the "Worthing," burn oil, and are all capable of over 22 knots.

In Southampton Docks the Southern Railway has a magnificent property, which has now become the first passenger port in the United Kingdom. It covers about 200 acres of land equipped with 42 miles of rail. (H. A. Wa.)

SOUTHERN RAILWAY SYSTEM serves that part of the United States which is known historically as the Old South, and in modern economic statistics as the South-east. Its network of lines extend from the Potomac and Ohio rivers on the north to the Gulf of Mexico on the south and from the Mississippi river on the west to the Atlantic ocean on the east. The Southern Railway Company was chartered (1894) to acquire the properties which then constituted the Richmond and Danville and the East Tennessee, Virginia and Georgia systems, including many of the oldest railroads in the territory. These, with the South Carolina and Georgia railroad, the Cincinnati Southern railway, the Alabama Great Southern railroad, the New Orleans and Northeastern railroad, the Georgia Southern and Florida railway and the Northern Alabama railway, comprise the present system. The Mobile and Ohio railroad, operated separately, is affiliated.

The Southern Railway System operates 8,000 m. of railroad, has 60,000 employees, owns 2,300 locomotives, 78,000 freight cars and 1,400 passenger train cars, represents an investment in road and equipment of $771,000,000; and in the year 1928 performed a transportation service equivalent to the movement one mile of 11 billion tons of freight and one thousand million passengers. During the 35 years of life of Southern Railway Company the investment in road and equipment has increased 140% and the volume of freight traffic has increased 600%. (L. Fo.)

SOUTHEY (sŭ*th*'ĭ), **CAROLINE ANNE** (1786–1854), second wife of Robert Southey (*q.v.*), daughter of an East Indian captain, Charles Bowles. She was born at Lymington, Hants, on Oct. 7, 1786. She sent anonymously to Southey a narrative poem called *Ellen Fitzarthur*, and this led to the acquaintanceship and long friendship, which, in 1839, culminated in their marriage. *Ellen Fitzarthur* (1820) may be taken as typical, in its prosy simplicity, of the rest of its author's work. Soon after her marriage her husband's mental state became hopeless, and from this time till his death in 1843, and indeed till her own, her life was a sad one. Her correspondence with Southey, neglected in the official biography, was edited by Professor Dowden in 1881. Mrs. Southey died at Buckland Cottage, Lymington, on July 20, 1854, two years after Queen Victoria had granted her a pension of £200.

SOUTHEY, ROBERT (1774–1843), English poet and man of letters, was born at Bristol on Aug. 12, 1774. His father, Robert Southey, an unsuccessful linendraper, married Margaret Hill in 1772. When he was three, Southey passed into the care of Elizabeth Tyler, his mother's half-sister, at Bath, where most of his childhood was spent. In 1788 he was entered at Westminster school. After four years there he was privately expelled by Dr. William Vincent (1739–1815), for an essay against flogging called *The Flagellant*, written for a school magazine. His uncle, Herbert Hill, chaplain of the British factory at Lisbon, who had paid for his education at Westminster, determined to send him to Oxford with a view to his taking holy orders, but the news of his escapade at Westminster had preceded him, and he was refused at Christ Church. Finally he was admitted at Balliol, where he lived a life apart, and gained little or nothing except a liking for swimming and a knowledge of Epictetus.

Revolutionary Youth.—In the vacation of 1793 Southey's enthusiasm for the French Revolution found vent in writing an epic poem, *Joan of Arc,* published in 1796 by Joseph Cottle, the Bristol bookseller. In 1794 Coleridge, then on a visit to Oxford, was introduced to Southey, and filled his head with dreams of an American Utopia on the banks of the Susquehanna. The members of the "pantisocracy" were to earn their living by tilling the soil, while their wives cared for the house and children. Coleridge and Southey soon met again at Bristol, and with Robert Lovell developed the emigration scheme. Lovell had married Mary Fricker, whose sister Sara married Coleridge, and Southey now became engaged to a third sister, Edith. Miss Tyler, however, would have none of "pantisocracy" and "aspheterism," and drove Southey from her house. To raise the necessary funds for the enterprise Coleridge and he turned to lecturing and journalism. Cottle generously gave Southey £50 for *Joan of Arc;* and, with Coleridge and Lovell, Southey had dashed off the drama, printed as the work of Coleridge, on *The Fall of Robespierre.* A volume of *Poems* by R. Southey and R. Lovell was also published by Cottle in 1795. Southey's uncle, Mr. Hill, now desired him to go with him to Portugal. Before he started for Corunna he was married secretly (Nov. 14, 1795) to Edith Fricker. On his return to England he and his wife had lodgings for some time at Bristol. He was entered at Gray's Inn in February 1797. At the end of 1797 his friend Wynn began an allowance of £160 a year, which was continued until 1806, when Southey relinquished it on Wynn's marriage. His *Letters written during a Short Residence in Spain and Portugal* was printed by Cottle in 1797, and in 1797–1799 appeared two volumes of *Minor Poems* from the same press. In 1798 he paid a visit to Norwich, where he met Frank Sayers and William Taylor, with whose translations from the German he was already acquainted. He then took a cottage for himself and his wife at Westbury near Bristol, and afterwards at Burton in Hampshire. At Burton he was seized with a nervous fever which had been threatening for some time. He moved to Bristol, and after preparing for the press his edition of the works of Thomas Chatterton, undertaken for the relief of the poet's sister and her child, he sailed in 1800 for Portugal, where he began to accumulate materials for his history of Portugal. He also had brought with him the first six books of *Thalaba the Destroyer* (1801), and the remaining six were completed at Cintra.

Life at Greta Hall.—In 1801 the Southeys returned to England, and at the invitation of Coleridge, who held out as an inducement the society of Wordsworth, they visited Keswick. After a short experience as private secretary to Isaac Corry, chancellor of the exchequer for Ireland, Southey in 1803 settled at Greta Hall, Keswick, which he and his family shared thenceforward with the Coleridges and Mrs. Lovell. There he accumulated a library consisting of over 14,000 volumes, including valuable mss. and a collection of Portuguese authorities probably unique in England. After 1809, when Coleridge left his family, the whole household was dependent on Southey's exertions. His nervous temperament suffered under the strain, and he found relief in keeping different kinds of work on hand at the same time, in turning from the *History of Portugal* to poetry. *Madoc* and *Metrical Tales and Other Poems* appeared in 1805, *The Curse of Kehama* in 1810, *Roderick, the last of the Goths,* in 1814. This constant application was lightened by a happy family life. Southey was devoted to his children, and was hospitable. He met Walter Savage Landor in 1808, and their affection was lasting.

From the establishment of the Tory *Quarterly Review* Southey, whose revolutionary opinions had changed, was one of its most regular and useful writers. He supported Church and State, opposed parliamentary reform, Roman Catholic emancipation, and free trade. He did not cease, however, to advocate measures for the immediate amelioration of the condition of the poor.

With William Gifford, his editor, he was never on very good terms, and would have nothing to do with his harsh criticisms on living authors. His relations with Gifford's successors, Sir J. T. Coleridge and Lockhart, were not much better. In 1813 the laureateship became vacant on the death of Pye. The post was offered to Scott, who refused it and secured it for Southey. A government pension of some £160 had been secured for him, through Wynn, in 1807, increased to £300 in 1835. In 1817 the unauthorized publication of an early poem on *Wat Tyler*, full of his youthful republican enthusiasm, brought many attacks on Southey. He was also engaged in a bitter controversy with Byron, whose first attack on the "ballad-monger" Southey in *English Bards and Scotch Reviewers* nevertheless did not prevent them from meeting on friendly terms. Southey makes little reference to Byron in his letters, but Byron asserts (*Letters and Journals*, ed. Prothero, iv. 271) that he was responsible for scandal spread about himself and Shelley. In this frame of mind, due as much to personal anger as to natural antipathy to Southey's principles, Byron dedicated *Don Juan* to the laureate, in what he himself called "good, simple, savage verse." In the introduction to his *Vision of Judgment* (1821) Southey inserted a homily on the "Satanic School" of poetry, unmistakably directed at Byron, who replied in the satire of the same name. The unfortunate controversy was renewed even after Byron's death, in consequence of a passage in Medwin's *Conversations of Lord Byron*.

Meanwhile the household at Greta Hall was growing smaller. Southey's eldest son, Herbert, died in 1816, and a favourite daughter in 1826; Sara Coleridge married in 1829; in 1834 his eldest daughter, Edith, also married; and in the same year Mrs. Southey, whose health had long given cause for anxiety, became insane. She died in 1837, and Southey went abroad the next year with Henry Crabb Robinson and others. In 1839 he married his friend Caroline Bowles. (*See* SOUTHEY, CAROLINE.) But his memory was failing, and his mental powers gradually left him. He died on March 21, 1843, and was buried in Crosthwaite churchyard. A monument to his memory was erected in the church, with an inscription by Wordsworth.

Works.—The amount of Southey's work in literature is enormous. His collected verse, with its explanatory notes, fills ten volumes, his prose occupies about forty. But his greatest enterprises, his history of Portugal and his account of the monastic orders, were left uncompleted, and this, in some sense, is typical of Southey's whole achievement in the world of letters; there is always something unsatisfying, disappointing, about him. This is most true of his efforts in verse. Some of Southey's subjects, "The Poet's Pilgrimage" for instance, he would have treated delightfully in prose; others, like the "Botany Bay Eclogues," "Songs to American Indians," "The Pig," "The Dancing Bear," should never have been written. Of his ballads and metrical tales many have passed into familiar use as poems for the young. Among these are "The Inchcape Rock," "Lord William," "The Battle of Blenheim," and the ballad on Bishop Hatto.

If we turn from his verse to his prose we are in a different world; there Southey is a master in his art, who works at ease with grace and skill. "Southey's prose is perfect," said Byron, truly. His interest and his curiosity are unbounded as his *Common-Place Book* will prove; his stores of learning are at his readers' service, as in *The Doctor*, a rambling miscellany, valued by many readers beyond his other work. For biography he had a real genius. The *Life of Nelson* (2 vols., 1813), which has become a model of the short life, arose out of an article contributed to the *Quarterly Review;* he contributed another excellent biography to his edition of the *Works of William Cowper* (15 vols., 1833–1837), and his *Life of Wesley; and the Rise and Progress of Methodism* (2 vols., 1820) is only less famous than his *Life of Nelson*. But the truest Southey is in his *Letters:* the loyal, gallant, tender-hearted, faithful man is revealed.

A collected edition of his *Poetical Works* (10 vols., 1837–38) was followed by a one volume edition in 1847. Southey's letters were edited by his son Charles Cuthbert Southey as *The Life and Correspondence of the late Robert Southey* (6 vols., 1849–50); further selections were published in *Selections from the Letters of Robert Southey* (4 vols., 1856), edited by J. W. Warter; and *The Correspondence of Robert Southey with Caroline Bowles. To which are added: Correspondence with Shelley, and Southey's Dreams* (1881), was edited, with an introduction, by Professor E. Dowden. An excellent selection from his whole correspondence, edited by Mr. John Dennis, as *Robert Southey, the story of his life written in his letters* (Boston, Massachusetts, 1887), was reprinted in Bohn's Standard Library (1894). *See* also *Southey* (1879) in the English Men of Letters Series, by Professor E. Dowden, who also made the selection of *Poems by Robert Southey* (1895) in the Golden Treasury Series. W. Haller, *Early Life of Robert Southey (1774–1803)* (Columbia, 1917). A full account of his relations with Byron is given in *The Letters and Journals of Lord Byron* (vol. vi., 1901, edited R. E. Prothero), in an appendix entitled "Quarrel between Byron and Southey," pp. 377–399. Southey figures in four of the *Imaginary Conversations* of W. S. Landor, two of which are between Southey and Porson, and two between Southey and Landor.

SOUTH GEORGIA, an island in the South Atlantic Ocean, area 1,600 sq.m. It is mountainous, with snowy peaks 6,000 to 8,000 ft. high, their slopes furrowed with deep gorges filled with glaciers. Its geological constitution—gneiss and argillaceous schists, with no trace of fossils—shows that the island is, like the Falklands, a surviving fragment of some greater land-mass now vanished, most probably indicating a former extension of the Andean system. South Georgia is politically attached to the Falklands, and since 1904 has been the chief centre for whaling. The chief settlement is at Grytviken on the north coast.

SOUTH HADLEY, a town of Hampshire county, Massachusetts, U.S.A., occupying 18·5 sq.m. on the Connecticut river, 12 m. N. of Springfield, directly opposite Mt. Tom. It is served by an electric line which connects with the Boston and Maine and the New York, New Haven and Hartford railways at Holyoke, across the river. Pop. (1920) 5,527 (25% foreign-born white); 1928 local estimate 7,200. South Hadley is the seat of Mount Holyoke college.

SOUTH HOLLAND, the most crowded province of the Netherlands: area 1,133 sq.m., and population (1926) of 1,814,536 showing the greatest increase per sq.m. during the 20th century. It is a delta between the lower Maas and Waal. It includes the detached island of Goeree-Over Flakkee, and other islands are Voorne-Putten, Rozemburg, Ysselmonde, Hoekschewaard, and Dordrecht. The Hook of Holland harbour, built (1866–72) near Rotterdam, is an important approach to Central Europe from the east coast of Britain. At Sassenheim in the extreme north there used to be Trilingen castle in which Jacqueline of Bavaria died (1433). Rynsburg was the home of Spinoza.

New coasts have appeared and new interests have arisen, though the Hague, situated on this old-village line, remains the political capital of the province and of the Netherlands (*q.v.*). Rotterdam (*q.v.*), Schiedam (43,000) and Dordrecht (55,000), Delft (49,000), Leyden (70,000) and Gouda (28,000) lie within the province. Vianen on the Lek is reputed to be the *Fanum Dianae* of Ptolemy; Gorichem was one of the first towns to be taken (1572) from the Spaniards by the "Sea Beggars."

SOUTH KINGSTOWN, a town of Rhode Island, U.S.A. Pop. (1925), 6,085. It is an old tree-shaded town, on an arm of Point Judith salt pond, and has colonial houses. In Great Swamp on Dec. 19, 1675 the Narragansett Indians made their last stand in King Philip's War, and were defeated by the forces of the Massachusetts, Plymouth and Connecticut Colonies under Governor Josiah Winslow (of the Plymouth Colony).

SOUTH METROPOLITAN GAS COMPANY. This undertaking in London possesses by statute the sole right to supply gas to nearly the whole of the county of London south of the Thames, with nearly two million people. It is an amalgamation of supply companies, completed in 1885.

In 1928 the South Metropolitan company had behind it a history of 104 years of enterprise. It was in 1802 that William Murdock, the friend and assistant of Matthew Bolton and James Watt, lit with coal gas the famous engine works at Soho, near Birmingham, and gas lighting was used in London for the first time when the Carlton Palace Gardens were illuminated by an enterprising German named Winsor. The company, it will be seen, began work very soon after the first experiments were made. Yet we may recall that as late as 1809 a scientist like Sir Humphry Davy declared that "it would be as easy to bring down a bit of the moon to light London as to succeed in doing so with gas." It is also on record that in 1813 two gentlemen were prosecuted for making "divers noisome and offensive stinks" in experiment.

In 1928 the company had an issued capital of £9,739,340, upon which it pays dividends strictly limited by act of parliament. The company is identified with profit-sharing. In 1928 the stock held by employees amounted to over £500,000. (L. C. M.)

SOUTH MILWAUKEE, a city of Milwaukee county, Wisconsin, U.S.A., on Lake Michigan, 10 m. S. of Milwaukee; served by the Chicago and North Western and the Milwaukee Electric railways. Pop. (1920), 7,598 (27% foreign-born white); 1928 local estimate, 10,000. The city was founded in 1892 and incorporated in 1897.

SOUTH MOLTON, a town in Devonshire, England. Pop. (1921) 2,818. The remains of a British camp are visible 2 m. south of the town. The Domesday survey relates that the manor had been royal demesne of Edward the Confessor. It has a weekly market and a fair dating from 1246, and the fair which is held on St. John the Baptist's day, dates from 1490.

SOUTHOLD, a township of Suffolk county, New York, occupying the peninsula at the N.E. of Long island, and including the islands E.N.E. of this peninsula: Plum island, on which defences protect the eastern entrance to Long island sound, Little Gull island, Great Gull island and Fisher's island. Pop. (1920), 10,147. The mainland area is about 25 m. long and its average width is 2 m. A permanent settlement was made in 1640.

A meeting-house was built in 1642, and biblical laws were enforced. Southold was originally one of the six towns under the New Haven jurisdiction, but in 1662 was placed under Connecticut; in 1664 it objected strongly to the transfer of Long island to the duke of York; in 1670 refused to pay taxes imposed by Gov. Francis Lovelace of New York; in 1672 petitioned the king to be under Connecticut or to be a free corporation; in 1673, when the Dutch got control of New York, withstood the Dutch commissioners, with the help of Connecticut; and, in 1674, after English supremacy was again established in New York, still hoped to be governed from Connecticut. The township was chartered by Governor Edmund Andros in 1676.

See Epher Whitaker, *History of Southold, L.I.: Its First Century* (Southold, 1881); *Southold Town Records* (2 vols., Southold, 1882–84); Peter Ross, *A History of Long Island* (1902); Ella B. Hallock, *The Story of the 275th Anniversary Celebration of the Founding of Southold Town* (1915); B. F. Thompson, *History of Long Island* (1918).

SOUTH ORANGE, a village of Essex county, New Jersey, between Orange and Maplewood. Pop. (1920) 7,274 (80% native white). It is a residential community, 300 ft. above sea-level. Among the landmarks are an old stone house mentioned in documents as early as 1680, the Baldwin house (*c.* 1717), and the Timothy Ball house (1743).

SOUTH PASADENA, a city of Los Angeles county, California, U.S.A. Pop. (1920) 7,652 (87% native white); 1928 local estimate, 15,000. It is primarily a residential suburb. There is an ostrich farm which attracts many visitors.

SOUTHPORT, seaside resort, Lancashire, England. Pop. (1921) 76,621. It is a favourite holiday resort.

The great promenade along the shore is 2 m. in length; in its centre is the pier, 1 m. long. Lord Street, the main thoroughfare, is an excellent boulevard. Other facilities for outdoor enjoyment are provided in Hesketh Park, the Botanic Gardens, Kew Gardens, South Marine Park, and the Winter Gardens. Southport was incorporated in 1867, became a county borough in 1905 and a parliamentary borough in 1918.

SOUTH PORTLAND, a city of Maine, U.S.A., opposite Portland, with which it is connected by four bridges and a ferry. Pop. (1920) 9,254 (88% native white); 1928 local estimate 12,000. It is the seat of the State reform school for boys. Until 1895 South Portland was part of the town of Cape Elizabeth.

SOUTH RIVER, a borough of New Jersey, U.S.A., served by the Raritan River railroad. Pop. (1920) 6,596 (40% foreign-born white); 1928 local estimate 12,000. There are large brick and tile works. The profit from the public utilities owned and operated by the borough meets the costs of the government. A settlement was established here in 1720 by Samuel Willett. The borough was incorporated in 1896.

SOUTHSEA: *see* PORTSMOUTH.

SOUTH SEA BUBBLE, the name given to a series of financial projects which originated with the incorporation of the South Sea Company. In 1711 the South Sea Company was formed, and was granted a monopoly of the British trade with South America and the Pacific islands. It was highly successful, and early in 1718 the king became its governor. Towards the end of 1719 the directors of the company put before the Government, the head of which was Charles Spencer, 3rd earl of Sunderland, a more ambitious scheme. In return for further concessions the company offered to take over the whole of the national debt (£51,300,000) and to pay £3,500,000 for this privilege. The aim of the directors was to persuade the annuitants of the State (the bulk of the debt was thus held) to exchange their annuities for South Sea stock; the stock would be issued at a high premium and thus a large amount of annuities would be purchased and extinguished by the issue of a comparatively small amount of stock. Moreover, when this process had been carried out the company would still receive from the Government a sum of something like £1,500,000 a year in interest. The offer was accepted in 1720, the company having raised its bid to £7,567,000 in competition with the directors of the Bank of England.

In a few weeks the company had persuaded over one-half of the Government annuitants to become shareholders in the company. Meanwhile the stock of the company had been appreciating steadily in value, and when the new scheme was launched the public began to purchase it eagerly. From 128½ at the beginning of the year the price had risen by June to 890, and in July it touched 1,000. At this tremendous premium the directors sold five millions of stock. The extraordinary success of the company produced a crowd of imitations—many of them audacious hoaxes—and the wild speculation which followed involved the numerous honest companies in disaster. In August the fall in the price of South Sea stock began. By November it had fallen to 135, and in four months the stock of the Bank of England fell from 263 to 145. Thousands were ruined, and many who were committed to heavy payments fled from the country. A committee of secrecy of the House of Commons reported in February 1721. The company's books contained fictitious entries, and it was shown that favours secured from the State had been purchased by gifts to ministers, some of whom had also made large sums of money by speculating in the stock. The chief persons implicated were John Aislabie (1670–1742), chancellor of the exchequer; James Craggs, joint postmaster-general; his son James Craggs, secretary of state; and to a lesser degree the earl of Sunderland and Charles Stanhope, a commissioner of the Treasury. Aislabie resigned his office in January, and being found guilty of the "most notorious, dangerous and infamous corruption," was expelled from the house and imprisoned. Both the elder and the younger Craggs died in March, while, owing to the efforts of Walpole, both Sunderland and Stanhope were acquitted, the latter by the narrow majority of three. By act of Parliament the estates of the directors were confiscated; these were valued at £2,014,123, of which £354,600 was returned to them for their maintenance, the balance being devoted to the relief of the sufferers. The South Sea Company continued to exist, without any great prosperity, until the 19th century.

SOUTH SHETLAND, a chain of islands on the border of the Antarctic region, lying about 500 m. S.E. of Cape Horn, and separated by Bransfield Strait from Graham Land. Deception Island is of volcanic origin, but Otto Nordenskjöld (*Antarctica*, London, 1905) found no exterior evidence of volcanic activity.

Most of the islands are rocky and mountainous, and some peaks are between 6,000 and 7,000 ft. in height. Covered with snow for the greater part of the year, and growing nothing but lichens, mosses and some scanty grass, the South Shetlands are of interest almost solely as a haunt of seals, albatrosses, penguins and other sea-fowl. In 1819 William Smith of the English brig "Williams" observed the South Shetland coast on the 19th of February. Revisiting it in October, he landed on King George I. Island, taking possession for England; he also gave the whole chain the name it bears. A smaller group lying 200 m. east of the

South Shetlands, bears the name of South Orkney. It was discovered by the English captain, Powell, in 1821.

SOUTH SHIELDS, seaport, Durham, England, on the Tyne. Pop. (1921) 116,635. It is connected with North Shields and Tynemouth by steam ferries. The church of St. Hilda has a picturesque old tower. The Tyne dock has an area of 50 ac., the tidal basin of 10 ac., and the quays and yards over 300 ac. Coal is largely exported. (*See* NEWCASTLE-UPON-TYNE.) The South Pier is a massive structure about 1 m. long, and the North Pier protects the river mouth from the Northumberland bank at North Shields. Constant dredging maintains a depth of 30 ft. Near the harbour is a Roman fort, where coins etc. have been dug up. This site was afterwards occupied by a fort, which was captured by the Scots in 1644. The town was founded by the convent of Durham in the 13th century, but until the 19th century it was only a fishing station. In 1832 it was given a member to parliament, and in 1850 a charter of incorporation.

SOUTHWARK, a central borough of London. Pop. (1921) 184,404; area 1,131 acres. The borough is connected with the City of London by Blackfriars, Southwark and London bridges; the thoroughfares converge at St. George's Circus; another important junction is the "Elephant and Castle."

The name is taken from the southward works or fortifications of London. Numerous Roman remains have been found. Southwark witnessed various episodes during the invasions of the Norsemen, and was fortified by the Danes against the City in the reign of Ethelred the Unready. Besides the priory of St. Mary Overy, there was the hospital of St. Thomas, founded in 1213 from the neighbouring priory of Bermondsey, being the origin of the modern hospital of the same name in Lambeth (*q.v.*). Bordering the river (Bankside) was Winchester House, a seat of the bishops of Winchester for five centuries from 1107.

The convergence of roads to cross London Bridge gave Southwark its mediaeval importance and its inns became famous (*e.g.*, the *"Tabard"* of the Canterbury Tales). At an early date it was incorporated, and its familiar title of "The Borough" still survives. It came, at least in part, under the jurisdiction of the City in 1327. Edward III. granted the city forever the town and borough of Southwark, a privilege confirmed by Edward IV. In this connection was constituted the Bridge Ward Without, the alderman of which is elected not by the borough, but by the other aldermen from among themselves. The authority of the City over the borough is now merely nominal.

At Bankside were the Bear and the Paris Gardens and the Globe theatre, the scene of the production of many of Shakespeare's plays for fifteen years after its erection in 1599.

Southwark is a bishopric of the Church of England created by act of 1904 (previously a suffragan bishopric in the diocese of Rochester), and also of the Roman Catholic Church. The cathedral of St. Saviour belonged to the Augustinian priory of St. Mary Overy, or Overies (*i.e.*, St. Mary over the river).

SOUTHWELL, ROBERT (*c.* 1561–1595), English Jesuit and poet, son of Richard Southwell of Horsham St. Faith's, Norfolk, was born in 1560/61. He was educated at Douai and at Paris, joining the Society of Jesus. In 1584, an act was passed, forbidding any English-born subject of the Queen who had taken priest's orders in the Roman Catholic Church since her accession to remain in England longer than forty days on pain of death. But Southwell at his own request was sent to England in 1586 as a Jesuit missionary with Henry Garnett. He went from one Catholic family to another, administering the rites of his Church, and in 1589 became domestic chaplain to Ann Howard, whose husband, the first earl of Arundel, was in prison convicted of treason. It was to him that Southwell addressed his *Epistle of Comfort*. This and other of his religious tracts, *A Short Rule of Good Life, Triumphs over Death, Mary Magdalen's Tears* and a *Humble Supplication to Queen Elizabeth*, were widely circulated in manuscript. That they found favour outside Catholic circles is proved by Thomas Nashe's imitation of *Mary Magdalen's Tears* in *Christ's Tears over Jerusalem*.

After six years of successful labour Southwell was arrested (1592). He was imprisoned at first in Richard Topcliffe's house, where he was repeatedly put to the torture in the vain hope of extracting evidence about other priests. Transferred to the gatehouse at Westminster, he was so abominably treated that his father petitioned Elizabeth that he might either be brought to trial and put to death, if found guilty, or removed in any case from "that filthy hole." Southwell was then lodged in the Tower, but he was not brought to trial until Feb. 1595. Much of his poetry, none of which was published during his lifetime, was probably written in prison. On Feb. 20, 1595, he was tried before the court of King's Bench on the charge of treason, and was hanged at Tyburn on the 21st.

St. Peter's Complaint with other Poems, published anonymously in 1595, was reprinted thirteen times during the next forty years. A supplementary volume entitled *Maeoniae* appeared later in 1595, and *A Foure fould Meditation of the foure last things* in 1606. This, which is not included in Grosart's reprint (1872) in the Fuller Worthies Library, was published by Mr. Charles Edmonds in his *Isham Reprints* (1895). *A Hundred Meditations of the Love of God,* in prose, was first printed from a ms. at Stonyhurst College in 1873.

See Sidney Lee's account in the *Dict. Nat. Biog.;* Alexis Possoz, *Vie du Père R. Southwell* (1866); and a life in Henry Foley's *Records of the English Province of the Society of Jesus* (1877, i. 301–387). Foley's narrative includes copies of the most important documents connected with his trial, and gives full information of the sources.

SOUTHWELL (SUDWELLE, SUWELL, SUTHWELL), a cathedral city of Nottinghamshire, England, 16 m. N.E. of Nottingham on the L.M.S. Pop. (1921) 3,085. The foundation of the earliest church and possibly of the earliest settlement is attributed to Paulinus (7th century). Another church followed after the devastations of the Northmen, in 960, on the foundation of King Edgar. In 958 land at Southwell was granted to the archbishop of York by Edwy. A detailed description of the great manor is given in Domesday. The building of the present church began in the reign of Henry I. Southwell remained under the lordship of the see of York until it was taken over by the ecclesiastical commissioners. King Henry VIII., after the dissolution of the monasteries, contemplated the erection of the church into a cathedral. The cruciform cathedral is 306 ft. in length, with a Norman nave. The archbishops of York had a palace here dating from the 15th century. The "great chamber" was restored in 1882, and since 1904 the building has been converted into a residence for the bishops of Southwell. The episcopal see was founded in 1884. In 1927 the diocese was divided—a new see being established at Derby.

SOUTH-WEST AFRICA. A mandated territory in South Africa, formerly German South-West Africa. Its area is 312,194 sq.m., excluding the strip extending to the Zambezi, and known as the Caprivi Zipfel, which has been attached to the Bechuanaland Protectorate. The country extends from 17° S. to 28° 57′ S., and from the Atlantic ocean to 21° E. It is bounded on the north by Angola, on the east by the Bechuanaland Protectorate and the Cape Province of the Union of South Africa, on the south by the Cape Province, and on the west by the Atlantic ocean. The northern boundary follows the Kunene and Okavango rivers for a considerable distance.

Physical Features.—The greater part of South-West Africa forms part of the high plateau of South Africa, the general elevation being between 3,000 and 4,000 feet. The edge of the plateau is well defined in the north and south of the country, but is indefinite in the centre. The highest part of South-West Africa is about Windhoek, where the Khomas Hochland reaches up to 6,700 ft., the Onyati mountains attain a height of 7,198 ft., and the Auas mountains rise in their highest point, Molteblick, to 7,886 feet. Between the high plateau and the Atlantic is the Namib desert, which slopes regularly toward the sea, attaining its greatest width toward the south, and having an average width of about 60 miles. On the plateau, especially in the east and north, occur many shallow depressions, or pans, up to 2 m. across. In the wet season they may contain fresh, brackish, or salt water; in the winter the salt pans dry up and become encrusted with salt. The Etosha pan cannot, perhaps, be classified with these smaller occurrences. In the winter it, too, may be dry, but in the rainy season it is covered by a sheet of shallow water. Its extent is 1,355 sq. miles.

The climate is hot and dry. Along the coast the rainfall is about 1 in. per annum; inland, it increases from 6 in. in the south to 12 in. in the centre and 22 in. in the north. The low rainfall along the coast is partly explained by the cold Benguela current, which flows northward, and is responsible for much fog and comparatively low temperatures along the coastal lands. Except for the Kunene and Okavango rivers in the north, and the Orange in the south, there are no perennial streams. Fresh water can be obtained from shallow wells in the sandy beds of the intermittent streams.

Vegetation.—The Namib is almost devoid of vegetation near the coast, except for such plants as can exist, on account of the fogs, e.g., *Sarcocaula, Aloe dichotoma,* and the *Welwitschia mirabilis.* About 25 m. inland cacti and euphorbias appear, and in the river channels thorn trees (Acacia spp.) occur. On the plateau, in the south, semi-desert conditions prevail, low shrubs and scant grass being the chief plants, with trees along the river beds. The commonest plants here are *Salsola aphylla* (the Ganna bush), *Rhigozum trichotomum* (the three thorn bush), *Acacia giraffae* (Kameeldoorn), and species of aloes and euphorbias. Northward, as far as Rehoboth, karroo conditions are characteristic. Then a park-like grass country is reached, studded with thorn trees. From about Windhoek the country is covered with bush, mostly of thorn trees. Toward the north the bush becomes thicker, and includes belts of Mopane forest; about the Okavango the vegetation becomes richer and more tropical.

Population.—In 1921 the population included 177,462 Bantu, 30,845 other natives and coloured, and 19,432 Europeans. The latter had increased by 1926 to 24,115. Among the non-European inhabitants are Bushmen, Hottentots, Damara, Herero, Ovambo. (*See* separate articles.) For the accommodation of these people reserves have been set aside. The only towns with a European population of more than a thousand, in 1926, are Windhoek (3,809), which also has about 4,000 natives, and is the administrative capital; Luderitz (1,234), a small seaport; Keetmanshoop (1,159), the centre of a small mining industry, 180 m. E. of Luderitz Bay; and Swakopmund (1,125). The last will probably cease to grow, since shipping has been diverted to its young, but more conveniently situated rival, Walvis Bay (*q.v.*).

Occupations.—In the moister northern area, maize, potatoes, pumpkins and beans are grown, but the climate elsewhere is too dry for much agriculture. Farther south, along the Avob river are several good artesian wells, which offer opportunities for irrigation and the growth of wheat. In 1926 there were, in South-West Africa, 1,650 farms, with 12,351 morgen under crops, the area devoted to maize being 9,241 morgen. The country is more suitable for pastoralism. In the drier areas of the south and centre, sheep and goats are kept, while in the north, and in parts of the centre, cattle thrive. The following figures give the numbers of live stock in the country:—Cattle, 567,798; sheep, 1,174,958; goats, 967,720; donkeys, 45,363; horses, 16,160. In addition to these there were, in the native reserves, 53,566 large stock and 221,157 small stock.

The following minerals were exported in 1926:—Copper ore, 41,967 tons (£319,000), almost entirely from about Tsumeb; alluvial diamonds, 638,801 carats (£2,000,752); cassiterite, 198·9 tons (£39,500). Other minerals, such as iron, marble and gold, are believed to occur, but are not being exploited. The output of vanadium in the Grootfontein area is increasing.

Administration.—The administration of South-West Africa is vested in the Government of the Union of South Africa. The country, exclusive of Ovampoland, a native area, is divided into 17 magisterial divisions, under magistrates, who have administrative and judicial powers. At the head is the administrator, assisted by an executive of four other members, who are chosen by the Assembly from its own members. By the addition of these other members, chosen by the administrator and approved by the governor-general, the executive may become an advisory council. The Legislative Assembly, established, like the executive committee and the advisory council, in 1925, consists of 18 members, 12 being elected and six being appointed by the administrator, subject to the approval of the governor-general. It has powers to legislate on all matters, except such as are expressly reserved, *e.g.,* native affairs, railways, immigration, banking, etc. The Roman-Dutch law of the Cape Province is administered throughout the territory, together with ordinances, passed by the Legislative Assembly, and some portions of German law.

(R. U. S.)

RECONSTRUCTION

After the conquest of German South-West Africa in 1915 by the Union forces under Gen. Botha the conquered territory was placed under martial law. The German troops were interned and subsequently (in 1919) repatriated, together with some 600 "undesirables." German civilians were allowed to return to their homes and continue their ordinary business. They gave the authorities no serious trouble, partly because they believed in the ultimate victory of Germany in the World War. This was evidenced by the local banks and traders maintaining a rate of exchange of 24 marks to the £ sterling until Nov. 1918. When this artificial rate broke down serious losses followed. The Germans, however, continued to entertain false hopes and after the armistice they appealed to President Wilson for help on "self-determination" lines, saying that they wished to become an autonomous republic leagued to Germany. They got no satisfaction from Wilson and were told (Oct. 1919) by the governor-general of the Union, Lord Buxton, that the severance from Germany was irrevocable. But the Germans, numbering 8,000, still desired to live under the German Civil Code.

In 1923 Gen. Smuts, prime minister of the Union, in London, made an arrangement with Germany; and this arrangement was given legal sanction by an act of the Union parliament (Act 30 of 1924) and in the result out of 3,489 German adults only 261 refused to accept British nationality. At that time (1925) there were fully 10,000 non-German white settlers in the country, the majority South Africans.

The constitutional position was clear. By the Treaty of Versailles Germany ceded her colonies to the principal Allied and Associated Powers and the mandate for its administration was conferred on "his Britannic majesty for and on behalf of the Government of the Union of South Africa." By the terms of the mandate the country could be governed by the mandatory as if it were an integral part of its own territory. Martial law ended on Jan. 3, 1921.

The mandatory had undertaken to treat the Germans "as part of the people, with the same privileges and the same responsibilities as the others." By Act 42 of 1925 of the Union parliament a legislative assembly for South-West Africa was set up. The territory was divided into 12 constituencies, each electing one member. The franchise was confined to adult European males and the electors numbered some 6,500. Besides the elected members, six members were nominated by the Union Government. An executive committee of five members, under the chairmanship of the administrator, was elected by the assembly, which met first in June 1926. Its functions were severely limited; it had less power than the provincial councils in the Union, for it had no control of education. Nevertheless, it served a useful purpose. In 1928 the administrator was able to refer to the healthy financial state of the country, to the success of the land settlement schemes and to the increase of immigration and of trade. Arrangements were made (1928–29) for the settlement in the territory of some 300 Boer families living in southern Angola.

Native Affairs.—In general the natives accepted Union rule willingly. In 1917 it was found necessary to send a military force into Ovamboland, where German authority had been very slight. Excellent relations were established with the Ovambo. In 1922 the Bondelzwart Hottentots, irritated by certain regulations with regard to cattle-branding, taxes on dogs and other matters, rose in revolt. The rising was suppressed with considerable loss of life and in a manner which gave rise to justly adverse criticism. In 1925 the Bastaards or Rheoboths, a small Dutch-speaking sept with much white blood, who had a *raad* (parliament) of their own, claimed complete autonomy and defied the authorities. On this occasion much tact and patience were shown and the difficulty was overcome without bloodshed. For most of the tribes large reserves were provided, the chief trouble, in an arid country, being to secure them adequate water supplies. In the legislative assembly, one member of the administrative advisory council is charged with the care of native interests. Largely because of the native troubles an inquiry by the Permanent Mandates' Commission into the administration of the mandate was held in November, 1928.

Sir Howard Gorges governed the country in the martial law period; he was succeeded (Oct. 1920) by Gysbert Hofmeyr, after whom A. J. Werth became administrator (June 1925).

See the *Official Year Book of the Union of South Africa: No. 8* (Pretoria, 1927), and the annual reports to the League of Nations. *See* also MANDATE. (F. R. C.)

SOUTH-WEST AFRICA, CAMPAIGN IN. For some time before the year 1914 the proximity of the German Protectorate of South-west Africa, sharing a common frontier on its southern and eastern borders with the Union of South Africa, had been recognized by the Government of the latter country as an important factor in its military arrangements.

On Aug. 6, 1914, the Union Government undertook to assume all obligations resting upon the British regular garrison in South Africa, and on Aug. 10, to send a military expedition of its own against German South-west Africa. The British Government accepted both offers, and indicated the enemy seaports and the wireless installation in Windhoek as the first objectives. In September a mixed force under Brig.-Gen. Lukin was landed at Port Nolloth and disposed thence eastwards along the southern enemy border to Steinkopf, the line of observation being continued to Upington by another force under Lt.-Col. Maritz. The first Union troops to occupy enemy territory were those commanded by Col. Beves, which landed unopposed at Luderitz bay on Sept. 18. On Sept. 9 Maritz joined the Boer rebellion and deserted to the enemy. Though only 11,000 rebels took the field, 30,000 loyal troops acted against them and offensive action against the enemy was delayed for four months. A Union detachment with two guns was captured at Zandfontein on Sept. 26, a reverse due to Maritz. It was thus only on Feb. 11, 1915 that Botha took command at Swakopmund.

Disposition of Forces.—The position then was that the northern force (Gen. Botha) held Walvis bay and Swakopmund, facing the troops of the enemy chief command (Lt.-Col. Franke). The central force (Brig.-Gen. Sir D. McKenzie) occupied Luderitz bay with its forward troops at Tshaukaib, 40m. inland, in touch with the enemy on the railway line to Keetmanshoop. The southern force (Brig.-Gen. Van Deventer) watched the German force (Maj. Ritter) on the southern enemy border. The eastern force (Col. Berrangé), considerably smaller than the rest, was mobilizing for an advance along the Kuruman and Molopo rivers against the eastern border of the enemy, whose detachments here lay at Rietfontein and Hasuur. The Royal Navy conveyed, escorted and disembarked the whole of the forces and their supplies from the base at Cape Town.

The theatre of the campaign, 322,350sq.m. in area, is a plateau 3,500ft. above sea level. A waterless tract, 40 to 100m. broad on the coast side and 200m. inland, intervenes between the first rise to the plateau and the border. Water is scarce everywhere, and the water holes were well known and far apart. The railways were much damaged by the enemy, and the Union engineers repaired 1,040m. and laid 340m. of new line during the campaign. The enemy forces consisted of 2,000 soldiers and 140 officers, and in addition 7,000 male Europeans, many with military training. Of military material and equipment the German commander had abundance; he enjoyed throughout a substantial advantage in respect of artillery.

Botha's Campaign.—On Feb. 23, Gen. Botha moved from Swakopmund and secured Rössing on the railway line and Husab on the Swakop river. The river route was selected for the main advance, and on March 18, after careful and tedious preparations, Gen. Botha again advanced and heavily defeated the enemy at Riet and Pforte in the Swakop valley, capturing two guns and 284 prisoners. Sixty miles of the river route were now secured, and, after another period of preparation, a third advance was made on April 26 and Karibib occupied on May 5, after a series of rapid turning movements by mounted troops. The enemy withdrew to the north, and Windhoek was occupied on May 12.

The Auxiliary Movements.—Gen. Botha's infantry (Skinner) had meantime advanced along the railway and occupied Usakos. On March 30 the central force occupied Aus, and on April 26 at Gibeon, McKenzie's mounted troops, after rapid sustained marching, overtook and heavily attacked the enemy retiring from the south. The eastern force (Berrangé) left Kuruman on March 6 and joined hands with the southern force on April 20 at Kabus. The southern force (Gen. Smuts) defeated the enemy at Nabas on March 8 and at Kabus on April 20. The capital occupied, the southern area was conquered.

A conference between the Union commander and Gov. Seitz at Giftkuppe on May 21 proved abortive, and the final stage of the campaign against the enemy, now concentrated in the north, ensued. Gen. Botha advanced from Karibib on June 18. The main body (mounted troops and infantry) moved in the centre with the commander-in-chief, while strong mounted forces operated to the east and west, commanded respectively by Myburgh and Brits. The enemy retired rapidly, and on June 27 Brits was ordered to move widely to the north-west and head the enemy off at Namutoni, while Myburgh was to swing in on Tsumeb from the east. These movements were carried out exactly, and the enemy, defeated on July 1 at Otavi by the leading mounted brigade of the centre, forestalled at Namutoni, and having lost Tsumeb, surrendered on July 9, 1915.

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SOUTH-WESTERN ISLANDS or **SERWATTI ISLANDS,** the name of two chains of islands in the Banda sea, of the Malay Archipelago. Wetar, the largest island, is 70 m. by 20 miles.

Administratively the islands form part of the residency of Amboyna. The estimated population of all the islands is about 40,000, Wetar, which is uncivilized, having 7,500. Kisar has as settlers the descendants of European soldiers of the time of the old Dutch East India Company.

SOUZA-BOTELHO, ADÉLAIDE FILLEUL, MARQUISE DE (1761–1836), French writer, was born in Paris on May 14, 1761. Her mother, Marie Irène Catherine de Buisson, daughter of the seigneur of Longpré, near Falaise, married a bourgeois of that town named Filleul. It was reported, though no proof is forthcoming, that Mme. Filleul had been the mistress of Louis XV. Her husband became one of the king's secretaries, and Mme. Filleul made many friends, among them Marmontel. Their eldest daughter, Julie, married the marquis de Marigny (1727–1781); Adélaide married in 1779 Alexandre de Flahaut de la Billarderie, comte de Flahaut, who was many years her senior. In Paris she soon gathered round her a salon, in which the principal figure was Talleyrand. There are many allusions to their liaison in the diary of Gouverneur Morris. In 1785 was born her son Auguste Charles Joseph de Flahaut (*q.v.*), who was generally known to be Talleyrand's son. Mme. de Flahaut fled from Paris in 1792 and joined the society of *émigrés* at Mickleham, Surrey, described in Mme. d'Arblay's *Memoirs.* Her husband remained at Boulogne, where he was arrested on Jan. 29, 1793, and guillotined. Mme. de Flahaut now supported herself by writing novels, of which the first, *Adèle de Sénange* (London, 1794), which is partly autobiographical, was the most famous. She presently left London for Switzerland, where she met Louis Philippe, duke of Orleans. She travelled in his company to Hamburg, where she lived for two years, earning her living as a milliner. She returned to Paris in 1798, and in 1802 she married José Maria de Souza-Botelho Mourão e Vasconcellos (1758–1825), Portuguese minister plenipotentiary in Paris. Mme. de Souza lost her social power after the fall of the First Empire. She died on

April 19, 1836. She brought up her grandson, Charles, duc de Morny, her son's natural son by Queen Hortense.

SOVA, ANTONIN (1864–), Czech poet, began his literary career early in the '90s with verse, describing Prague and his native region of Southern Bohemia. His introspective poems, in *Lyrics of Love and Life, Mastered Sorrows* and *Once Again Shall We Return,* include good lyrics, and he has been compared with Verlaine. Disillusionment drove him to seek escape in visionary poems which reveal symbolism. In 1913 appeared *Harvests,* a volume in which reconciliation predominates. The later poems are written with the crystalline simplicity of folk songs, and in some Sova is the spokesmen of Czech aspirations. He also wrote novels and short stories.

SOVEREIGN: *see* Pound.

SOVEREIGNTY. While society is in a rude state or only tribally organized there is no distinct sovereignty, no power which all persons habitually obey. Thus there is no sovereignty among wandering groups of Australian savages: each family is isolated, each horde is a loose and unstable collection. When the horde has become a tribe there may exist no definite sovereign. Distinct in time of war, the power of the chief may be fluctuating and faint in time of peace; even in time of war it may be subject to the authority of a council. Tribes of the same ethnic stock may form a sort of federation, permanent or temporary. "With the council of the confederacy," it has been said, "and, more generally, in the confederacy, sovereignty arises and the true political tradition is evolved" (F. H. Giddings, *Principles of Sociology,* p. 285). When the city and the State are conterminous the seat of sovereignty becomes defined. Such was the condition of things in Greece, as considered by Aristotle in his *Politics.* He discusses the question what is the supreme power in the State (3. 10), which he defines as an aggregate of citizens (3. i.), and he recognizes that it may be lodged in one, a few, or many. In his view the distinctive mark of the State is not so much sovereignty (7. 4) as self-sufficiency; a State is not a mere aggregate of persons; it is a union of them sufficient for the purposes of life (7. 8). The early Roman jurists speak little of sovereignty. But later, with the belief in the existence of an empire entitled to universal sway, an absolutist theory of sovereignty was developed in the writings of jurists.

Among the theories prevalent in the middle ages was one that mankind formed a unity, with the pope and the emperor at the head of it: the universal church and the universal emperor ruled the world. (Rehm, *Geschichte der Rechtswissenschaft,* p. 198). When the power of the emperor was weakened, and the idea of a universal ruler was gone, a new test of sovereignty was applied —that of external independence; the true sovereign States were *universitates superiorem non recognoscentes.* There were times and countries in the middle ages in which the collective power of the community was small: many of the great corporations were virtually autonomous; the central authority was weak; the matters as to which it could count upon universal obedience were few. In such circumstances the conception of sovereignty was imperfect. The modern theory is first clearly stated in Jean Bodin's book *On the Commonwealth* (French ed., 1576; Latin version, 1586). He writes thus: "Respublica est familiarum rerumque inter ipsas communium, summa potestate ac ratione moderata multitudo." His theory, which corresponded to the France of Louis XI., was a theory of despotism.

One favourite theory was that sovereignty originated in a social contract. Hobbes, in his *Leviathan* expounded his notion of an agreement by which absolute power was irrevocably transferred to the ruler. Rousseau assumes his famous *pacte social,* the terms of which are: "Chacun de nous met en commun sa personne et toute sa puissance sous la suprême direction de la volonté générale; et nous reçevons encore chaque membre comme partie indivisible de tout" (*Du Contrat social,* 1. c. 6).

Among the different senses in which "sovereign" has been used are the following:—

a. "Sovereign" may be titular—the king in Great Britain.

b. The legal sovereign: the person or persons who, according to the law of the land, legislate or administer the government.

c. The political or constitutional sovereign: the body of persons in whom the actual power at any moment or ultimately resides. Sometimes this is designated "the collective sovereignty."

d. Sovereignty is also used in a wider sense, as the equivalent of the power of the whole nation or society (Gierke, 3. 568).

The distinction between real and nominal sovereignty was familiar to mediaeval writers, who recognized a double sovereignty, and distinguished between (1) the real or practical sovereignty resident in the people, and (2) the personal sovereignty of the ruler (Adolf Dock, *Der Souveranitätsbegriff,* etc., p. 13).

Sometimes sovereignty is defined as the organized or general will of the community. "Sovereignty resides in the community" (Woodrow Wilson).

This was the belief in the French Revolution. "Sachez que vous êtes rois et plus des rois," said a revolutionary orator cited by Taine. It was the language of the founders of the American constitution and contemporary political writers.

The same theory assumes a more subtle form, especially in the writings of Hegelians. Sovereignty is with them a term descriptive of the real will of the community, which is not necessarily that of the majority.

Sovereignty is used in a further sense when Plato and Aristotle speak of the sovereignty of the laws (*Laws,* 4. 715; *Politics,* 4. 4; 3. 15). Thus Plato remarks: "I see that the State in which the law is above the rulers, and the rulers are the inferiors of the law, has salvation." (*See* also Gierke, *Genossenschaftsrecht,* 3. 8.) Even in mediaeval writers, such as Bracton, is found the notion that the king is subject to the laws (J. N. Figgis, *The Divine Right of Kings,* p. 13). We find the same expressed by many German jurists (Gierke iii., x.). In *Der Souveranitätsbegriff im Bodin,* etc., by Adolf Dock [1897] p. 6, and in *La Conception juridique de l'état,* by Combothecra, p. 90. There are many definitions—some ideal—of sovereignty.

Half Sovereign States.—The phrase *half sovereign States* was invented by J. J. Moser to describe States possessing some of the attributes of sovereignty. Under this class are grouped very diverse communities.

Feudalism had terms to express the varieties of fiefs which existed under it; modern international law has no generally-accepted terminology for the still greater variety of States which now exist. These varieties tend to multiply, and it is difficult to reduce them all to a few types. The theory that States are equal, and possess all the attributes of sovereignty, was never true. It is still more at variance with the facts in these days when a few great States predominate, and when the contact of western States with African and Asiatic States or communities gives rise to relations of dependence falling short of conquest. We have:

1. States which have complete independence, complete autonomy, external and internal, and which are recognized in international law as sovereign States.

2. States which have complete external independence, but are more or less subject permanently to other States as to their internal affairs. Of this class there are now few examples.

3. States which enjoy complete autonomy as to internal affairs, but which are more or less subject to other States as to foreign relations. These are some examples:—

a. Protectorates and Suzerainties (*q.v.*).

b. The unions between a superior and inferior State, *e.g.,* the relations of the various States to the old Holy Roman empire; the relations of the Ottoman Porte to its Christian provinces. In the middle ages the question was often mooted whether States subject to feudal superiors, or the States forming the empire, were sovereign. Grotius (1. 1. ch. 3, 23. 2), holds that the *nexus feudalis* is consistent with *summum imperium.*

4. States which have, by treaty or otherwise, parted with some portion of their sovereignty and formed new political units: what Herbert Spencer calls "compound political heads." For years one of the burning questions in the politics of the United States was the question whether the individual States of the Union remained sovereign.

5. Another division includes anomalous cases, such as Egypt, in which one Government administers a country as to which another State retains certain powers.

6. The territories governed or administered by chartered companies form a class by themselves. Nominally such companies are the delegates of some States; in reality they act as if they were true sovereigns.

7. Two other classes may be mentioned: (*a*) cases of real union between States, as formerly between Austria and Hungary; (*b*) personal unions, distinguished from the above-named forms—*e.g.*, the union of Great Britain and Hanover.

8. A small group consists of instances of *condominium* or arrangements similar thereto; *e.g.*, the arrangements as to the Samoa islands from 1889 to 1899.

According to modern usage the appellation "sovereign State" belongs only to States of considerable size and population exercising without control the usual powers of a State, *e.g.*, able to declare peace or war.

Colonies.—It is sometimes suggested that self-governing colonies are to be regarded as true States. Undoubtedly some of them can no longer be regarded as colonies in the old sense. The self-governing colonies forming part of the "multicellular British State," as F. W. Maitland describes it (*Political Theories of the Middle Ages*, p. x.), have an essentially "state-like character." If Liberia is a State, the same may surely be said of Canada.

With the creation of the League of Nations, however, the theory of sovereignty has become still more academic and impracticable. India and the Dominions are equal members with Great Britain of the League. As a member of the League the sovereignty of Great Britain is limited to the same extent as that of Ireland or any other member. And there are at least a dozen States in Europe members of the League, which enjoy, both in fact and in law, less independence than the dominions. The old distinction between sovereign and non-sovereign States has ceased to exist. A sovereign State is now obsolete. Even the United States is not absolutely sovereign. There is no State more rigorously bound by treaties. Nevertheless a new life has been given to the doctrine by the appeal of the succession States in central Europe to the League in their attempts to coerce their minorities to respect their sovereignty. The only valid sovereignty is that of the rule of law.

Many attempts have been made to enumerate the attributes of sovereignty, *i.e.*, the regalia, prerogatives, etc., as they were called. For example, Bodin gives a list of the properties of *majestas* or sovereignty: (*a*) "Legem universis, etc., singulis civibus dare posse; (*b*) bellum indicere aut pacem inire; (*c*) to appoint and change magistrates; (*d*) power of final appeal; (*e*) power of pardon; (*f*) raising revenue; (*g*) coining money" (*De republica*, vol. i. ch. 10). Bluntschli (*Allgemeine Staatslehre*, i. 575) enumerates these attributes: (*a*) right of recognition of *majestas;* (*b*) independence; (*c*) power to determine constitution; (*d*) right of legislation; (*e*) action through deposed organs; (*f*) irresponsibility. These enumerations are open to the objection that they merely describe the action of the State at a particular time or indicate a theory of what an ideal State should be. *See* PROTECTORATE, SPHERES OF INFLUENCE, STATE, SUZERAINTY.

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(J. MAC.; X.)

SOVIET BANKING SYSTEM. The banking system of the U.S.S.R. was introduced with the establishment of the State Bank of the U.S.S.R., which commenced operations on November 16th, 1921. It was for a time the only bank in the Union. The reason for this was, that the civil war, the Decree of December 14th (27th), 1917, for the nationalisation of the banks, the curtailment of the money system and the exchange of commodities on a money basis, caused the old credit system to disappear.

When the civil war came to an end in 1921, and the so-called "New Economic Policy" was introduced,—which, among other things, implied the restoration of the money system and the exchange of commodities on a money basis,—the Soviet Government realised the necessity for having a banking system in the country. It commenced by establishing the State Bank for the operations of which, funds, in the form of the paper currency in circulation at the time, were allocated from the Treasury. Soon, other credit institutions, mostly State, municipal and co-operative, began to spring up and by the middle of 1928 a number of banks of different types were in being.

Of these types of banks the principal are:

(a). Long term credit banks, in which are included: The Industrial and Electrical Long Term Credit Bank of the U.S.S.R., known as the "Prombank,"—the function of which is to accumulate funds for providing long term credits for the purpose of enlarging existing and erecting new factories and works for industry and electrification; the Central Municipal and Housing Bank of the U.S.S.R., known as the "Tsekombank,"—the function of which is to finance house building in towns and the development of municipal enterprises; and finally, the Central Agricultural Bank,—the function of which is to provide credits for agriculture.

(b). Municipal Banks, operating with funds provided mostly out of local budgets. Their function is to finance local industries, local housing and municipal enterprises. On July 1st, 1928, 116 such banks (incl. branches) were in operation.

(c). Co-operative Credit Banks, like the "Vsekobank," the "Ukrainbank" and several other banks, which provide credits for the various types of co-operative enterprises.

Counting the branches of the State Bank, and the rural banks connected with the Central Agricultural Bank, the total number of credit institutions in the U.S.S.R. on July 1st, 1928, may be put at 1,291. (In this are not included Agricultural Credit unions numbering 47 on the said date, and the smallest rural banks—so-called Agricultural Credit Societies, numbering about 9,000.) In addition, there are in the U.S.S.R. 15,138 savings banks, which take deposits, but engage in no active transactions.

The predominant rôle in the Soviet Banking system is played by the State Bank. A year after it was established, the Government granted the Bank power to issue its own chervonetz notes. In issuing these notes the State Bank took measures for the improvement of the circulation of currency. Chervontsi began to be issued towards the end of 1922.

By the end of 1924, the last of the depreciated Soviet roubles were withdrawn, and the depreciation of the currency, that had been going on for several years, was stopped.

The State Bank issues bank-notes—chervontsi—in accordance with the Act of October 11, 1922. This Act provides for the issue of chervontsi in denominations of: 1, 2, 3, 5, 10, 25 and 50 chervontsi. (1 chervonetz is equal to the previous, Russian gold, ten rouble piece, *i.e.*, 7·74234 grammes of fine gold.) The State Bank notes have a backing of precious metals and stable foreign exchange to an amount of not less than 25% of the issue.

Simultaneously with the State Bank notes, other currency is in circulation, viz., Treasury notes, in denominations, expressed in gold roubles, of 5 roubles, 3 roubles and one rouble, and also silver, copper and bronze coins, in denominations of one rouble and less. The Treasury notes and coins are not issued by the State Bank, but by the Commissariat for Finance; they are actually put into circulation, however, through the State Bank.

The total amount of money in circulation on July 1st, 1928, was 1,701·1 million roubles, of which, State Bank notes amounted to 1,019·4 million roubles; Treasury Notes 494·0 million roubles, and coins, 187·7 million roubles.

The State Bank with its 622 branches negotiated loans and discounts as follows:

	(In millions of roubles)	
	All Banks	*State Bank*
1-10-1925	2,921.3	1,643.9
1-10-1926	4,066.2	2,071.1
1-10-1927	6,103.3	2,982.2
1- 7-1928	7,698.3	3,262.5

On July 1st, 1928, the State Bank advanced credits to various enterprises, in the form of loans and discounts, amounting to 3,262·5 million roubles, which represents 42·4% of the total sum advanced in similar transactions by all the banks combined.

In addition to fulfilling the functions of a bank of issue, regulating the circulation of money, and of the principal short term credit bank, the State Bank at the same time acts as the chief cashier of the Treasury, and all business connected with the State budget, in Moscow and in the provinces, is transacted through it. As a consequence, the State Bank always has available considerable sums standing to the account of the Treasury. These sums of money, its note emissions, the current accounts and deposits of other persons and institutions, and the capital of the Bank, comprise the main liabilities of the State Bank.

On July 1st, 1928 the liabilities of the State Bank were made up as follows: Capital, 365·4 million roubles; bank-notes issued, 1,046·1 million roubles; current accounts and deposits, 1,251·0 million roubles.

A part of the resources thus accumulated, the Bank places to its fund for covering bank-note issues and part is invested in securities. The greater part of these resources, however, is invested in loans and discounts. The principal clients of the State Bank who apply to it for credits are: the State trusts—in whose hands are concentrated the principal industrial enterprises of the country, such as, the coal mines, oil fields, metallurgical works, sugar, leather and textile mills, etc.; the syndicates—mainly the trading enterprises, which supply the above mentioned enterprises with raw materials and market their products; the railways; the various types of co-operative unions, and other banks. The financing of foreign trade—both imports and exports—also represents an important part of the operations of the State Bank.

The interest charged by the State Bank ranges from 8 to 10 per cent per annum. Operations are conducted in the usual form of discounting bills; opening of special current accounts against the security of bills or goods; granting fixed term loans on goods, and issuing of letters of credit against goods in pledge. A relatively small proportion of the credits are advanced in the form of loans for special purposes, *i.e.*, loans on promissory notes, usually with some additional security.

See S. S. Katzenellenbaum, *Russian Currency and Banking, 1914–24* (1925); *Soviet Union Year Book*, 1928, compiled and edited by A. H. Santalov and L. Segal. (S. S. K.)

SOVIET SYSTEM. The Soviet system was not the fruit of speculation upon the theory of representation and government. It had its origin in the daily needs of a revolutionary struggle. It was evolved to fit the political tactics of a subtle realist. It survived because it was well adapted to the requirements of the working-class dictatorship which Lenin established in Russia. Its idea has, none the less, something in common with the theoretical views held before the World War by Sorel in France, and by the Guild Socialists in England. The same tendency reappears in the Constitution of Fascist Italy. All of these systems depart from Western Democracy by grouping citizens on a functional rather than a territorial basis. Not passive residence in a given area, but the active performance of socially useful work constitutes the qualification of an elector.

The word soviet means council. In their original form, the Russian soviets were simply committees of strikers. During the general strike of 1905 an organization suited to the momentary need had to be rapidly improvised. Each factory or workshop in Moscow and Petrograd constituted a natural unit. Its workers knew each other, possessed common interests and a mass consciousness, and could easily pick leaders and representatives. Each factory chose delegates in a rough ratio to the number of its employees, and these met in a soviet which sat in permanence, and directed the strike. The revolution of 1917 repeated the same tactics, and revived the old mechanism. The Soviets, however, survived the strike, and assumed the task of controlling the weak Provisional Governments, which followed each other from March to November. They spread to the army, where each battalion chose its soviet of soldiers. They were imitated in the villages. As they spread over Russia, it was natural to link them up in congresses, which could speak for the masses of the population, workers, soldiers and peasants. It was not for any theoretical reason that Lenin preferred them to the democratic Constituent Assembly, as the organ of government after his *coup d'état.* He had a majority in the soviets, whereas his chief rivals, the Social Revolutionaries, dominated the Assembly. History had thrown up a tool admirably suited to the purposes of a working-class dictatorship. A soviet represented only the workers and peasants: the old ruling class could not influence it, or enter it. It could be elected, recalled or re-elected, with ease and without formalities, so that in a time of rapid change, it reflected the mood of the moment. What was, at the start, a method of organizing a class for a sharp political struggle, became after the *coup d'état* a machine for governing Russia.

The limitations of the soviet franchise follow inevitably from the root idea of the revolution. The purpose of the soviets is not to elicit the general will of the whole population. That for a Communist is an absurdity. One might as well talk, as Bukharin has put it, of a general will common to sheep and wolves. The purpose of the soviets is to express the will of the workers in their struggle with the *bourgeoisie.* They are councils of war, and naturally one does not permit the enemy to elect them. Every adult of either sex is a voter, from 18 years of age, with the exception of those disqualified as *bourgeois.* These latter include all employers of labour (other than domestic servants and apprentices), all who live by "speculation" (meaning private trade), or by rent or interest, certain classes identified with the old *régime* (notably priests and members of the Tsarist police), together with criminals and the insane. Brain workers (doctors, teachers, etc.) are grouped by their professions, and vote on the same terms as manual workers. Housewives are recognized as a working group, and vote in the towns in regional units. The exclusions, important in the early days of the revolution, are no longer of much consequence. About 5% of the adult population is disfranchised in the towns, and less than 1% in the villages.

The number of workers in each unit (factory, professional group, or village) determines the number of delegates to be elected. But a deliberate disparity exists between urban workers and peasants. The former were the more reliable fighting element in the class struggle. One urban *elector* has, in the higher soviets, five times the voting power of each *inhabitant* of a village. Actually the advantage is as three to one.

Only the soviets at the base of the system, those of the town and village, are directly elected. Village soviets are grouped to elect the soviet of the *volost* (parish), while the *volost* soviets elect that of the *uyézd* (county). The important unit is, as in the old days, the Gubernia (Government), and its soviet, or congress of soviets, is chosen by the soviets of the towns and *volosts* in its area. The sovereign body in each of the republics which form the Soviet Union, is a Congress of Soviets, chosen by the soviets of the "Governments" and larger cities. The Union Congress in the same way represents the congresses of the component republics. The national and federal congresses are big, unwieldy bodies (in the case of the Union including 1,500 members) which meet only once a year for about ten days. The real legislative body is a central executive committee, which meets at least three times a year. The chief power, that is to say, resides in a body chosen indirectly at six removes from the electorate. The will of the proletariat passes through a highly elaborate sieve.

After 11 years, the revolution is in process, perpetually on the alert against its foes at home and abroad; there is no relaxation of the dictatorship first proclaimed in Nov. 1917. For two or three years after that date certain Socialist parties, other than the ruling Communist Party, were tolerated (the Left Revolutionary Socialists and the Mensheviki or Minority Social Democrats), but even these have now ceased to exist as legal groups. The Communist Party is to-day, and for long has been, the only organized political group. It alone enjoys the right of meeting; it alone may use the printing press, the wireless and the cinema; it alone may present its lists of candidates at elections. Even within this party, though informal groups exist and differences of opinion are freely debated at conferences and in the press, any organization of sectional tendencies is regarded as disloyal.

The case only becomes worse when one takes into account the tight discipline of this party, a survival from the days when it lived underground as a secret organization. It could survive only by cultivating the austerer virtues, by claiming from its adherents a devotion which over-rode all ties of business or family, and by imposing monastic vows of poverty and obedience. Even to-day no member may draw more than a fixed maximum income, which in Moscow is limited to 225 roubles per month (about $112 or about £25). Entry to this party is hedged by rigid tests of character and orthodoxy; the conduct of the novice is scrutinized during a period of probation; expulsions, and even wholesale purges, on account of lack of zeal or heretical opinions, occur frequently. This party has always possessed, and still nominally possesses, the democratic organization usual in all Socialist parties. It elects its officers and governing committees, and decides its policy at representative conferences. But, especially since the death of Lenin, its central machine, under the control of its secretary, Stalin, has attained an overgrown authority; it may even seek to nominate the officials of local branches, and to control the voting at conferences by the admission and expulsion of members.

The institution of the dictatorship means, primarily, that all important decisions of policy are made by the Communist Party, and especially by its standing political committee ("Politburo"). The soviets, even those at the apex of the system, do little more than register the previous decisions of the governing party. There may be a hot and prolonged debate within the party over each new departure of policy, accompanied by frank polemics in the press. But when once the final vote is taken at a party congress, it becomes binding upon every member of the party. A defeated minority must sit silent, when the same topic comes before a soviet. This system eliminates from the soviet apparatus any possibility of an organized opposition. There are, indeed, in every soviet a number of non-party deputies, who even form the majority in the village soviets, and about half the membership of the *volost* and *uyezd soviets*. But they possess no organization, and do not challenge the established principles of the Communist *régime*.

Russians have eliminated most of the issues which in other countries form the material of politics. There is no standing clericalist controversy, as in France, no dispute over the limits of *laissez-faire*, as in Great Britain, no division over high and low tariffs, as in the United States. Politics in Russia, apart from foreign questions, mean the supervision of the socialized industries, the measures to be taken for the development of agriculture, the accumulation of a surplus for the purchase of machinery abroad, the promotion of public health and education, and, above all, the tactics best adapted to neutralize the indifference of the peasants towards the purposes of a Socialist State. If a soviet was, in its origins, a council of officers conducting the class-war, it is to-day a board meeting of the directors of a complicated industrial apparatus.

The characteristic franchise on which the soviets rest is not in fact, their chief distinction. They differ from other representative bodies mainly in this, that no sharp distinction exists between legislative, administrative and judicial functions. There is no covenanted civil service, though every soviet engages its clerks and even its experts. Nor is there any independent judiciary: judges are named by the soviets, and the appointments are frankly political. Every soviet, whether national or municipal, groups itself, after each annual election, into standing sub-committees, each entrusted with some branch of the administration. Each member specializes, and finds congenial work in inspecting and supervising the work of schools, hospitals and other public institutions, or in watching the administration of the Labour Code. In a country which had only the most meagre tradition of self-government, the soviets have performed an inestimable service by educating large numbers of the working-class in the details of public administration. Of recent years it has been the policy of the Communist Party to favour the election each year of as large a number as possible of new members of the soviets, in order to spread this experience widely, and to win intelligent support for its work. Its watchword is now "to broaden the base of the dictatorship."

A soviet election involves the minimum of public controversy. The Communist Party will issue a manifesto outlining the results of the past year's work and its plans for the future. But there can be no reply from any organized opposition. Old members who are standing again publish in the newspaper of the factory an account of their personal work and achievements. In each factory preliminary group meetings are held, at which the candidates are questioned. Finally the elected works council of the factory draws up an official list of candidates. This is submitted to a general meeting of all the employees of the concern. Alternate nominations are invited, as a matter of form, but are rarely, if ever, forthcoming. After some platform oratory, while the band plays the *Internationale*, the list is adopted *en bloc* by a show of hands. The procedure has only the most distant resemblance to an election as democratic countries understand that word: it is, in fact, an organized demonstration of unanimity. The list will always be one acceptable to the local Communist Party, though it will always include a large proportion of non-members.

Unofficial opinion finds some little expression in proposing resolutions at these election meetings, which, if carried, become the mandates of the deputies. In the villages there is often a sharp contest, in which the richer peasants oppose the poorer and "middle" peasants, who are more disposed to accept Communism.

The vast territory which the world knows as Russia (the component republics are: the Russian Federation, Transcaucasia, Ukraine, White Russia, Uzbekistan and Turkmenistan; the two first of these are themselves federations) is governed under a Federal Constitution, which admits the right to secede. It would be unworkable, were it not that one tightly-disciplined party exists, which prescribes general principles, checks any tendency to particularism, and settles the controversies over jurisdiction to which the loosely-drafted Constitution often gives rise. The Communist Party supplies the place of a ruling race, or of the trained bureaucracy of the old *régime*, and is the cement which holds together Great Russians and Little Russians, Tatars, Georgians and Turcomans, Christians, Jews and Muslims. In its distribution of powers the Soviet Union is the most highly centralized federation in the world. But in its attitude towards the many languages and cultures of its territory, it has shown an admirable liberality. Wherever a non-Russian race occupied a compact area, an autonomous republic or territory was created. This was done not only for peoples of equal culture, like the Ukrainians or the Germans of the Volga, but also for depressed races like the Tatars and the Bashkirs, who possessed neither schools nor a vernacular literature before the Revolution. To such races the new era has brought, for the first time, complete equality with the Great Russians, and ample opportunity for the development of their native culture and language. But every racial minority, *e.g.*, a Polish or Jewish village in White Russian or Ukrainian territory, enjoys the full right to use its own language in its schools.

The Union of Socialist Soviet Republics deliberately erased the word "Russian" from its official title because it is regarded as a

Socialist League of Nations, the nucleus of a world-wide federation. To the Union are reserved five departments: (1) foreign affairs, (2) defence, (3) foreign trade, (4) transport, (5) posts and telegraphs. Next come five departments over which the Union exercises control, and lays down general principles, while it leaves to the component republics the detailed administration and some initiative in legislation. These are (1) labour, (2) finance, (3) workers' and peasants' inspection (a department of audit), (4) internal trade, and (5) the Supreme Council of Public Economy. Finally, there are six departments in which the Republics enjoy complete autonomy: (1) agriculture, (2) home affairs, (3) justice, (4) education, (5) health, (6) social welfare.

The administration of each of these departments, alike in the Union and in the Republics, is placed under a "Commissariat," which differs little from the Western conception of a Ministry. The commissar is, however, usually the chairman of a small board, or "collegium," which meets daily and takes its decisions in common. The Council of Commissars acts as a cabinet, and has, in the intervals between the sittings of the executive of the Congress of Soviets, the right to issue emergency decrees and legislation. Of these commissariats the most important in a socialized State is, of course, the Supreme Council of Public Economy, which coordinates the relations of the productive "trusts" (*i.e.*, the nationalized industries), the distributive "syndicates" (which sell their product), fixes the level of prices, and, in the last resort, determines what proportion of the profit shall be set aside as new capital, and what proportion shall be assigned to raise wages. But the most characteristic institution is the central planning department (Gosplan) which collects statistics, estimates output, and works out schemes for the expansion of industry, the exploitation of raw materials, and the development of electric power.

Lastly, it should be explained that the sovereign body of the Union, which must finally pass or ratify legislation, is a two-chambered institution. On the Council of Nationalities, in effect a Senate, each autonomous republic and territory has a single representative, and little Tatary counts for as much as Great Russia. It deals with the cultural rights of the nationalities. To the other chamber, known as the Central Executive Committee, the cabinet (Council of Commissars) is responsible, and is elected by it. The assent of both chambers is theoretically required for legislation. No provision exists for conflicts between them, since both are equally emanations of the ruling Communist Party.

It is not easy to determine how much this soviet system, regarded as a constitutional experiment, contributes to the stability of the Communist *régime*. It rests on the support of the urban working-class, which feels itself the privileged ruler of the State. It has, that is to say, the assent of that part of the population which is strategically important, for the industrial area is the centre of Russia, and of its network of communications.

The peasants are, passively acquiescent, preferring Communist rule to any visible alternative, since it has given them the land. Though real wages are low (with an index figure of 50 as against 100 in London and 40 in Warsaw) and housing conditions bad, the workers unquestionably have the sense that their whole environment is ordered for their good. No privileged class stands above them. Every career, including the professions and the officers' corps of the Red army, stands wide open to them. The entire educational system is devised for their benefit. The clubs, schools, crêches and playing fields grouped round every factory, offer them an active social life, which they themselves direct. Of all this the soviets are the natural political expression. They are based on the factory itself. The immense majority in every soviet, and even in their executive committees, is composed of manual workers.

The indirect method by which the higher soviets are chosen is, on the other hand, open to grave criticism. It would give the rank-and-file of the electorate only a weak and diluted influence over the larger issues of public policy, even if elections were free. As things stand to-day, the only guarantee that the will, even of the urban masses, shall prevail, lies in the anxiety of the Communist Party to keep their support. Though it retains its dictatorship, its attitude has perceptibly changed since the early years. It has its ear to the ground. It talks of itself as the mouthpiece of the masses. It has developed an elaborate system by which it receives a continuous stream of reports from every factory and village in Russia, on the trend of popular opinion, on grievances large and small, and on the defects of legislative drafts under the consideration of the soviets. The absence of individual liberty and civil rights is not resented by the workers, as it would be in the West, partly because Russia has had no experience of freedom, and partly because the dictatorship is exercised by workers for the workers' benefit. The gravest evil of the actual system—that it tolerates no opposition, and permits the criticism only of persons and of details—is inherent rather in the Communist dictatorship than in the soviet idea. That idea undoubtedly appeals to Russians as a native growth, a product of their own experience and history. Its obvious merits, in the first stages of election, are patent to the simplest citizen. Its graver defects, in the later stages, do not come under his observation. He accepts it as a racy and original form of democracy, while only the "intelligentsia" has the knowledge to contrast it with Western practice and theory. (H. N. Br.)

Bibliography.—An ample technical literature in the Russian language expounds the rapidly developing Soviet constitution. For the non-Russian reader, the clearest and frankest statement of the ideas that underlie it is Bukharin's *ABC of Communism*. A useful account of its provisions in its earlier phase is Andrew Rothstein's *The Soviet Constitution*. *How the Soviets Work* (Vanguard Press) by H. N. Brailsford is an attempt to describe the working of the system.

SOVIET TRADE ORGANIZATIONS. The control and conduct of the foreign trade of the U.S.S.R. are carried out by *Narcomtorg* (the People's Commissariat for Trade) and its local branches. Trade Delegations have been set up in all countries with which the U.S.S.R. has diplomatic relations.

The entire foreign trade of the Soviet Union as regards the quantity and quality of goods to be exported or imported is regulated by the plans drawn up for each year by *Narcomtorg*, and which are ratified by the Council for Labour and Defence in consonance with the State Planning Commission. *Narcomtorg* and the Trade Delegations abroad supervise and control purchases and sales from the point of view of the legality of the transactions, their commercial advantage, and their concordance with the foreign trade policy of the Government and the export-import plan laid down.

Anglo-Soviet Trade.—The trading relations between Great Britain and the U.S.S.R., which had broken down during the war, revolution and blockade, began gradually to be restored in 1920, after the decision of the Inter-Allied Supreme Council at Paris on January 16th, 1920, to raise the blockade against Soviet Russia. The actual resumption of trade dates from June 1920, and the first organization to carry out such trade was Arcos, Ltd., established in 1920. A trade agreement was concluded between Great Britain and the U.S.S.R. on March 16th, 1921, which was terminated by the British Government in May 1927.

The foreign trade of the U.S.S.R. being a State monopoly can be conducted only by organizations specially authorized to perform export and import operations. The organizations conducting the foreign trade of the U.S.S.R. in Great Britain are registered under and subject to British jurisdiction.

According to the functions performed by the different organizations, they can be classed in the following groups: (1) trading organizations; (2) merchant shipping organizations; (3) insurance organizations; (4) banks; (5) representatives of various trading and industrial organizations of the U.S.S.R.

The trading organizations also fall into the three following groups:

(A) Limited liability companies with Soviet capital;
(B) Mixed companies with Soviet and foreign capital;
(C) Co-operative organizations with Soviet capital.

To group (A) belong: (a) Arcos, Ltd., purchasing and selling agency for the principal exporting and importing organizations in the U.S.S.R. Paid-up capital £900,000. (b) Russian Oil Products, Ltd., sole agents for Great Britain and Ireland of the Naphtha Syndicate of the U.S.S.R. Paid-up capital £100,000. (c) White Sea Timber Trust, Ltd. (paid-up capital £100,000), Russhollandless, Ltd. (share capital £150,000), and Russangloless, Ltd. (share capital £150,000), agents for the sale in Great Britain of Russian timber and timber products. (d) Kniga (England), Ltd., exporters from Great Britain of books, periodicals, stationery, etc. Share capital £3,000 (fully paid). (g) Mosekust (Russian Handicrafts), Ltd., importers of Russian lace, carpets, ivory, toys, china, etc. Share capital £100.

To the group (B) belong: (a) The Russo-British Grain Export Co., Ltd., sole selling agents in Great Britain and Ireland for the Corn Export Company, *Exportkhleb,* Moscow; importers of Russian grain, seeds, oilcakes, offals, vegetable oils, etc. Share capital £200,000 (fully paid). (b) Russian Wood Agency, Ltd., agents for the sale of Russian timber materials on behalf of Exportless, Severoless, Sevsapless, Karelless and other Russian timber trusts. Share capital £240,000 (fully paid); Dvinoless Export, Ltd. (share capital £100,000, fully paid), and Russnorvegoless, Ltd. (registered as a Norwegian limited liability company, with a share capital of £300,000), importers of Russian timber materials.

To group (C) belong: (a) Centrosojus (England), Ltd., agents in Great Britain and Ireland for the Central Union of Russian Consumers' Co-operative Societies, *Centrosoyúz,* Moscow, and for other co-operative unions in the U.S.S.R. Share capital £250,000 (fully paid). (b) Selskosoyúz, Ltd., agents in Great Britain for the various agricultural co-operative unions. Share capital £50,000 (fully paid). (c) Ukrainian Co-operatives, Ltd., representatives in Great Britain of the Ukrainian Co-operative Societies. Paid-up capital £21,000. (d) Central Association of Flax Growers, Ltd., sole representatives of Exportlen, Ltd., Moscow; importers from the U.S.S.R. of flax, tow and hemp. Capital £44,750.

The only merchant shipping organization is the Anglo-Soviet Shipping Co., Ltd., the loading brokers and agents for the Soviet Mercantile Fleet, *Sovtorgflot.* Share capital £1,000 (fully paid). The only insurance organization is the Black Sea and Baltic General Insurance Co., Ltd., which are the London correspondents of the U.S.S.R., State Insurance Department, *Gosstrakh.* Share capital £100,000. There are two banks. The Moscow Narodny Bank, Ltd. (paid-up capital £750,000) finances the foreign trade of co-operative organizations. The Bank for Russian Trade, Ltd. (paid-up capital £550,000) finances Russian trade with Great Britain other than co-operative trade. Finally, there are in Great Britain representatives of the U.S.S.R. State Bank; and of *Gostorg, Ukrgostorg,* and *Zakgostorg,* which are the State import and export trading offices of Russia, of the Ukraine, and of Transcaucasia respectively.

The Extent of Anglo-Soviet Trade.—During the eight years from the renewal of trade between Great Britain and the U.S.S.R. in June 1920, to the end of June 1928, the total turnover of Anglo-Soviet trade amounted to £216,649,000. The following table shows the actual figures of sales and purchases of the Soviet trading organizations in Great Britain. Sales are goods invoiced to buyers, c.i.f. British ports. Purchases are orders placed with British firms, f.o.b. British ports.

Year	Soviet sales in Great Britain	Soviet purchases in Great Britain
	£	£
1920	..	2,810,000
1921	1,866,000	7,281,000
1922	5,933,000	9,433,000
1923	10,458,000	4,659,000
1924	19,444,000	14,801,000
1925	26,908,000	31,171,000
1926	23,617,000	13,440,000
1927	23,362,000	10,140,000
1928	24,198,000	6,375,000
Grand total for whole period	119,831,000	96,818,000

The principal articles purchased in Great Britain during the whole period consisted of: cotton, £16,226,000; grain, £11,235,000; various machinery, £12,114,000; wool and wool yarn, £8,587,000; rubber, £7,817.000; hides and skins, £6,281,000; tea, coffee and cocoa, £5,833,000; chemicals, £5,264,000; fabrics, £4,132,000. The principal Soviet sales in Great Britain during the eight years were: timber materials, £37,818,000; furs, £18,961,000; wheat and other grain products, £17,775,000; oil products £19,193,000; butter, £11,700,000; flax, hemp and tow, £8,455,000. There was a big decline in trade after the break of diplomatic relations between the two countries in May 1927.

Soviet-American Trade.—Trade between the U.S.S.R. and the United States is now conducted by the following four organizations with headquarters in New York: The Amtorg Trading Corporation; the All-Union Textile Syndicate, Inc.; Centrosoyus, Inc.; and Selskosoyúz, Inc. In addition to these, a number of concessionaire firms export from the Soviet Union.

The Amtorg is an extensive import and export organization trading in every kind of commodity with the exception of cotton and wool. The All-Union Textile Syndicate is purchasing in the United States machinery and raw materials for the textile industry of the U.S.S.R. Centrosoyus sells on the American market goods imported from the Consumers' Co-operative Societies of the U.S.S.R., chiefly furs, flax, and hemp, and purchases for the same bodies various goods for consumption and for office equipment. Selskosoyus is selling on the American market goods imported from the agricultural co-operatives of the U.S.S.R., and purchases in the United States agricultural machinery and equipment, tractors, and so on. The figures are:

Year	Soviet sales in the United States	Soviet purchases in the United States
1913–14	$23,294,000	$31,557,000
1922–23	2,705,000	..
1923–24	5,492,000	43,917,000
1924–25	11,307,000	86,939,000
1925–26	30,649,000	47,618,000
1926–27	20,252,000	72,850,000
1927–28 (preliminary) .	25,000,000	95,000,000

The principal commodities sold in the United States in 1926–27 were: furs, $9,763,000; manganese, $1,351,000; flax, tow, etc., $1,112,000. Cotton is the principal article purchased by the U.S.S.R. from the United States; in the first nine months of 1927–8, Soviet purchases of cotton in America amounted to $60,608,000. In the same period orders for machinery and equipment amounted to $10,000,000. Next in importance came agricultural machinery, tractors, and motor transport. (L. SE.)

SOWERBY, JAMES (1757–1822), English natural-history artist, was born in London on March 21, 1757. He became a student at the Royal Academy, and subsequently taught drawing, but turned to the illustration of botanical and conchological works, and published *English Botany* (36 vols., 1790–1814), and *British Mineralogy* (5 vols., 1804–1817). He planned and partly carried out *The Mineral Conchology of Great Britain* (7 vols., 1812–1846), concluded after his death by his sons.

SOWING, in agriculture, the planting of seed for the raising of crops. The scattering of seed by hand is the simplest and oldest method.

The seed must not fall more thickly at one point of the cast than at another, and the standard of seeding per acre must be rigidly adhered to; hence manual-sowing demands considerable skill and experience. It is still preferred in some districts for the sowing of corn crops; and in some cases the plough is followed by a furrow-presser, the seed falling into the "nicks" made by it, though under ordinary circumstances the face of the field as left in "seams" by the furrow-slices from the plough is in a suitable condition for broadcasting. So well, indeed, is the ploughing done in many countries that broadcasting gives perfectly good results, and broadcasting machines reaching up to 15ft. wide are in common use in place of hand-sowing, as these get over the ground more quickly and deposit the seed more regularly.

As early as 1662 a sowing-machine was invented by Joseph Locatelli in Carinthia. In England the early history of mechanical sowing is chiefly connected with the name of Jethro Tull, who about 1730 invented the corn-drill. Cooke's drill brought out in 1783 was the definite precursor of the modern drill. The drill, besides depositing the seed at a uniform depth, sows it in parallel rows at equal distances from one another and thus makes possible the use of the horse hoe and facilitates the suppression of weeds amongst growing crops, the latter advantage being specially marked in the case of root crops. The "cup-feed" and the "force-feed" are the commonest and most generally useful types. The cup-drill consists of a long box carried upon wheels and divided diagonally into two sections by a partition. The forward section contains the seed which drops through apertures, the size of which can be regulated by slides, to the bottom section. A spindle geared to the ground-wheels by cogs passes longitudinally through the centre of this section and carries disks, round the rims of which are fitted small cups. As the horses pull the drill forward, the spindle and disks revolve and the cups scoop up the seed and pour it into the funnels; thence it proceeds down a series of tubes or "spouts" and drops into shallow furrows traced by small coulters travelling immediately in front of the streams of seed. The coulters can be raised or lowered by levers and are kept down to their work by weights or pressers, which can be regulated according as deep or shallow sowing is required.

In the force-feed type of drill the seed falls through apertures in the bottom of the seed-hopper into funnels, through which extends a shaft carrying bowl-shaped wheels, one for each. These wheels are either spirally-grooved inside or else cogged and serve to feed the seed regularly into the funnels. Instead of coulters, the drill is often fitted with shoes or revolving disks, similar in action to those of the disk-harrow. The tooth and brush pinion, the perforated disk and the chain feed drills, are other types differentiated according to the method by which the seed is "fed" from the hopper and the kind of crop being sown.

Liquid-manure drills distribute chemical manure mixed with water and are often fitted with a seed-box for root seeds, the manure and the seed being deposited through the same spout. Drills are also made in which dry fertilizers may be deposited with the seed in a similar manner.

The wheelbarrow seeder, a long box pierced with openings and carried transversely on a skeleton wheelbarrow, is used for sowing grass seed.

The Maize Lister.—In the United States the maize or Indian-corn crop exceeds all others in value, and machines used in planting and handling this crop are of great importance. Corn (maize) is sometimes "listed" or planted in a continuous row like wheat, and for this purpose a machine known as a lister is employed.

In its general construction this machine is a sulky plough, having a double mould-board, which turns the furrow in both directions. Immediately behind the plough is a sub-soiler for deepening the furrow and penetrating to the moist soil below the surface. A seed-box is mounted on the plough beam, and is provided with a feed-plate operated by a shaft geared to one of the wheels. The seed is delivered to the furrow in rear of the mould-boards and covered by two shovels fixed behind which turn the soil back into the furrow.

The Corn Planter.—Maize, however, is commonly planted in equally spaced "hills," which form rows at right angles to each other, so that a cultivator may be driven through them both lengthwise and crosswise of the field. This work is usually done by a machine called a check-row corn planter.

In using the corn planter, a wire, having buttons attached thereto, at intervals corresponding to the distance between the hills, is first stretched across the field and anchored at its ends. This wire is then placed upon the guide rollers at the side of the machine and passes between the jaws of a forked lever, which is connected at its other end with a rocking shaft passing across the machine and serving to oscillate a feed-plate in the bottom of each seed-hopper. As the buttons on the check-wire strike the forked lever, the latter is drawn to the rear and causes the feed-plate to drop the seed through the tubes into the open space between the plates of the furrowing shoe. A reel at the rear of the machine is used to take up the check-wire as the planter progresses. (P. McC.)

SOYA BEAN, also known as the soja bean and in the United States as the soy bean, is a leguminous plant native to southeastern Asia. It has been cultivated in China and Japan since long before written records were kept, and from the standpoint of uses and value is the most important legume now grown in those countries. Although limited acreages are grown in Italy, France, southern Russia, Hawaii, Egypt, South Africa and in a few countries of South America, its culture at present is largely confined to China, Manchuria, Japan, Chosen (Korea) and the United States. It is also more or less important in India, Indo China and the Malayan islands.

Although first introduced into the United States in 1804, the soy bean has become important only during the last 10 or 15 years. Only eight varieties were grown in 1898, whereas at present more than 60 varieties are handled by growers and seedsmen. Previous to 1917, the soy bean acreage was less than 500,000, but by 1924 it had increased to 2,500,000. The soy bean can be grown in any climate suitable to maize or cotton, and the crop is now grown generally over the eastern half of the United States. Recent increases in acreage have been most marked in the maize belt and some of the Southern States. Introduction and breeding of improved varieties have extended the culture of the crop far beyond what were first considered its limits of profitable production, and it is destined to become a crop of great economic importance in the United States. Its principal uses are hay, pasture, silage, oil and oil meal, and human food (*see* SOYA BEAN OIL). It can be used advantageously, either as a seed crop or a forage crop, in many systems of rotation; also as a catch crop where new seedings of grass or clover have failed. In combinations with other crops, such as corn, cow-peas, Sudan grass or sorghums, it furnishes a well-balanced ration for live stock, a large yield and a great variety of forage. The seed is rich in oil which makes the crop an important source of vegetable oil, and the resultant residue makes a highly concentrated and nutritious feed relished by all kinds of live stock.

Cultivation.—The growing of soy beans is easy when ordinary precautions are followed in preparing the soil and selecting suitable varieties. Where they have not been grown previously it is advisable to inoculate the soil with sweet clover or alfalfa. The use of fertilizer is recommended in sandy soil or in soils of low fertility. Seeding is usually done with an ordinary grain drill, the rows being spaced far enough apart to allow for cultivation when the crop is grown for seed. Indian corn planters are used when planting with maize, most modern planters having special attachments for the soy bean seed to permit planting in the hill or row with the maize. (L. S. R.)

SOYA BEAN OIL. An oil also known as "Bean Oil," obtained from the seeds of the leguminous plant *Soja* (*Glycine*) *hispida,* which is extensively cultivated in the Far East, where for centuries the oil and the expressed cake have been used as food.

The oil is obtained by expressing the ground seed in Anglo-American presses (*see* COCONUT OIL AND COPRA). The beans, which contain from 18% to 20% of oil, yield by expression on the practical scale about 13%. Damaged seeds are extracted with a volatile solvent, whereby almost all the oil is recovered. The expressed meal is valued for its albumenoid content, and is especially suitable for feeding to dairy cattle, causing an increase in the secretion of milk fat. The oil expressed from sound seed is pale yellow in colour and only needs filtering over fuller's earth to be fit for edible purposes. Soya bean oil contains up to 6% of linolenic acid and therefore falls into the class of drying oils. In addition to its use as an edible oil, it finds extensive employment for soap-making; boiled with a cobalt dryer it is used in the United States for the manufacture of paints.

In 1926 there were exported from Manchuria 1,423,000 tons of beans and 165,000 tons of oil. Great Britain imported 46,000 tons of beans and 43,000 tons of oil, while Germany consumed 370,000 tons of beans and 20,000 tons of oil. (E. L.; G. H. W.)

SOZOMEN, the name of a famous 5th-century church historian. Hermias Salamanes (Salaminius) Sozomenus (*c.* 400–443) came of a wealthy family of Palestine. He tells us that he was brought up under monkish influences. After studying law in Beirūt he settled down as an advocate in Constantinople, where he wrote his *Ἐκκλησιαστικὴ Ἱστορία* about the year 440. The nine books begin with Constantine (323) and come down to the death of Honorius (423). The work, dedicated to Theodosius II., has reached us only in a mutilated condition, at least half a book being wanting. It is a plagiarism of the ecclesiastical historian Socrates (*q.v.*), but Sozomen has referred to the principal sources used by Socrates (Rufinus, Eusebius, Athanasius, Sabinus, the collections of epistles, Palladius), and has not unfrequently supplemented Socrates from them. The whole of the ninth book is drawn from Olympiodorus. Sozomen wished to present a picture in which monasticism should be brought into still stronger prominence.

Sozomen also wrote an *Epitome of History* from the Ascension of Christ to the defeat of Licinius (323) which is not now extant. (*See* his *History*, i. 1.)

For bibliography *see* the article on the church historian, SOCRATES. Most of the editions and discussions named there cover Sozomen as well (the volume of Hussey's edition containing Sozomen appeared in 1860). The latest English translation, revised by Hartranft, is published in the Nicene and Post-Nicene Fathers, 2nd series, vol. ii. In addition *see* Nolte in the *Tübing. Quartalschr.* (1861), p. 417 *sqq.*; C. de Boor, "Zur Kenntniss der Handschriften der Griech. Kirchenhistoriker," in *Zeitschrift für Kirchengeschichte*, vi. 478 *sqq.*; Sarrazin, "De Sozomeni historia num integra sit," in the *Commentationes philologae jenenses*, i. 165 *sqq.*; Rosenstein, "Krit. Untersuchungen über d. Verhältniss zwischen Olympiodor, Zosimus und Sozomen," in *Forsch. z. deutschen Gesch.*, vol. i.; Batiffol, "Sozomène et Sabinos," in *Byzant. Zeitschr.* vii. 265 *sqq.*

SPA, a town in the province of Liége, Belgium, less than 20 m. S.E. of Liége, famous for mineral springs first discovered in 1326. They are supposed to have given the common name of "spa" to such resorts. The town is 850 ft. above sea-level. In the 18th century it was the most fashionable resort in Europe for the medicinal use of such waters. In 1807 much of the town was burned down, while the principal buildings, the Casino and the Pouhon, are quite modern. Spa still attracts about 20,000 visitors annually. Pop. (1925), 8,320.

SPA, CONFERENCE OF (July 5–16, 1920). This was the first occasion after the World War of 1914–18 on which the heads of the German and Allied Governments negotiated on a formal footing of equality. The crucial questions at issue were the execution of the disarmament clauses and the coal delivery clauses of the Treaty of Versailles, and in both cases the Germans were compelled to sign protocols dictated by the Allies under threat of military sanctions which were set out in the documents, and included an eventual Allied occupation of the Ruhr basin.

A German proposal for the general settlement of the reparation problem was rejected, but no general Allied counter-proposal was put forward. An inter-Allied agreement was made for the allocation of prospective German payments, an agreement which has since been modified in detail, but which still governs the situation. It was provided that France should receive 52% of sums obtained from Germany, the British Empire 22%, Italy 10% and Belgium 8%, while the remaining 8% was to be divided between the other Allied Powers. By a subsequent agreement among the several members of the British Commonwealth 86·85% of the British Empire's share was allocated to Great Britain. Another article in the Spa Agreement provided for the allocation of reparation payments from Austria, Bulgaria and Hungary, and "cost of liberation" payments from Italy, Czechoslovakia, Rumania and Yugoslavia. At this conference the Supreme Council (*q.v.*) also came to an agreement with Germany for the trial of war criminals. (*See* REPARATIONS.)

SPACE-TIME. The Theory of Relativity has brought about a fundamental change in the scientific conception of space and time, described in a famous saying of Minkowski—"From henceforth space in itself and time in itself sink to mere shadows, and only a kind of union of the two preserves an independent existence." This union, called "space-time," is the subject of the present article. As the conceptions are of considerable difficulty, most readers will probably find it best to read first the article RELATIVITY for a more elementary introduction to the subject.

All our thoughts and concepts are called up by sense-experiences and have a meaning only in reference to these sense-experiences. On the other hand, however, they are products of the spontaneous activity of our minds; they are thus in no wise logical consequences of the contents of these sense-experiences. If, therefore, we wish to grasp the essence of a complex of abstract notions we must for the one part investigate the mutual relationships between the concepts and the assertions made about them; for the other, we must investigate how they are related to the experiences.

So far as the way is concerned in which concepts are connected with one another and with the experiences there is no difference of principle between the concept-systems of science and those of daily life. The concept-systems of science have grown out of those of daily life and have been modified and completed according to the objects and purposes of the science in question.

The more universal a concept is the more frequently it enters into our thinking; and the more indirect its relation to sense-experience, the more difficult it is for us to comprehend its meaning; this is particularly the case with pre-scientific concepts that we have been accustomed to use since childhood. Consider the concepts referred to in the words "where," "when," "why," "being," to the elucidation of which innumerable volumes of philosophy have been devoted. We fare no better in our speculations than a fish which should strive to become clear as to what is water.

SPACE

In the present article we are concerned with the meaning of "where," that is, of space. It appears that there is no quality contained in our individual primitive sense-experiences that may be designated as spatial. Rather, what is spatial appears to be a sort of order of the material objects of experience. The concept "material object" must therefore be available if concepts concerning space are to be possible. It is the logically primary concept. This is easily seen if we analyse the spatial concepts for example, "next to," "touch," and so forth, that is, if we strive to become aware of their equivalents in experience. The concept "object" is a means of taking into account the persistence in time or the continuity, respectively, of certain groups of experience-complexes. The existence of objects is thus of a conceptual nature, and the meaning of the concepts of objects depends wholly on their being connected (intuitively) with groups of elementary sense-experiences. This connection is the basis of the illusion which makes primitive experience appear to inform us directly about the relation of material bodies (which exist, after all, only in so far as they are thought).

In the sense thus indicated we have (the indirect) experience of the contact of two bodies. We need do no more than call attention to this, as we gain nothing for our present purpose by singling out the individual experiences to which this assertion alludes. Many bodies can be brought into permanent contact with one another in manifold ways. We speak in this sense of the position-relationships of bodies (*Lagenbeziehungen*). The general laws of such position-relationships are essentially the concern of geometry. This holds, at least, if we do not wish to restrict ourselves to regarding the propositions that occur in this branch of knowledge merely as relationships between empty words that have been set up according to certain principles.

Pre-scientific Thought.—Now, what is the meaning of the concept "space" which we also encounter in pre-scientific thought? The concept of space in pre-scientific thought is characterized by the sentence: "we can think away things but not the space which they occupy." It is as if, without having had experience of any sort, we had a concept, nay even a presentation, of space and as if we ordered our sense-experiences with the help of this concept, present *a priori*. On the other hand, space appears as a physical reality, as a thing which exists independently of our thought, like material objects. Under the influence of this view of space the fundamental concepts of geometry: the point, the straight line, the plane, were even regarded as having a self-evident character. The fundamental principles that deal with these configurations were regarded as being necessarily valid and as having at the same time an objective content. No scruples were felt about ascribing an objective meaning to such statements as "three empirically given bodies (practically infinitely small) lie on one straight line," without demanding a physical definition for such an assertion. This blind faith in evidence and in the immediately real meaning of the concepts and propositions of geometry became uncertain only after non-Euclidean geometry had been introduced.

Reference to the Earth.—If we start from the view that all spatial concepts are related to contact-experiences of solid bodies, it is easy to understand how the concept "space" originated, namely, how a thing independent of bodies and yet embodying their position-possibilities (*Lagerungsmöglichkeiten*) was posited. If we have a system of bodies in contact and at rest relatively to one another, some can be replaced by others. This property of allowing substitution is interpreted as "available space." Space denotes the property in virtue of which rigid bodies can occupy different positions. The view that space is something with a unity of its own is perhaps due to the circumstance that in pre-scientific thought all positions of bodies were referred to one body (reference body), namely the earth. In scientific thought the earth is represented by the co-ordinate system. The assertion that it would be possible to place an unlimited number of bodies next to one another denotes that space is infinite. In pre-scientific thought the concepts "space" and "time" and "body of reference" are scarcely differentiated at all. A place or point in space is always taken to mean a material point on a body of reference.

Euclidean Geometry.—If we consider Euclidean geometry we clearly discern that it refers to the laws regulating the positions of rigid bodies. It turns to account the ingenious thought of tracing back all relations concerning bodies and their relative positions to the very simple concept "distance" (*Strecke*). Distance denotes a rigid body on which two material points (marks) have been specified. The concept of the equality of distances (and angles) refers to experiments involving coincidences; the same remarks apply to the theorems on congruence. Now, Euclidean geometry, in the form in which it has been handed down to us from Euclid, uses the fundamental concepts "straight line" and "plane" which do not appear to correspond, or at any rate, not so directly, with experiences concerning the position of rigid bodies. (On this it must be remarked that the concept of the straight line may be reduced to that of the distance. A hint of this is contained in the theorem: "the straight line is the shortest connection between two points." This theorem served well as a definition of the straight line, although the definition played no part in the logical texture of the deductions.) Moreover, geometricians were less concerned with bringing out the relation of their fundamental concepts to experience than with deducing logically the geometrical propositions from a few axioms enunciated at the outset.

Let us outline briefly how perhaps the basis of Euclidean geometry may be gained from the concepts of distance. We start from the equality of distances (axiom of the equality of distances). Suppose that of two unequal distances one is always greater than the other. The same axioms are to hold for the inequality of distances as hold for the inequality of numbers. Three distances $\overline{AB'}$, $\overline{BC'}$, $\overline{CA'}$ may, if CA' be suitably chosen, have their marks BB', CC', AA' superposed on one another in such a way that a triangle ABC results. The distance CA' has an upper limit for which this construction is still just possible. The points A, (BB') and C then lie in a "straight line" (definition). This leads to the concepts: producing a distance by an amount equal to itself; dividing a distance into equal parts; expressing a distance in terms of a number by means of a measuring-rod (definition of the space-interval between two points).

When the concept of the interval between two points or the length of a distance has been gained in this way we require only the following axiom (Pythagoras' theorem) in order to arrive at Euclidean geometry analytically. To every point of space (body of reference) three numbers (co-ordinates) x, y, z may be assigned—and conversely—in such a way that for each pair of points A (x_1, y_1, z_1) and B (x_2, y_2, z_2) the theorem holds:

$$\text{measure-number } AB = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}.$$

All further concepts and propositions of Euclidean geometry can then be built up purely logically on this basis, in particular also the propositions about the straight line and the plane. These remarks are not, of course, intended to replace the strictly axiomatic construction of Euclidean geometry. We merely wish to indicate plausibly how all conceptions of geometry may be traced back to that of distance. We might equally well have epitomised the whole basis of Euclidean geometry in the last theorem above. The relation to the foundations of experience would then be furnished by means of a supplementary theorem. The co-ordinate may and *must* be chosen so that two pairs of points separated by equal intervals, as calculated by the help of Pythagoras' theorem, may be made to coincide with one and the same suitably chosen distance (on a solid). The concepts and propositions of Euclidean geometry may be derived from Pythagoras' proposition without the introduction of rigid bodies; but these concepts and propositions would not then have contents that could be tested. They are not "true" propositions but only logically correct propositions of purely formal content.

Difficulties.—A serious difficulty is encountered in the above represented interpretation of geometry in that the rigid body of experience does not correspond *exactly* with the geometrical body. There are no absolutely definite marks and, moreover, temperature, pressure and other circumstances modify the laws relating to position. It is also to be recollected that the structural constituents of matter (such as atom and electron, *q.v.*) assumed by physics are not in principle commensurate with rigid bodies, but that nevertheless the concepts of geometry are applied to them and to their parts. For this reason consistent thinkers have been disinclined to allow real contents of facts (*reale Tatsachenbestände*) to correspond to geometry alone. They considered it preferable to allow the content of experience (*Erfahrungsbestände*) to correspond to geometry and physics conjointly.

This view is certainly less open to attack than the one represented above; as opposed to the atomic theory it is the only one that can be consistently carried through. Nevertheless it would not be advisable to give up the first view, from which geometry derives its origin. This connection is essentially founded on the belief that the ideal rigid body is an abstraction that is well rooted in the laws of nature.

Foundations of Geometry.—We come now to the question: what is *a priori* certain or necessary, respectively in geometry (doctrine of space) or its foundations? Formerly we thought everything; nowadays we think—nothing. Already the distance-concept is logically arbitrary; there need be no things that correspond to it, even approximately. Something similar may be said of the concepts straight line, plane, of three-dimensionality and of the validity of Pythagoras' theorem. Even the continuum-doctrine is in no wise given with the nature of human thought, so that from the epistomological point of view no greater authority attaches to the purely topological relations than to the others.

Earlier Physical Concepts.—We have yet to deal with those modifications in the space-concept which have accompanied the advent of the theory of relativity. For this purpose we must consider the space-concept of the earlier physics from a point of view different from that above. If we apply the theorem of Pythagoras to infinitely near points, it reads

$$ds^2 = dx^2 + dy^2 + dz^2,$$

where ds denotes the measurable interval between them. For an empirically-given ds the co-ordinate system is not yet fully determined for every combination of points by this equation. Besides being translated, a co-ordinate system may also be rotated. This signifies analytically: the relations of Euclidean geometry are covariant with respect to linear orthogonal transformations of the co-ordinates.

In applying Euclidean geometry to pre-relativistic mechanics a further indeterminateness enters through the choice of the co-ordinate system: the state of motion of the co-ordinate system is arbitrary to a certain degree, namely, in that substitutions of the co-ordinates of the form $x' = x - vt$

$$y' = y$$
$$z' = z$$

also appear possible. On the other hand, earlier mechanics did not allow co-ordinate systems to be applied of which the states of motion were different from those expressed in these equations. In this sense we speak of "inertial systems." In these favoured-inertial systems we are confronted with a new property of space so far as geometrical relations are concerned. Regarded more accurately, this is not a property of space alone but of the four-dimensional continuum consisting of time and space conjointly.

Appearance of Time.—At this point time enters explicitly into our discussion for the first time. In their applications space (place) and time always occur together. Every event that happens in the world is determined by the space-co-ordinates *x, y, z,* and the time-co-ordinate *t.* Thus the physical description was four-dimensional right from the beginning. But this four-dimensional continuum seemed to resolve itself into the three-dimensional continuum of space and the one-dimensional continuum of time. This apparent resolution owed its origin to the illusion that the meaning of the concept "simultaneity" is self-evident, and this illusion arises from the fact that we receive news of near events almost instantaneously owing to the agency of light.

This faith in the absolute significance of simultaneity was destroyed by the law regulating the propagation of light in empty space or, respectively, by the Maxwell-Lorentz electro-dynamics. Two infinitely near points can be connected by means of a light-signal if the relation

$$ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2 = 0$$

holds for them. It further follows that *ds* has a value which, for arbitrarily chosen infinitely near space-time points, is independent of the particular inertial system selected. In agreement with this we find that for passing from one inertial system to another, linear equations of transformation hold which do not in general leave the time-values of the events unchanged. It thus became manifest that the four-dimensional continuum of space cannot be split up into a time-continuum and a space-continuum except in an arbitrary way. This invariant quantity *ds* may be measured by means of measuring-rods and clocks.

Four-dimensional Geometry.—On the invariant *ds* a four-dimensional geometry may be built up which is in a large measure analogous to Euclidean geometry in three dimensions. In this way physics becomes a sort of statics in a four-dimensional continuum. Apart from the difference in the number of dimensions the latter continuum is distinguished from that of Euclidean geometry in that ds^2 may be greater or less than zero. Corresponding to this we differentiate between time-like and space-like line-elements. The boundary between them is marked out by the element of the "light-cone" $ds^2 = 0$ which starts out from every point. If we consider only elements which belong to the same time-value, we have

$$-ds^2 = dx^2 + dy^2 + dz^2.$$

These elements *ds* may have real counterparts in distances at rest and, as before, Euclidean geometry holds for these elements.

Effect of Relativity, Special and General.—This is the modification which the doctrine of space and time has undergone through the restricted theory of relativity. The doctrine of space has been still further modified by the general theory of relativity, because this theory denies that the three-dimensional spatial section of the space-time continuum is Euclidean in character. Therefore it asserts that Euclidean geometry does not hold for the relative positions of bodies that are continuously in contact.

For the empirical law of the equality of inertial and gravitational mass led us to interpret the state of the continuum, in so far as it manifests itself with reference to a non-inertial system, as a gravitational field and to treat non-inertial systems as equivalent to inertial systems. Referred to such a system, which is connected with the inertial system by a non-linear transformation of the co-ordinates, the metrical invariant ds^2 assumes the general form:

$$ds^2 = \sum_{\mu\nu} g_{\mu\nu} dx_\mu dx_\nu,$$

where the $g_{\mu\nu}$'s are functions of the co-ordinates and where the sum is to be taken over the indices for all combinations 11, 12, . . . 44. The variability of the $g_{\mu\nu}$'s is equivalent to the existence of a gravitational field. If the gravitational field is sufficiently general it is not possible at all to find an inertial system, that is, a co-ordinate system with reference to which ds^2 may be expressed in the simple form given above:

$$ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2;$$

but in this case, too, there is in the infinitesimal neighbourhood of a space-time point a local system of reference for which the last-mentioned simple form for *ds* holds. This state of the facts leads to a type of geometry which Riemann's genius created more than half a century before the advent of the general theory of relativity of which Riemann divined the high importance for physics.

Riemann's Geometry.—Riemann's geometry of an *n*-dimensional space bears the same relation to Euclidean geometry of an *n*-dimensional space as the general geometry of curved surfaces bears to the geometry of the plane. For the infinitesimal neighbourhood of a point on a curved surface there is a local co-ordinate system in which the distance *ds* between two infinitely near points is given by the equation

$$ds^2 = dx^2 + dy^2.$$

For any arbitrary (Gaussian) co-ordinate-system, however, an expression of the form

$$ds^2 = g_{11}dx_1^2 + 2g_{12}dx_1dx_2 + g_{22}dx_2^2$$

holds in a finite region of the curved surface. If the $g_{\mu\nu}$'s are given as functions of x_1 and x_2 the surface is then fully determined geometrically. For from this formula we can calculate for every combination of two infinitely near points on the surface the length *ds* of the minute rod connecting them; and with the help of this formula all networks that can be constructed on the surface with these little rods can be calculated. In particular, the "curvature" at every point of the surface can be calculated; this is the quantity that expresses to what extent and in what way the laws regulating the positions of the minute rods in the immediate vicinity of the point under consideration deviate from those of the geometry of the plane.

This theory of surfaces by Gauss has been extended by Riemann to continua of any arbitrary number of dimensions and has thus paved the way for the general theory of relativity. For it was shown above that corresponding to two infinitely near space-time points there is a number *ds* which can be obtained by measurement with rigid measuring-rods and clocks (in the case of time-like elements, indeed, with a clock alone). This quantity occurs in the mathematical theory in place of the length of the minute rods in three-dimensional geometry. The curves for which $\int ds$ has stationary values determine the paths of material points and rays of light in the gravitational field, and the "curvature" of space is dependent on the matter distributed over space.

Just as in Euclidean geometry the space-concept refers to the position-possibilities of rigid bodies, so in the general theory of relativity the space-time-concept refers to the behaviour of rigid bodies and clocks. The space-time-continuum however differs from the space-continuum in that the laws regulating the behaviour of these objects (clocks and measuring-rods) depend on where they happen to be. The continuum (or the quantities that describe it) enters explicitly into the laws of nature, and conversely these properties of the continuum are determined by physical factors. The relations that connect space and time can no longer be kept distinct from physics proper. Nothing certain is known of what the properties of the space-time-continuum may be as a whole. Through the general theory of relativity, however, the view that the continuum is infinite in its time-like extent but finite in its space-like extent has gained in probability.

TIME

The physical time-concept answers to the time-concept of the extra-scientific mind. Now, the latter has its root in the time-order of the experiences of the individual, and this order we must accept as something primarily given. One experiences the moment "now," or, expressed more accurately, the present sense-experience (*Sinnen-Erlebnis*) combined with the recollection of (earlier) sense-experiences. That is why the sense-experiences seem to form a series, namely the time-series indicated by "earlier" and "later." The experience-series is thought of as a one-dimensional continuum. Experience-series can repeat themselves and can then be recognized. They can also be repeated inexactly, wherein some events are replaced by others without the character of the repetition becoming lost for us. In this way we form the time-concept as a one-dimensional frame which can be filled in by experiences in various ways. The same series of experiences answer to the same subjective time-intervals.

The transition from this "subjective" time (*Ich-Zeit*) to the time-concept of pre-scientific thought is connected with the formation of the idea that there is a real external world independent of the subject. In this sense the (objective) event is made to correspond with the subjective experience. In the same sense there is attributed to the "subjective" time of the experience a "time" of the corresponding "objective" event. In contrast with experiences external events and their order in time claim validity for all subjects.

This process of objectification would encounter no difficulties were the time-order of the experiences corresponding to a series of external events the same for all individuals. In the case of the immediate visual perceptions of our daily lives, this correspondence is exact. That is why the idea that there is an objective time-order became established to an extraordinary extent. In working out the idea of an objective world of external events in greater detail, it was found necessary to make events and experiences depend on each other in a more complicated way. This was at first done by means of rules and modes of thought instinctively gained, in which the conception of space plays a particularly prominent part. This process of refinement leads ultimately to natural science.

The measurement of time is effected by means of clocks. A clock is a thing which automatically passes in succession through a (practically) equal series of events (period). The number of periods (clock-time) elapsed serves as a measure of time. The meaning of this definition is at once clear if the event occurs in the immediate vicinity of the clock in space; for all observers then observe the same clock-time simultaneously with the event (by means of the eye) independently of their position. Until the theory of relativity was propounded it was assumed that the conception of simultaneity had an absolute objective meaning also for events separated in space.

This assumption was demolished by the discovery of the law of propagation of light. For if the velocity of light in empty space is to be a quantity that is independent of the choice (or, respectively, of the state of motion) of the inertial system to which it is referred, no absolute meaning can be assigned to the conception of the simultaneity of events that occur at points separated by a distance in space. Rather, a special time must be allocated to every inertial system. If no co-ordinate system (inertial system) is used as a basis of reference there is no sense in asserting that events at different points in space occur simultaneously. It is in consequence of this that space and time are welded together into a uniform four-dimensional continuum. *See* RELATIVITY. (A. EI.)

Electro-magnetic Field.—We commonly say that a material object exists in *space* and in *time*. The scientist often adds that it is in a *gravitational field* and in an *electro-magnetic field*. By these four terms we seem to be attributing four different backgrounds to the object. But already three of these have been reduced to one; the special theory of relativity has amalgamated space and time into space-time; and the general theory of relativity with its Riemannian geometry has absorbed the gravitational field into space-time. Is it not possible to make a further generalization so as to absorb the electro-magnetic field? If so there will be but a single background to all material activity—one unified field.

Progress has been made towards this anticipated unification, but the theories are, as yet, not entirely definitive. The chief trouble is that electro-magnetism cannot be fully treated without entering into problems of electrons and the fine structure of matter; so that the field theory is held back pending developments in our understanding of atomic physics and quanta. The best known unified field theory is that of H. Weyl, proposed in 1918. He showed that a rather more general geometry than that of Riemann affords place for four coefficients additional to the ten $g_{\mu\nu}$, and that these can be identified with the four electro-magnetic potentials. A further development and reconstruction was given by A. S. Eddington in 1921. Starting from an "affine geometry" of the most general type, he found that a world-tensor can be derived which breaks up into a symmetrical and antisymmetrical part. The symmetrical part provides a Riemannian metric, and therefore comprises space, time and gravitation; the antisymmetrical part furnishes the electro-magnetic field. Thus, whilst the gravitational and electro-magnetic fields are seen to arise from a single background, the bifurcation is recognized to be very deep-seated. Einstein proposed certain developments and modifications of this theory in 1923.

Early in 1929 Einstein announced that he had reached a new solution of this problem of unification; and there was much public curiosity as to his new theory. There is little that can be said of a non-technical character about it, since the differences from previous unified theories can only be realized by experts, and its attractiveness (or otherwise) depends on the relative simplicity of the mathematical formula which expresses the field-law. In fact, the whole point left unsettled was the particular form of the mathematical expression, so that an exposition of Einstein's latest theory, which leaves out the mathematics, leaves out its main point. It may be said, however, that Einstein's geometrical foundation is a Riemannian geometry coupled with a postulate of distant parallelism. If two ships are near together we can say whether they are or are not sailing on parallel courses; but if they are some thousands of miles apart there is no meaning or definition of what shall be called parallel courses. Similarly, in Riemannian geometry there is no distant parallelism. Einstein postulates that although, conformably to Riemannian geometry, we cannot define parallel lines at a great distance apart by reference to space measures alone, by taking also into account electrical measurements a unique definition can be given. By conspiring to provide this distant parallelism the electro-magnetic and gravitational quantities are brought into association. The theory has not yet been fully worked out, and judgment must be suspended as to whether it will satisfy all requirements.

(A. S. E.)

SPADE-FISH (*Chaetodipterus faber*), a very deep-bodied, almost circular fish of the family *Ephippidae*, 2 to 3 ft. long, common in Atlantic waters from Massachusetts to Cuba and much prized for food. It has a small mouth, with brushlike teeth. The lateral line follows the humped curve of the body. In colour it is greyish, with four dark bands running from the top of the back down the body. It is also called angel-fish.

SPADE GUINEA, the name by which the guinea coined in the reign of George III. came to be known. It was so called because the reverse of the coin was designed with a shield pointed at the base after the fashion of a spade. *See* GUINEA.

SPADINI, ARMANDO (1883–1925), Italian painter, was born in Florence July 29, 1883. He first studied art in his native city but was chiefly inspired by the great Venetian artists, particularly by Giorgione and Paolo Veronese. Not until the International Exhibition at Venice in 1924 where 48 of his paintings were displayed was he assured of a definite place in modern Italian art. In 1910 he went to Rome where he established himself permanently. There he died on March 31, 1925. He painted a number of notable pastoral scenes and a few portraits but his best subjects are domestic scenes.

SPAGHETTI: *see* VERMICELLI and MACARONI.

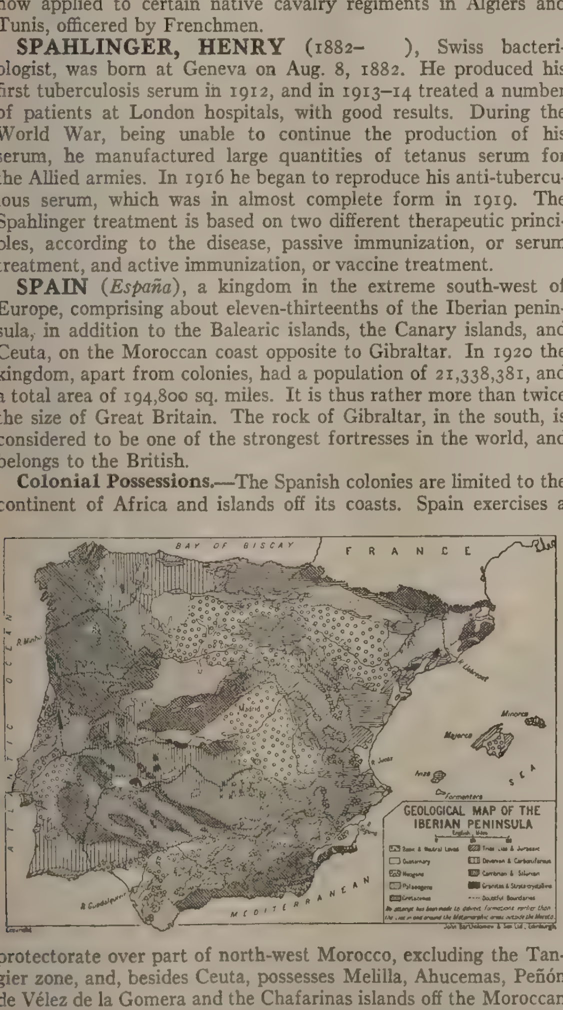
SPAGNA, LO (d. after 1530), the usual designation (due to his Spanish origin) of the Italian painter Giovanni di Pietro, a pupil and assistant of Perugino. Nothing is known of his early life. There is a marked absence of individuality about his style, which seems like an imitation of the manner of Raphael and of Pinturicchio in a less virile form. The chief of his numerous panel paintings are the "Nativity," in the Vatican, and the "Adoration of the Magi," at Berlin. Lo Spagna's frescoes reach a higher standard of merit than his panel pictures. The museum of the Capitol in Rome possesses a very beautiful series of life-sized fresco figures by him, representing Apollo and the Nine Muses from la Magliana, formerly ascribed to Raphael.

SPAHIS, originally the holders of fiefs in Central Asia who yielded personal military service to their superior chief (in Persian *sipari*, meaning warriors, and synonymous with *sepoy*). In time the term came to be applied to the soldiery furnished in their own stead. A similar institution existed in Turkey, and the "Spahis" were the light irregular cavalry which from the time of Sultan Amurath I. (1326) down to the beginning of the 19th century formed the flower of the Turkish army; at one period they are estimated to have numbered 130,000. "Spahis" is the term now applied to certain native cavalry regiments in Algiers and Tunis, officered by Frenchmen.

SPAHLINGER, HENRY (1882–), Swiss bacteriologist, was born at Geneva on Aug. 8, 1882. He produced his first tuberculosis serum in 1912, and in 1913–14 treated a number of patients at London hospitals, with good results. During the World War, being unable to continue the production of his serum, he manufactured large quantities of tetanus serum for the Allied armies. In 1916 he began to reproduce his anti-tuberculous serum, which was in almost complete form in 1919. The Spahlinger treatment is based on two different therapeutic principles, according to the disease, passive immunization, or serum treatment, and active immunization, or vaccine treatment.

SPAIN (*España*), a kingdom in the extreme south-west of Europe, comprising about eleven-thirteenths of the Iberian peninsula, in addition to the Balearic islands, the Canary islands, and Ceuta, on the Moroccan coast opposite to Gibraltar. In 1920 the kingdom, apart from colonies, had a population of 21,338,381, and a total area of 194,800 sq. miles. It is thus rather more than twice the size of Great Britain. The rock of Gibraltar, in the south, is considered to be one of the strongest fortresses in the world, and belongs to the British.

Colonial Possessions.—The Spanish colonies are limited to the continent of Africa and islands off its coasts. Spain exercises a protectorate over part of north-west Morocco, excluding the Tangier zone, and, besides Ceuta, possesses Melilla, Ahucemas, Peñón de Vélez de la Gomera and the Chafarinas islands off the Moroccan coast. On the Atlantic coast she holds Ifni and the Cape Juby territory, which merges southwards into the Rio de Oro colony. In the Gulf of Guinea Spain possesses the Fernando Po, Annobon, great and little Elobey, and Corisco islands, and, on the mainland, the Rio Muni district of Spanish Guinea, between the French Congo and the (French) mandated territory of the Cameroons in Africa.



John Bartholomew & Son Ltd., Edinburgh

PHYSIOGRAPHY

The Iberian peninsula covers the major portion of that section of the earth's surface which is included between latitudes 43° 47′ N. (Estaca de Vares) and 36° 0′ N. (Isleta de Tarifa) and between the meridians of 3° 19′ E. (Cabo de Creus) and 9° 30′ W. (Cape Roca). Of its area of some 223,000 sq.m., 85% is Spanish. It has been thought proper, therefore, to treat here of the physical geography and geology of the peninsula as a whole rather than to confine the treatment to Spain.

The peninsula is the least European in appearance of the three great Mediterranean peninsulas. Its massif character, the great central Meseta, the narrow Strait of Gibraltar by which it is separated from Africa, and the high barrier of the Pyrenees by which it is separated from the rest of Europe, all give it the physical appearance of a disconnected outlier of the Moroccan Meseta rather than that of a part of Europe. It is in very fact a world apart. Not only is it separated from the rest of Europe by a range of mountains difficult to cross except at its extremities; it is also separated from the Mediterranean by coastal ranges which leave between themselves and the sea only narrow and discontinuous strips of coastal plain that alone, of all the peninsula, have a Mediterranean history.

At first glance it would seem that the peninsula would serve to unite Africa and Europe, but, instead, its ranges of east-and-west mountains serve rather to separate them. Moreover, the peninsula furnishes no natural traffic routes between the Mediterranean and the Atlantic or between the Mediterranean and northwestern Europe. The closer physical connection with Africa than with the rest of Europe has had the disastrous consequence of the Islamic invasion and the five-hundred-year struggle with Islam which is accountable in large part for the slow development of Spain along European lines. To the physical character of the peninsula is due likewise the separation of Portugal from Spain and the 700-year separation of the kingdoms of Castile and Aragon. So sharply defined are the natural regions occupied by these two states that even now, though they have been united since the fifteenth century, their peoples differ sharply in physical type, customs, and social organization.

The Coasts.—Seven-eighths of the border of the peninsula are washed by the sea; yet the peninsula as a whole has relatively little access to the sea and comparatively few good harbours. Portugal alone of the whole peninsula has had an important maritime history and this has been due to the fact that the same Douro and Tagus rivers which by their deep canyons separate Portugal from the rest of the peninsula and explain her existence as a separate State afford good harbours in their estuaries.

The high continental mass which forms the greater part of the kingdom of Spain has few navigable rivers and a coastline that is for the most part steep and rocky and with relatively few indentations that are easily approached from the interior. The north coast has numerous indentations that form convenient harbours for small craft although the current that flows eastward along this coast frequently builds bars at their mouths. The best harbours are to be found in the *rias* or fiord-like indentations of the coast of Galicia. Here are the fine natural harbours of Pontevedra, Vigo, Corunna, and Ferrol.

The Portuguese seaboard is 500 m. long and, as compared with the rest of the peninsula, relatively low. On the southern half of the coast, however, mountain masses and spurs terminate in a number of high rocky headlands like Capes Mondego, Carvoeiro, da Roca, Espichel, de Sines, and St. Vincent. The lagoon of Aveiro and the estuaries of the Minho, Douro, Mondego, Tagus, Sado, and Guadiana rivers deeply indent the coast and furnish the principal harbours.

Along the Gulf of Cadiz is the broadest coastal plain of the whole peninsula. Eastward as far as the marshes at the mouth of the Guadalquivir (Las Marismas) it is lined by a series of sand dunes and bordered in part by a line of low, wave-built islands. Eastward from the mouth of the Guadalquivir the coast is more varied and includes the excellent harbour of the Bay of Cadiz.

The Mediterranean coast is bold and rocky from the Strait of Gibraltar almost to Cape Palos but is broken by the British-owned harbour of Gibraltar and the fine harbour of Cartagena. North of Cape Palos the coastal ranges again recede leaving a narrow coastal plain; but, in the northern part of the province of Alicante the mountains again advance to the sea and form the lofty headland of Cape de la Nao. The whole coast of the Bay of Valencia is low and swampy and lined with lagoons, furnishing little in the way of good harbours. All this coast is built of sediments brought down from the Meseta. This sedimentary character culminates in the great delta of the Ebro river. North of the mouth of the Ebro the coast alternates between *playas* and rocky headlands. The Llobregat river also forms a considerable delta just south of the harbour of Barcelona. From Barcelona a long monotonous sand-beach extends to the mouth of the Tordera river. Here begins the famous "costa brava" divided into two sections by the Gulf of Rosas and presenting a rough varied coast line of deep coves and steep, rocky bluffs.

The surface of the Iberian peninsula is noted for its striking contrasts and its vast expanses of dreary uniformity. There are mountains rising with Alpine grandeur above the snow line, but often sheltering rich and beautiful valleys at their base. Naked walls of white limestone tower above dark woods of cork and olive. In other parts, as in the Basque country, in Galicia, in the Serrania de Cuenca (between the headwaters of the Tagus and those of the Júcar), in the Sierra de Albarracin (between the headwaters of the Tagus and those of the Guadalquivir), there are extensive tracts of undulating forest-clad hill country. Almost contiguous to these there are broad plains of level tableland, some almost uninhabitable and some with a network of irrigation canals and richly cultivated like the Requena of Valencia. Continuous mountain ranges and broad tablelands give the prevailing character to the scenery; but there are, in addition, lofty isolated mountain peaks such as Monseny, Montserrat, and Mont Sant in Catalonia, the Peña Golosa in Valencia, and Moncayo on the border of Aragon and Old Castile, as well as many small secluded valleys such as those of Vich and Olot among the Catalonian Pyrenees.

The Meseta.—More than half the Iberian peninsula is occupied by the Meseta, an ancient earth-block consisting for the most part of flat-lying strata, broken and eroded and reduced in large part to a state of peneplanation. The Meseta slopes gradually from north to south and from west to east, its average altitude being about 2,000 ft. On the north it is bordered by the Cantabrian mountains and on the north-east by the Iberian ranges which separate the Meseta from the deep tectonic depression in which flows the Ebro river and terminate near the Gulf of Valencia. On the south the Meseta is bordered by the Sierra Morena, which is actually only the steep southern edge of the Meseta along the Baetic depression, and the Sierra de Alcaraz between the headwaters of the Guadalquivir and Segura rivers.

The Cantabrian mountains are divided into two sections—the Cantabro-Asturian section on the northern border of the Meseta and the Galician section which extends into Portugal as far as the Douro river. The Cantabro-Asturian section runs sensibly parallel to the north coast and culminates in the Peña de Cerredo (8,794 ft.), the highest point in the ranges of the Meseta. A characteristic of these mountains is the many *parameras* or isolated plateaux surrounded by steep mountains or walls of sheer cliffs. On account of the diversity of their origin and their many interruptions the Iberian ranges can better be characterized as the upturned north-east corner of the Meseta rather than a true mountain system. It reaches its highest point in the Sierra de Moncayo (7,593 ft.). South of the Jalón river it divides into two sections. One which borders on the Meseta forms the broken and picturesque Serrania de Cuenca. The other which lies nearer the Ebro depression forms the coast ranges that border the low, lagoon-strewn Bay of Valencia.

The Meseta is divided into northern and southern submesetas, representing respectively the ancient kingdoms of Castile and Aragon, by a central cordillera. This central cordillera consists of a series of crust-block mountains formed by successive fractures and vertical movements and extending *en echelon* northeastward from the Atlantic coast near Lisbon to the Nudo de Albarracín where it connects with the Iberian ranges. It divides the basin of the Douro river from that of the Tagus. There are lofty peaks reaching above the line of perpetual snow in the sierras of this central cordillera. The highest peak, the Plaza del Almanzo (8,727 ft.) in the Sierra de Gredos, is only a little lower than the highest of the Cantabrian peaks, while the Pico de Peñalara in the Sierra de Guadarrama reaches 7,888 ft. Even these highest crests are, however, only about 5,000 ft. above the general level of the Meseta. Between the Sierra de Guadarrama and the Sierra de Gredos and between the latter and the Sierra de Gata are high irregular surfaces filled with hills and *parameras*. Parallel to the western part of the central cordillera between the basins of the Tagus and Guadiana rivers are the Montes de Toledo, a shorter series of sierras that form a denuded highland of relatively low elevation and are separated from the Iberian ranges by the section of the Meseta known as La Mancha. Their highest point is Las Villuercas (4,920 ft.) in the Sierra de Guadalupe. Their westward extension into Portugal is known as the Montañas de Alentejo. The Sierra Morena is an even less continuous range than the central cordillera or the Montes de Toledo. Its westerly extension into Portugal ends at the rocky headland of Cape St. Vincent.

Geologically, geographically, and politically the Meseta is the true Spain. On all sides it is in general remarkably isolated from the coast so that the passes on its border and the river valleys that lead from it to the coast and to the Ebro and Guadalquivir depressions have been from earliest times geographical features of the highest importance. On the north-west, communication between León and Galicia is furnished by the Sil river which at an early date was followed by military roads and now forms part of the route of the railway to the port of Corunna. In the Cantabrian mountains the passes are fairly numerous and over them lie the routes of several railways connecting the interior with the ports of the Bay of Biscay. The two most remarkable passes in these mountains are the Pass of Pájares which carries the railway from León to Oviedo and the port of Gijón and that of Reinosa which leads down to the deep valley of the Besaya and is crossed by the railway from Valladolid to Santander. The east part of the range is crossed by railways from Burgos to Bilboa and San Sebastian, the latter following the picturesque gorge of Pancorbo and crossing the range at Idiazobal.

On the north-east the valley of the Jalón river affords the most important communication between Madrid and the Ebro depression. At an early date an important military road followed this depression. It is now traversed by the railway from Madrid to Saragossa. Farther south the southerly extension of the Iberian ranges long made direct communication between Madrid and Valencia difficult, and even now, although a branch line connects the Jalón valley with the coastal railway a short distance north of Valencia, the main communications between Madrid and the east and south-east coasts are across the southeastern part of the Meseta and the hill country between the Meseta and the Mediterranean.

The descent from the Meseta to the depression of the Guadalquivir is comparatively gradual but passes through the eastern part of the Sierra Morena are few, the principal one being the Puerto de Despeñaperros where the Magaña river, a tributary of the Guadalimar, has cut a deep gorge that the railway from Andalusia to Madrid follows in its ascent to the Meseta.

The central cordillera also offers considerable obstruction to easy communication between the northern and southern submesetas, although the hilly intervals between the sierras afford comparatively easy routes. Carriage roads cross the three main passes in the Sierra de Guadarrama (the passes of Somosierra, in the north-east, Novacerrada near the Pico de Peñalara, and Guadarrama a few miles south and west), while the railway from Madrid to Segovia passes through a tunnel close to the Guadarrama Pass and that from Madrid to Avila crosses the southwestern portion of the same sierra by a remarkable series of tunnels and cuts. The Sierra de Gredo has a road across it connecting Avila with Talavera de la Reina by way of the Puerto de Pico; but for the most part there are only bridle-paths across this sierra and the Sierra de Gata and no railway crosses either of them.

The Ebro and Baetic Depressions.—The Meseta is bordered on the north-east and on the south by two great transverse depressions. The most striking is that on the south, known as the Baetic depression now deeply eroded by the bed of the Guadalquivir. It is a gigantic fracture that has cut like a knife across all the strata of the Meseta and stands out with remarkable clearness from Cape St. Vincent to the eastern end of the Sierra Morena. The present Baetic depression is believed to be the remains of a strait which, up to the Tertiary period, connected the Mediterranean with the Atlantic. Later, on account of movements that produced the Penibaetic cordillera by which the present depression is bounded on the south and south-east, this strait was reduced to a gulf opening only to the Atlantic, and in time converted, whether by further uplift or by sedimentation alone, to the present valley. The sedimentary deposits of the Guadalquivir which flows along the most abrupt border of the depression at the foot of the Meseta has been built up on the materials worn off from the Meseta during the period of submergence and the sediments of marine origin to form the present fertile valley of Andalusia.

The Ebro depression forms a deep ravine between the north-east corner of the Meseta and the Pyrenees. Its two bordering walls converge to form an angle at the point where the depression is shut off from the Mediterranean by the Catalan coast range through which the Ebro river has now cut a tortuous gorge. At one time the depression was occupied by the sea which penetrated by way of the Gulf of Rosas but did not extend through to the Bay of Biscay. Later when the Catalan coast range emerged the depression was converted into a closed lake. The definition of the Ebro river and the successive terraces which now characterize both sides of the depression were brought about by the later uplift to which is due the present architecture of the Pyrenees.

The Ebro valley is divided into two sections by spurs from the Pyrenees on the one side and from the Sierra del Moncayo of the Iberian ranges on the other. The uppermost of these, a plateau of between 1,000 and 1,300 ft. above sea-level, is only about one-fourth the size of the lower portion. The valley of the Guadalquivir is also divided into an upper and a lower section as indicated by the change in the course of the river from a due west to a more south-west direction. The small upper valley is of considerable elevation while the much larger lower valley is mainly lowland and from Seville to the sea is composed of a perfectly level and marshy alluvium (Las Marismas).

Mountains Outside the Meseta Border.—The Pyrenees (*q.v.*) form a continuous wall between Spain and France with an average altitude higher than that of the Alps. Their snow-capped crests reach their highest point in the Pico de Aneto (10,965 ft.) in the great central massif of granitic rocks that form the core of the range. Few trails and no railroads cross the Pyrenees. The Catalan coast range which separates the Ebro depression from the coast is the youngest range of the peninsula and all evidence indicates that the region has suffered movements that have taken place in the Quaternary period. It represents the upper portions of a land mass now in large part submerged beneath the Mediterranean. The peaks Monseny (5,713 ft.) and Montserrat (4,064 ft.) are the outstanding crests. Erosion has moulded them into beautifully picturesque forms. Nearer the coast a series of hills of low elevation border the Catalan range throughout its whole length.

The Baetic system of the south-east part of the peninsula has been described as due to a series of thrusts that had their focus farther south and forced up against the rigid mass of the Meseta the land mass located in front of it. It is generally accepted that a long longitudinal fault which extends from the lower course of the Segura river to the Genil river divides the system into two groups. The mountains to the south of this fracture are known as the Penibaetic system. They lie near the Mediterranean coast and are considered to be prolonged across the Strait of Gibraltar by the mountains of the Riff. The great block of the Sierra Nevada of the Penibaetic system contains the highest crests of the peninsula and reaches its greatest altitude in Cerro Mulhacén (11,417 ft.). It is completely Alpine in character with glacial cirques, lakes, and moraines. The Penibaetic system includes at its eastern end the volcanic zone that forms the Cape de Gata. The extension westward from the Sierra Nevada to Point Marroquí appears to be cut by a series of transverse faults. The mountains north of the Penibaetic fault, though not exhibiting the high crests of the Penibaetic system, have a much broader area of high altitudes. They close the eastern end of the Baetic depression and extend eastward to form the Cape de la Nao. The dividing line between them and the Iberian ranges is generally placed at the Júcar river.

Rivers and Lakes.—The main water divide of the peninsula follows rather closely, in the north, east, and south, the border of the Meseta and the greater part of the drainage is westward by four large rivers, the Tagus (Spanish *Tajo*, Portuguese *Tejo*), Douro (Spanish *Duero*), Guadiana, and Guadalquivir. Only a limited part of the north-east corner of the Meseta is drained by the Ebro on account of the barrier of the Iberian ranges, and all the remaining rivers which drain to the Mediterranean are short as compared with those draining to the Atlantic. All the large rivers of the Atlantic slope rise in Spanish territory. The Tagus and the Douro have their lower reaches in Portugal and the lower Guadiana is partly in Portugal and partly on the boundary. Only the Guadalquivir and the Ebro, of the larger rivers, are entirely in Spanish territory. The longest of the rivers is the Tagus (565 m.). The rest in the order of their length are the Guadiana (510 m.), the Douro (485 m.), the Ebro (466 m.), and the Guadalquivir. The Minho, which divides the Cantabrian from the Galician mountains, and its tributary, the Sil, which rises in the north-west corner of the Meseta, is much shorter.

The mouths of the Minho, Douro and Tagus form estuaries which provide good harbours for shipping but all rapidly become unnavigable toward the interior. In fact only the Guadalquivir can really be classed as navigable for any appreciable distance from the sea, ships being able to ascend it as far as Seville. The others flow in deep rocky valleys which they have cut across the Meseta. Their water supply is scanty, their deeply cut valleys are difficult to cross, and the river beds so far below the level as to make them useless for irrigation. The Ebro makes its way to the Mediterranean by way of a tortuous gorge and so affords no means of river transportation to the sea. Its great importance lies in its plentiful waters for irrigation purposes derived from both the Pyrenees and the Cantabrian mountains. Lakes of any considerable size are few, the only important ones being two coastal lagoons in the Mediterranean—the Albufera de Valencia, the Mar Menor in Murcia—and the Laguna de la Janda in Cadiz behind Cape Trafalgar. There are many small alpine lakes, and small salt lakes are to be found in every steppe region.

GEOLOGY

Geologically the Iberian peninsula consists of a great massif (the Meseta) which has been composed by Archaean, Palaeozoic, and eruptive rocks partly concealed by a covering of Tertiary strata but characterized by the absence, excepting in its margins, of any marine deposits of Mesozoic age, and bordered on the north, east and south by zones of folding in which the Mesozoic and early Tertiary beds are involved. The Meseta is a fragment only of the great Hercynian mountain system which was formed across Europe at the close of the Carboniferous period. The earth-block which forms the Meseta was individualized at the close of the Palaeozoic era. During the Mesozoic era the Hercynian system of which it is a part was shattered and large portions of it sank beneath the sea and were covered by Mesozoic and Tertiary strata. But other portions remained above the sea and of these the Meseta was one. Around it the deposits of the Jurassic and Cretaceous seas were laid down. During the Tertiary era these deposits together with the earlier Tertiary beds were crushed against the old massif, thus forming the folded zones of the Baetic ranges on the south, the hills of southern Aragon in the east, and the Pyrenees on the north.

There are clear evidences of earlier (Huronian and Caledonian) movements on the Meseta, but worn folds of Carboniferous formations embedded in the Hercynian structure may represent in places an older discordant structure dependent on earlier movements.

Tertiary movements soldered to the Meseta the formations by the north-east, where the folding action lay within the early (Palaeogene) Tertiary period, and of the south-east, where the folding was most intense, in the later Neogene period before the Tortonian epoch. The Tertiary pressures also caused many important movements in the Hercynian massif itself. Ancient fractures were rejuvenated, large interior basins were formed, and the strata were folded and crushed with great violence in the borders of the massif. During the Pliocene period the Meseta was given a general tilt westward. Later differential Tertiary movements modified the Central Cordillera system and accentuated the separation of the northern from the southern submeseta, leaving them at very different altitudes from each other and from the marginal depressions and lowlands.

The areas of regional metamorphism on the Meseta are formed of plutonic rocks, broadly granites, which pass upwards into an Archaean, or strata crystalline series in Galicia, Portugal, and the Central Cordillera system. They appear elsewhere aligned with the Palaeozoic series, principally along a line from Alcántara to Andujar. This series shows these levels—the lowest, Augen-gneiss; the intermediate, micaceous gneiss with schists and crystalline limestones intercalated; and the uppermost, lustrous schists and phyllites. These materials appear now at the surface among granitic rocks—the massif of Galicia and North Portugal,—the central sierras,—in the Montes de Toledo, and in South Portugal on the plateau of Evora and Beja which extends eastward by the Sierra de Aracena to the Sierra Morena point north of Seville.

Palaeozoic.—The oldest Palaeozoic strata are referred, from their included fossils to the Cambrian, Ordovician and Silurian systems. They range through a vast region of Andalusia, Estremadura, Castile, Salamanca, León and Asturias, and along the peaks of the Pyrenees and the Cantabrian mountains. In eastern Galicia and Asturias, and in western León, the Cambrian and Silurian trendlines swing round a quarter-circle following the outline of Galicia and northern Portugal. The Silurian of the sierras (Ocejón, Alto Rey) lying to the north-east of the Sierra de Guadarrama trends south–south-west, south, and, finally, south-west. Round the gneissic vestiges of the Toledan massif the Cambrian and Silurian, partly metamorphosed, in the neighbourhood of the granites, trend west-ward and the north–west-ward in the Montes de Toledo and the Sierra de Altamira. From the Sierra Morena front the trendlines, running at first parallel to the line of front, swing to the west and west–north-west round the strata-crystalline of southern Portugal. Farther east they run freely to the north-west in the great belt of Palaeozoic which stretches from La Mancha to beyond the Portuguese frontier. The older Palaeozoic of the north culminates in the Teleno (7,181 ft.) belonging to the Montaños de León. In the south the Sierra Morena is the scarped southern edge of the main mass of the Palaeozoic, cut by a series of faults partly of Permian and partly of Pliocene date. The Palaeozoic also formed the two plateaux to the south of the Sierra Morena and a low plateau in the east notable for the complex lead-silver zone of Linares and La Carolina; and a broad plateau in the west extending from the Andévalo district south of the Sierra de Cuacena to the western shores of Portugal.

In the hinterland the Palaeozoic Sierras trend finally to the north-west, washing the Hercynian axial lines which curve into this direction from both the Sierra de Toledo and the Sierra Morena. At Montoro the course of the Guadalquivir has been imposed on the Palaeozoic by the removal of overlying Tertiary formations. East of Almadén the Palaeozoic is pierced by Quaternary basalts of the Campo de Calatrova beyond which tongues of Mesozoic projecting from La Mancha bring the Guadiana drainage into the Palaeozoic area.

Mesozoic.—In Portugal the Mesozoic series consist of deposits laid down in the geosyncline which existed to the west of the Meseta during that era and which disappeared at its close after retreating north of the present Tagus river draining the Upper Cretaceous. Geosynclinal conditions were most marked during the Jurassic whose "Tusitanian" stage has a thickness of 5,000 ft. in the Torres Vedras area. Jurassic limestones sketch the structural skeleton of the Mesozoic fringe of the Meseta. In the Mondego region, a Jurassic upfold, flanked on two sides by Turmian formations, runs west–south-west to Soure and then west–north-west to Cape Mondego by Verrede and Buarcos. This axis delimits on the south an area of worn Cretaceous reliefs above which stand out the Jurassic of Contanhede separated from the sea by a broad belt of high dunes. The Cretaceous, which appears in depressions along the principal axis as well as on the flanks of the Jurassic zone, is widely developed in the Cintra region where the Jurassic scarcely emerges. South of the Tagus river movements of Alpine date have brought up the Jurassic to form the higher parts of the complicated Sierra Arrabida which runs west–south-west to Cape Espichel. In Algarve the Lias and Jurassic, with a fringe of Cretaceous towards the littoral, are folded against the southern edge of the plateau and contribute granite and limestones to the complexity of the zone.

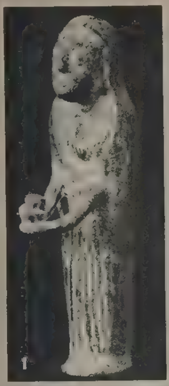
The lower Carboniferous rocks of Spain consist partly of limestones and partly of sandstones and conglomerates like the culm of Devonshire. It is in the culm of the province of Huelva that the celebrated copper mines of Rio Tinto are worked. The Upper Carboniferous is formed, to a large extent, of sandstones and shales, with seams of coal; but beds of massive limestones are often intercalated, and some of these contain *Fusulina* and other fossils like those of the Russian Fusulina limestone. In the Cambrian and Silurian areas of the north-west, Tertiary movements have probably compressed the strata in the arc of the western Asturias, but not in the Carboniferous area to the east where the Carboniferous has its most extensive development in Spain, covering a considerable section of the eastern Asturias, and extending more or less continuously through the provinces of León, Valencia and Santander.

The blue-grey mountain limestone of the lower Carboniferous form the triple massif of the Picos de Europa and the crests of many sierras. The culm, which also forms mountains, especially along the upper Deva, marks the transition to the continental conditions in which originated the sandstones and slates of the middle Carboniferous, with their intercalated beds of coal, principally the beds of the Tangres and Mieres basins. Tertiary movements raised the Carboniferous along an east–west axis to form the Cantabrian chain.

To the north of the Carboniferous of the central Asturias lies an area of Mesozoic marine invasion with deposits in a belt trending east and west behind the Palaeozoic "island" by the Cabo de Peñas district. From Peña Prieta eastward the altitude of the summits of the Cantabrian chain declines and the Cretaceous is rapidly substituted for the Carboniferous. In the half-circle between Peña Tabra and the Sierra de Alcaraz the Meseta is bordered by highlands principally of Mesozoic formations. The tectonic relations between these highlands and the Cantabrian system, which continues eastward in the Cretaceous to the Pyrenean front, is not clear.

The Permian is probably represented by some of the red sandstones, conglomerates, and slates in the Pyrenees, in the Sierra de Cuenca and in Andalusia. The Triassic system is well-developed in the north of the peninsula along the Cantabrian chain and eastwards to the Mediterranean. It is composed of red and variegated sandstones, dolomites, and marl, and contains deposits of gypsum, aragonite, and rock salt. The Jurassic overlies these strata and is especially important in the eastern part of the peninsula between Castile and Aragon, along the Mediterranean border, in Andalusia, and on the flanks of the Pyrenees. The early Jurassic conglomerates and grits are followed by limestones, some dolomitic variegated marl, and overlying spongy limestones or dolomites. The neritic Lias and Jurassic are important only on the borders of New Castile.

The Cretaceous forms the broad plateau of the Lora on the southern front of the Cantabrian mountains north-west of Burgos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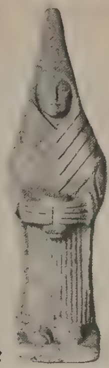
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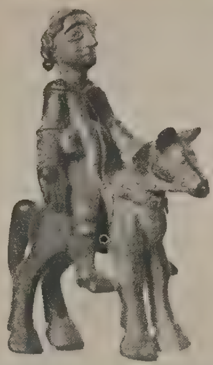
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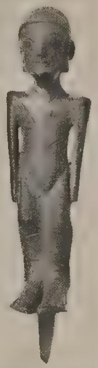
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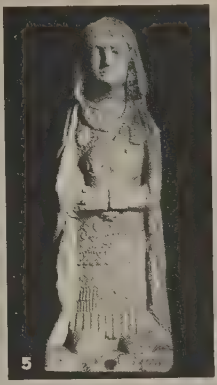
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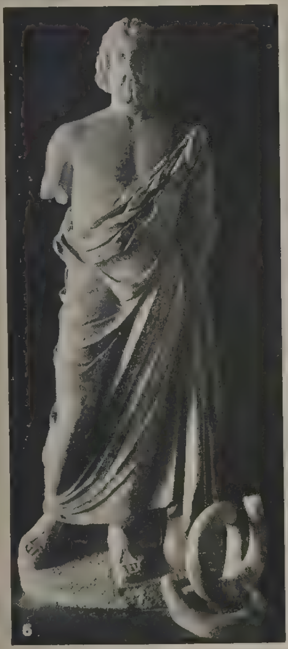
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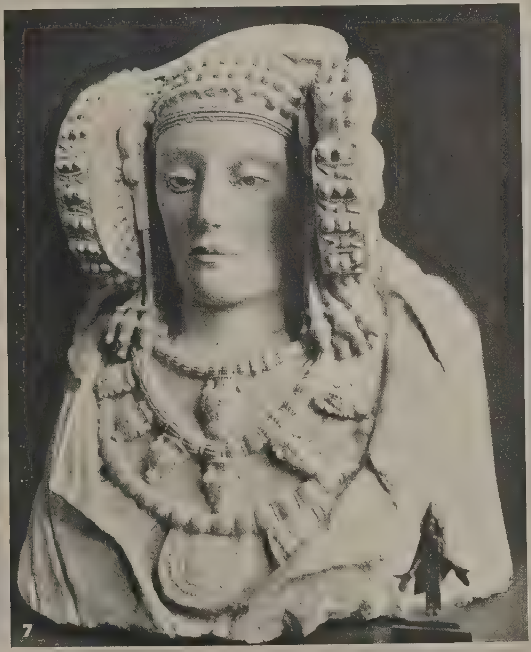
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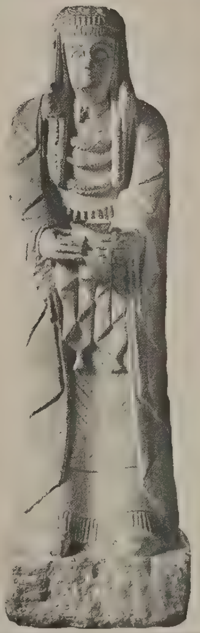
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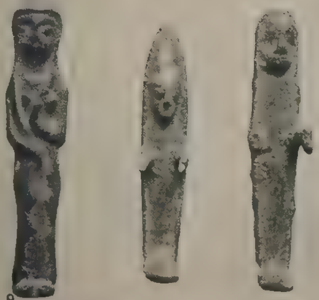
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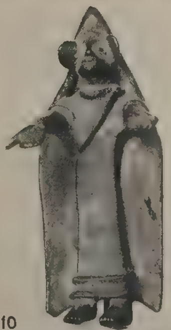
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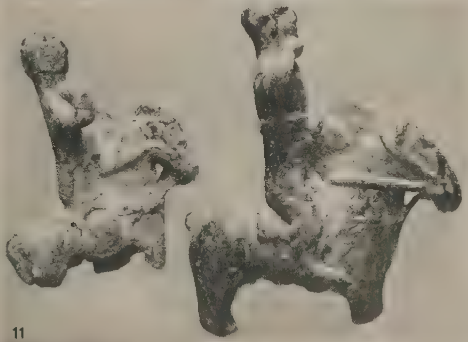
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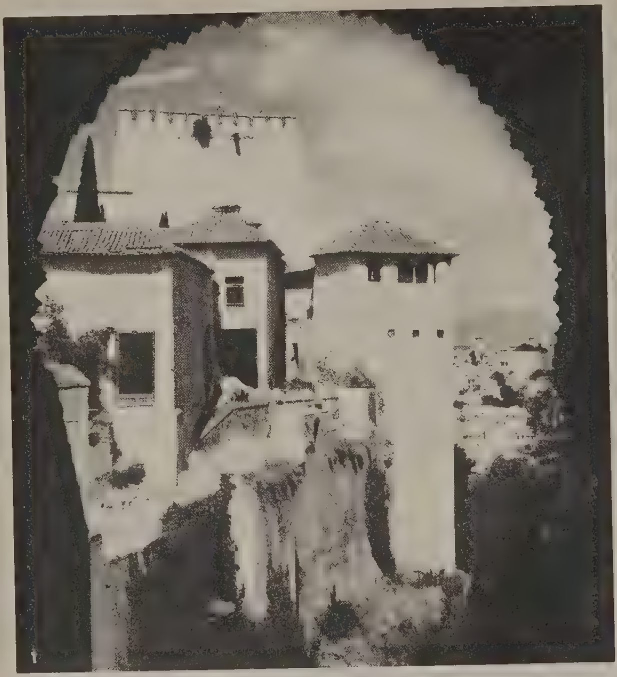
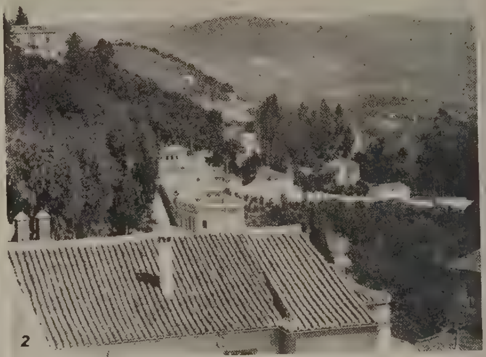
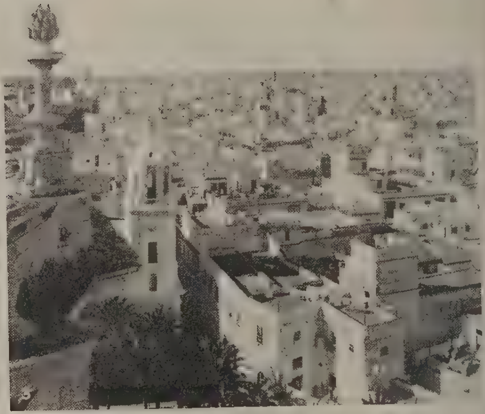
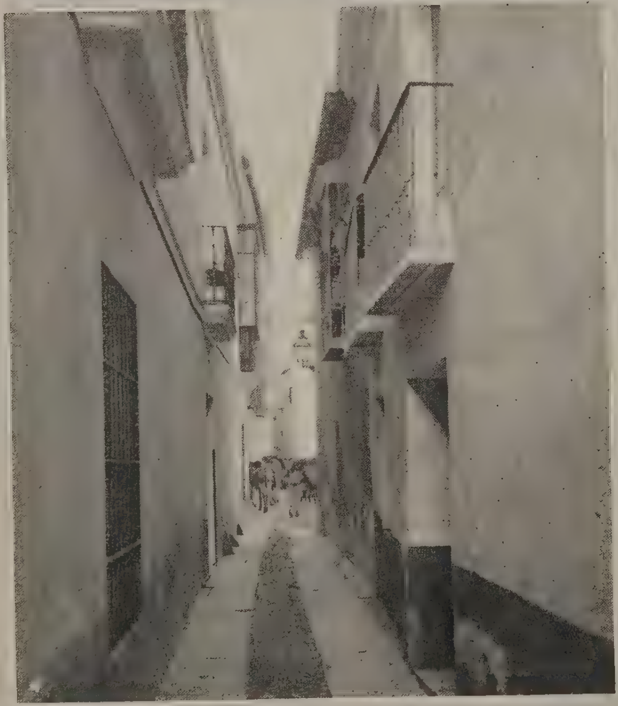
EXAMPLES OF OLD SPANISH ART

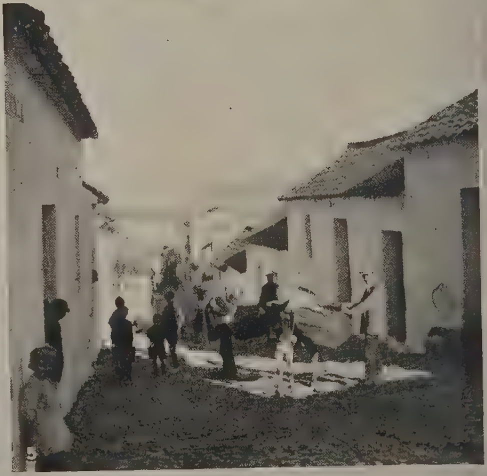
1. Iberian figure of La Luz (the light) near San Antonio el Pobre. 2. Statue from Cerro de los Santos. 3. Iberian bronze figurine of a man on horseback, from the south-eastern part of Spain. 4. Iberian bronze figurine. 5. Statue from Cerro de los Santos. 6. Asklepios statue of Emporion discovered during excavations made in 1909. 7. Dama de Elche. Figure now in the Louvre. 8. Statue from Cerro de los Santos. 9. Iberian figures from Castellar de Santisteban (St. Stephen), Province of Jaen. 10. Bronze Iberian figurine from Santa Elena. 11. Horsemen from south-eastern Spain











PHOTOGRAPHS, (1) BURTON HOLMES FROM EWING GALLOWAY, (2, 3, 4, 5) PUBLISHERS PHOTO SERVICE

SPANISH SCENES

1. A wall and two of the many towers of the Alhambra, magnificent palace of ancient Moorish kings. Built within a strong fortress on a high plateau in Granada
2. View of Granada. The Mountain of the Sun in the Sierra Nevada seen in the background
3. Looking from a cathedral tower over the city of Cadiz towards the harbour
4. Narrow street in Cadiz. This type of street is often found in olden cities of Spain as well as in other countries of Europe
5. Looking across the bay toward Gibraltar from the city of Algeciras. The big rock may be seen in the distance

and extends southward and westward into a Cretaceous isthmus in the northern side of Miocene "Straits of Burgos." An upfold brings it to the surface again in the island-like Sierra de Atapuerca on the south side of the "straits" toward the Montes de Oca. From the scarp of the Urbión the Cretaceous dips gently southward and Upper Cretaceous limestones form small, bare, fault-bounded plateaux sharply contrasting with the pine-clad slopes of the lower Cretaceous and appearing at the surface not only on the margin of the zone but in the upfolds of small radius among the Tertiaries of the Domo, at Burgo de Osma, Sovia and elsewhere.

South of the Jalom river beyond the Paramess de Molina the border of the Meseta is formed principally of Jurassic limestones and marl commonly capped by horizontal limestones of the Cretaceous and forming a series of high plains rather than mountains in which the *muela,* or molar-tooth, summit is typical. The different alineations, however, are known as the Serrania de Cuenca, Montes Universales, and Sierra de Albarracin.

Tertiary.—Deposits of Tertiary age cover rather more than a third of Spain. On the Meseta the Tertiary formations were laid down in the basins of Old and New Castile and in the minor systems of Castello Branco (Beira Baixa); Badajoz, and others of the Tagus and Guadiana valleys. In the west arkose grits of Lutetian date from a broad, monotonous plain in the provinces of Zamora and Salamanca and the old Tertiary (Palaeogene) beds appear also in the east near Lerma and in the plateau of Sovia. Elsewhere the outer deposits of Palaeogene are insignificant. The continental Miocene, unconformable on the Palaeogene, consists of fine-grained materials laid down within the basins of the Palaeogene, and the Cretaceous to which it is unconformable had been folded in the margins of the basins, by rivers (Tartonian), brackish ponds (Sarmatian) and in marshy ponds (Pontian). In spite of stratigraphic discontinuity the forms of the Miocene relief are constant and characteristic. The type form is the tableland (*mesa*), with its flat upper surface of the limestone cap (*paramo*), its slope of marl (*cuesta*), and its sands or clays of the lower slopes forming plains (*elanuras, canapiñas, campos*). As the erosion advances the worn table-lands appear as truncated pyramids or form low *mesas* capped by the beds of harder marl. Finally great stretches of plain are formed on the level of the Tortonian on lower Sarmatian. Space will not permit a full description of the Tertiary formations elsewhere. The Eocene marine strata are developed in the basin of the Ebro and Miocene deposits occupy some small tracts especially on the coast of Valencia although most of the sandy Tertiary rocks of the latter district are Pliocene. In the Baetic depression the marl of the Tertiary rocks of whatever level are of great importance, supplying the rich soil of the Cijarafe olive groves west of Seville and of the vineyards of Jerez.

Quaternary deposits spread over about a tenth of the country. The largest tract of them is to be seen to the south of the Cantabrian mountains, although another but little smaller flanks the Sierra de Guadarrama and spreads out over the great plain from Madrid to Cáceres.

From the rivers Douro, Tagus, Guadalquivir and Ebro, E. H. Pacheco has described recently four fundamental terraces at heights of 30, 100, 200 and 330 ft., which are fairly constant within limits of 4–33 ft. from the higher terraces, and he has commented on the absence of terraces on the Spanish section of the Guadiana river. The highest terrace is of late Pliocene date and to it are referred the famous rañas, extensive platforms of coarse detritus high on the northern front of the Montes de Toledo. The others seem to be related to the terminal moraines of the Pleistocene glaciation with which, in some cases at least, they are continuous. There moraines are found as low at 2,300 ft. on the Sierra de Estrella (one of the westernmost sierras of the central cordillera); and the topography of the Picos de Europa (of the Cantabrian mountains), the Sierra de Guadarrama and the Sierra de Gredos (of the central cordilleras), the Sierra Nevada, and the Iberian ranges from the Demanda to Moncaya has been modified to some degree by glaciation. But the centres of glaciation in each of these cases were relatively small, and the action local. Only in the Pyrenees are the glacial phenomena of real topographical importance. The terraces, on the other hand, are of first importance, making irrigation possible in areas otherwise arid.

CLIMATE AND SOILS

Looking at Spain as a whole, for the year as a whole, we can distinguish, in respect of temperature, the very different climates of the equable Biscayan and north Atlantic coasts; of the interior, with extremes of temperature always, but with a winter which varies from the traditional nine months of the higher parts of Old Castile to the short two-months winter of the lowlands of Extremadura; of the Mediterranean coast with its very short winter and rather hot summer; and of the subtropical south and south-east, where winter, in the popular sense, hardly exists.

More important is the distinction in respect of rainfall between Spain of the north-west and north (roughly as far south as the line León-Pamplona-Huesca), with a mean annual rainfall of 24 in. and over, fairly well distributed over the year, and the rest of the country, arid Spain, with rains insufficient in quantity, or badly distributed, or, more commonly, both. There is a general decline in the mean annual rainfall from north-west (Santiago, 66 in.) to south-east (Almeria, *c.* 10 in.), but this is interrupted by the minimal rainfall of the basin of Old Castile, where Salamanca and Zamora, like Zaragoza in the Ebro basin, lie within an isohyet of 12 in., and by the orographic rainfalls, which are sometimes remarkable; thus, in the Baetic calcareous zone, in spite of a rainless summer season, the annual rainfall may be of 80 in. on the outskirts of the Serranía de Ronda.

The rains of arid Spain are spasmodic, Mediterranean rains falling in large drops for a few hours of a few days of the year. They are also irregular in amount from year to year; the rainfall records of 95 years for San Fernando, near Cadiz, for example, show a mean deviation, from the mean, of 26%. Long-term data are accordingly necessary for the construction of satisfactory maps of rainfall, while the number of long-term stations is limited (contrast France, 31·3 in.; Portugal, 31·6 in.).

Irregularity of the seasonal rain-supply, and the entrenched courses of the rivers of the interior, prevent much use being made of their waters for the partial relief, by irrigation, of the prevailing aridity. Both of these difficulties are now being overcome for the rivers of the Ebro system by the provision of immense engineering works. (*See* ARAGON.) On the lower courses of the rivers of the short eastern slope the relief is, by exception, highly favourable to the establishment of important irrigation systems. (*See* VALENCIA.)

Properly conserved, arid soils, although they are inevitably exposed to the sterility resulting from sequences of years of drought, have, nevertheless, certain advantages of chemical composition, due to the smaller degree to which plant foods are lost by leaching, which enable them to maintain a standard of productivity lower than that of more humid regions and requiring a greater output of labour, but more independent of artificial fertilization, especially if natural manure is supplied by pasturing. Dry-farming, the *cultivo de secano,* is the third and most widespread of the geographical institutions of arid Spain.

Subsoils include the Andalusian "black-earths" and new soils, chestnut or red in colour. An extreme type is the *calvero* soils, for which the Castilian name seems likely to become internationalized. In the *calveros,* which arise commonly from past or present attempts to extend cultivation beyond its proper limits, the soil cap is discontinuous and the native rock conspicuous on the surface; tufts of permanent vegetation depend on, and protect, the small patches of soil; in the open spaces lichens are the chief covering, with occasionally transitory grasses.

Saline soils occur locally, in the more arid parts of Old and, especially, of New Castile and of the Ebro basin, and elsewhere, but the extension of the saline area is greatly modified by human agency. In east Spain, in general, and in Andalusia, red soils, the "Mediterranean red earths," are commoner than chestnut, and in the dry south-eastern corner tawny or grey soils are commoner than red; the precise significance of the colour is not known.

FLORA

The Northern, humid area is dominated by mesophytic formations of the Central European and North Atlantic type, while the rest of Spain is characterized by xerophytic formations distinctly Mediterranean in type. Increasing aridity and proximity to the African continent are reflected in marked African features in the vegetation of the south-east. Further, owing to its extraordinary variety of climates, altitudes, exposures and soils, Spain is richer in botanic species than any other European district of the same size, and endemic species are particularly numerous. These are not only characteristic of the higher parts of the Pyrenees and of the Cantabrian and Central ranges, but they also occur in great numbers in the central plateaux of the interior. Of the 5,660 vascular species which have been identified, about one-third are Central European or Alpine in character, one-quarter are endemic, one-fifth are Mediterranean and one-twelfth are African and Atlantic.

At the present day less than 5% of Spain is under forest. Of this over one-third is pinewood. Deciduous forests are practically confined to the humid north, where Central European formations of oak, beech, chestnut, birch, ash and lime, with meadows and heath-moors, are dominant. In arid Spain the vegetation, eminently xerophytic, is mainly evergreen. Conifers, such as the Spanish pine (*Pinus halepensis*), the pinaster (*P. pinaster*), the Corsican pine (*P. larico*), the stone-pine (*P. pinea*) and the Pinsapo fir (*Abies pinsapo*) and junipers, typically *Juniperus thurifera,* are common, especially on the upper slopes of the main ranges, but by far the most typical trees of dry Spain are the two species of oak, *Quercus ilex,* the evergreen or holm-oak, and *Quercus suber,* the cork oak. *Quercus ilex* is the most widespread tree in Spain. Deciduous species are not entirely absent from arid Spain, but they are, however, very largely confined to the vegas, with their black poplar groves, and the higher, more humid valleys of the northern ranges bordering and crossing the central Mesetas. Here beech, birch and lime occur, but even many of these show drought-resisting features. Sweet chestnut woods are characteristic of siliceous mountain soils in the south. In central Spain, woodland formations are practically confined to the mountain slopes, and the predominating vegetation over the Mesetas is a scrub of evergreen bushes and large herbaceous plants of the Cistaceae and Labiatae families. Areas dominated by Cistus scrub are known to the Spaniards as *jarales,* and are particularly extensive over the Middle Tagus and Guadiana basins and on the slopes of the Sierra Morena, where the ladanum bush (*Cistus ladaniferus*) is particularly abundant. Areas, on the other hand, which are characterized by the aromatic Labiatae, such plants as thyme, lavender, sage and rosemary, are known as *tomillares* (from *tomillo,* thyme) and occur chiefly in the La Mancha (*q.v.*) region.

Leguminosae, particularly Spanish broom (*Spartium junceum*) and furze are also common in the interior.

In the past a far greater proportion of Spain was forested than is so at the present day. The pinewoods of the Iberic and Carpetanian ranges, the important cork oak-woods of the south and of Catalonia, and the many scattered stretches of evergreen oak are clearly relics of far greater forests, which have been destroyed by ruthless clearing and exploitation by man. As a result, in many of the uncultivated stretches of arid Spain there now exist formations which can only be regarded as degenerate forms of vegetation, due to the destruction of the original forests. Large areas in Murcia, in parts of La Mancha and on the plateaux of Guadix and Huescar in Granada, are covered with esparto grass (*q.v.*).

In the south-east of the peninsula the extreme aridity of much of the area, combined with the high temperatures, has given rise to semi-desert conditions, with a distinctly African type of vegetation. The dwarf palm (*Chamerops Humilis*) grows in this region, but is nowhere a very important feature of the vegetation.

The eastern districts, from Catalonia southward to Cape Nao, have a distinctly Mediterranean type of vegetation, evergreen shrubs, including many aromatics, of the class known to the French as maquis and described by the Spaniards as *monte bajo* to distinguish it from *monte alto*—the forest.

FAUNA

Cut off from Europe by the Pyrenees and in recent geological touch with Africa, Spain has European fauna of special types, with marked African affinities in the South and many local varieties.

Of mammals which come under this head the most important are the common genet (*Genetta genetta*), which extends into south-west France, and a species of ichneumon (*Herpestes widdringtonii*), which is restricted to the peninsula. Both the above constitute the only European representatives of the tropical Old World family of Viverridae or civets. The Barbary ape (*Macacus sylvanus*), which inhabits the peninsula of Gibraltar and is the only species existing in a wild state in Europe, is generally believed to have been introduced from Africa at a very early date. Of the mammals peculiar to the peninsula, but showing greater affinities with the fauna of Northern and Central Europe, the most typical are the Spanish lynx (*Lynx pardellus*), a purely Iberian species; the Andalusian wild cat (*Felis sylvestris tartessia*); the Spanish wolf (*Canis lupus signatus*), peculiar to central Spain; the Spanish fox (*Vulpes vulpes silaceus*); the Iberian weasel (*Mustela iberica*), the Spanish red deer (*Cervus elaphus*), the Iberian hare (*Lepus granatensis*), the large Guadarrama squirrel (*Sciurus vulgaris infuscatus*), several voles and various smaller forms, such as the Andalusian dormouse.

The birds of Spain are very numerous, partly owing to the position of the peninsula on the route of bird migration between North Europe and Africa, by way of the Strait of Gibraltar. Spain is visited by groups migrating south in winter and others moving north in spring. Thus the guillemot and gannet appear on the Cantabrian coast in winter, while the flamingo nests in the Quadalquivir marshes in May.

A feature of Spanish ornithology is the large number and variety of the birds of prey. These include the bearded vulture (*Gypaëtus barbatus grandis*), still common in the mountains of central and northern Spain, though dying out elsewhere, and two special forms, the Spanish eagle-owl (*Bubo bubo hispanus*), confined to the peninsula, and the Spanish Imperial eagle (*Aquila heliaca adalberti*), which is also found in North Africa. Other peculiar subspecies are the royal cuckoo (*Cuculus canorus minor*), and the Iberian green woodpecker (*Picus viridis sharpei*). The azure-winged magpie (*Cyanopica cyanus cooki*) is remarkable in that it represents a genus which only occurs elsewhere in Eastern Asia. The red-legged partridge (*Alectoris rufa*) and two species of sand-grouse (*Pterocles orientalis* and *P. alchata*), though not peculiar to the peninsula, are common in the so-called steppe areas and, besides the flamingo (*Phoenicopterus ruber*), the southern shrike (*Lanius excubitor*), two quails, the Andalusian hemipode (*Turnix sylvatica*), and other water birds, are characteristic of the south.

Though a large number of reptiles occur in Spain, only the viper (*Pelias berus*), which is not abundant, is deadly to man. The great *Coelopeltis monspessulanus,* sometimes 5 ft. long, is the largest Spanish lizard, while *Lacerta ocellata* is a large species abundant in central and southern Spain. The common Iberian land-tortoise (*Testudo iberica*) and the European pond-tortoise (*Emys orbicularis*) are also typical. The chameleon (*Chamoeleon vulgaris*), a rare African form, is sometimes found in southern Spain. The amphibians exhibit many autochthonous forms, notably *Chioglossa lusitanica,* a species of salamander, while the repulsive "gallipato" (*Pleurodeles waltli*), is abundant in tanks and pools. Insect life is remarkably rich, and many of the numerous species of beetles and butterflies are endemic. Trout abound in the mountain streams and lakes, and barbel, carp and tench are other common fresh-water fish.

POPULATION

The Iberian peninsula has such important remains of most of the phases of civilization, from the later Palaeolithic age onwards, that the racial make-up of its population is, doubtless, highly complex. It is said that, as in the Dordogne in France, and on the Welsh moorlands and elsewhere, very long-headed dark types which were characteristic of Western Europe in the Aurignacian period of the Palaeolithic, still occur among the people of the Basque Provinces and Tras-os-Montes. The peninsula, generally,

Provinces	Area in sq. miles	Pop. in 1900	Pop. in 1925 (estimate)	Density per sq.m. in 1925
New Castile:				
Madrid	3,084	775,034	1,136,760	368·5
Guadalajara	4,676	200,186	206,004	44·0
Toledo	5,919	376,814	463,836	78·3
Cuenca	6,636	249,696	292,650	44·1
Ciúdad Real	7,620	321,580	464,365	60·9
Old Castile:				
Burgos	5,480	338,828	340,355	62·1
Logroño	1,946	189,376	193,529	99·4
Santander	2,108	276,003	343,295	162·8
Avila	3,042	200,457	213,666	70·2
Segovia	2,635	159,243	171,481	65·0
Soria	3,983	150,462	154,534	38·7
Palencia	3,256	192,473	193,463	59·4
Valladolid	2,922	278,561	283,897	97·1
Asturias:				
Oviedo	4,205	627,069	777,395	184·8
Leon:				
Salamanca	4,829	320,765	328,368	68·0
Zamora	4,097	275,545	267,464	65·2
Leon	5,936	386,083	417,380	70·3
Estremadura:				
Badajoz	8,451	520,246	688,359	81·4
Cáceres	7,667	362,164	429,719	56·0
Galicia:				
Corunna	3,051	653,556	721,103	236·3
Lugo	3,814	463,386	473,514	124·1
Orense	2,694	404,311	416,142	154·4
Pontevedra	1,695	457,262	555,195	327·5
Andalusia:				
Almeria	3,360	359,013	368,732	109·7
Granada	4,928	492,460	590,980	119·9
Malaga	2,812	511,989	560,450	199·3
Cordova	5,299	455,859	591,275	113·5
Jaen	5,203	474,490	624,044	119·9
Cadiz (with Ceuta)	2,834	452,659	558,277	196·9
Seville	5,428	555,256	729,752	134·4
Huelva	3,913	260,880	360,101	92·0
Valencia:				
Castellon de la Plana	2,495	310,828	312,456	125·2
Valencia	4,150	806,556	970,064	233·7
Alicante	2,185	470,149	526,934	241·1
Murcia:				
Albacete	5,737	237,877	307,858	53·6
Murcia	4,453	577,987	658,826	147·9
Catalonia:				
Lérida	4,690	274,590	320,563	68·3
Gerona	2,264	299,287	336,529	148·6
Barcelona	2,968	1,054,541	1,403,957	473·0
Tarragona	2,505	337,964	355,423	141·8
Aragon:				
Huesca	5,848	244,867	252,237	43·1
Saragossa	6,726	421,843	510,218	75·8
Teruel	5,720	246,001	256,913	44·9
Navarre:				
Navarre	4,055	307,669	332,313	81·9
Basque Provinces:				
Biscay (Vizcaya)	836	311,361	434,170	519·3
Guipúzcoa	728	195,850	278,166	382·0
Alava	1,175	96,385	99,074	84·3
Balearic Islands	1,935	311,649	346,620	179·1
Canary Islands	2,807	358,564	509,287	181·4
Total	194,800	18,618,086	22,127,699	113·5

is inhabited by long-headed peoples without any of the large blocks of broad-heads which characterize, for example, France and Italy.

The Basque language (*q.v.*) is a mysterious survival in the western Pyrenees (Navarre), and in regions to the west of these, which are thence called the Basque Provinces. The Catalan language, widely spoken in north-east Spain and French Roussillon, is allied to Balearic speech and Provençal, and differs in many ways from Castilian Spanish, though both are derived, in the main, from Latin. The Galician dialect is akin to Portuguese. It was usually the east, south, and west coasts of the peninsula that were mostly in contact with ancient Mediterranean civilizations, and the contrast in culture, and in political relations between Galicia and the Asturias, on the one hand, and the rest of Spain has been marked in different ways at many different periods, but the natural differences between "pluviose" and "arid" Spain have played their parts here. The great regions of Spain, italicized in the table in the preceding column, all have bases in physical features.

It has often been said that Roman Spain had a large population, and estimates up to 40 or 50 millions have been ventured, but little is known save that Tarraco (Tarragona) was a very large place and that there were large garrisons. The first Spanish census was taken in 1594 and, if an estimate be added for parts not then included, a figure of 8,200,000 is reached. In 1787 the total was 10,268,150, in 1857 it was 15,464,340, in 1897 it had risen only to 18,132,475. Starting, therefore, with a relatively high figure in the 16th century, Spain fell behind other lands in the 19th century, when these developed industry. The Spanish empire in the New World was a severe drain upon the manhood.

It will be noted that there has been an increase in population in all the provinces since 1900.

The towns with a population (estimated) over 100,000 in Dec. 1925 were:—

Town	Pop. 1925	Town	Pop. 1925
Madrid	791,511	Saragossa	150,051
Barcelona	745,711	Murcia	149,485
Valencia	262,647	Bilbao	144,985
Seville	212,326	Granada	106,461
Málaga	157,250		

Madrid and Barcelona show the greatest increase in population. In 1877 Madrid had only 397,816 inhabitants; this had risen to 539,835 in 1900, and the subsequent quarter of a century has brought it to 791,511. Barcelona had 277,000 inhabitants in 1877; they had increased to 533,000 in 1900, and reached 745,711 in 1925.

Religion.—Roman Catholicism is the established religion, and, with the exception of a small number of Protestants, Jews, etc., claims the adherence of the whole population. The relations between Church and State were defined by concordat in 1851, and this has remained in force, except for the admission of more religious orders than those mentioned in the document, until the present time. The Constitution requires the State to support the clergy, the church buildings, etc. There are nine metropolitan sees and 51 suffragan sees. The archbishop of Toledo is primate, and the other archbishops reign at Burgos, Granada, Compostella, Saragossa, Seville, Tarragona, Valencia and Valladolid. Difficulties arose for the Roman Church during the Revolution from 1868 to 1877, especially in Catalonia and Andalusia, which were centres of Republicanism. But, with the Restoration and the great favour shown to the Church by the new monarchs, there came a marked revival in ecclesiastical and monastic life. The religious orders are very influential in education. There were 4,497 religious houses in 1924, 948 for men and 3,549 for women. Of those for the men, eight were technical schools, 215 were given over to preparation for the priesthood, 103 to charity and 90 to the simple meditative monastic life, while 532 were devoted to education. Charity, education (1,309 establishments) and meditation are the chief functions of the orders for women. The total number of monks would be (1924) about 12,000, and nuns 42,000. Spain possesses 66 cathedrals, 22 collegiate churches, 20,440 parishes and 15,107 chapels. Liberty of worship is allowed.

Constitution and Government.—Spain is an hereditary monarchy, the Constitution of which was voted by the Cortes and became law in 1876. The sovereign is inviolable, but his ministers are responsible to the Cortes, and none of his decrees is valid unless countersigned by a minister. The legislative authority is exercised by the sovereign in conjunction with the Cortes, a body composed of two houses—a senate and a chamber of deputies. The Senate is composed of members of three classes: (1) Members by right of birth or office—princes; nobles (with a certain annual income) and holding the rank of grandee (*grande*); captains-general of the army; admirals of the navy; the patriarch of the Indies; archbishops; cardinals; the presidents of the Council of State and of the Supreme Court and other high officials, all of whom must have retained their appointments for two years; (2) members nominated by the sovereign for life; and (3) members elected by the provinces, academies, universities, dioceses and State corporations. The members belonging to the first two classes must not exceed 180 in number, and there may be the same number of members of the third class. The lower house of the Cortes has 417 deputies, who cannot take State office pensions or salaries; but the ministers and State officials of a salary higher than 15,000 pesetas are exempted from this law. Both Congress (Chamber of Deputies) and Senate are supposed to meet every year. The executive is vested under the monarch in a council of ministers. The ministerial departments are Foreign Affairs, Justice and Worship, War, Marine, Finance, Interior, Public Instruction, Public Works and Labour.

In 1923 a decree appointed Gen. Primo de Rivera chief of the Government and president of a military directory. This was superseded by a civil Government in 1925 under Gen. de Rivera, composed of members of the new political party *Union Patriotica.* All the former ministerial departments have been set up again, but really everything continues much as before. Martial law was proclaimed from Sept. 1926 to Jan. 1927, and thereafter a general assembly was called.

Local Government.—Since 1918 every commune has its own *Ayuntamiento,* consisting of from five to 50 *Regidores* or *Concejales.* The *Ayuntamientos* have charge of the entire local government. Half the members are elected every second year, and the body appoints its own executive. Each Spanish province has its *Diputacion Provincial,* elected by the constituencies. This assembly meets annually and is permanently represented by the *Comision Provincial,* appointed annually. The State executive and the Cortes have little power to interfere with local government. The Basque Provinces have lost a former large measure of self-government, but though they are governed like the rest of Spain, certain *fueros,* or exemptions, are given them, a new statute of exemptions coming into force in 1925. All mayors and municipal councils in Spain were dismissed by decree in 1923 and replaced by members of the Associated Council of Householders. In 1924 a royal decree made possible a law establishing the *Estatuto Municipal,* governing the future municipal organization and administration. More freedom is granted to the *Ayuntamiento,* especially in drawing up its own organization. Women have been given the suffrage, and the voting age for males and females has been reduced to 23 years, and special representation was given to guilds and other corporations.

Spanish law is founded on Roman law, Gothic common law, and the national code proclaimed at the meeting of the Cortes at Toro in 1501 (the *Leyes de Toro*). The present civil code was put into force on May 1, 1889, for the whole kingdom. The penal code dates from 1870 and was modified in 1877. The commercial code was put into force on Aug. 22, 1885, the code of civil procedure on April 1, 1881, and the code of criminal procedure on June 22, 1882. In addition to courts held by justices of the peace, there are 522 courts of first instance (in the *Partidos judiciales*), above these come 50 provincial high courts, with appeal to the 15 divisional high courts, while there is a supreme high court at Madrid. Justices of the peace deal only with petty offences and small civil cases. A court of minors has been established.

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DEFENCE

Historical.—The feudal sovereignties of mediaeval Spain differed but little, in their military organization, from other feudal states (*see* Army). Mercenaries were the only forces on which reliance was placed for foreign wars. These troops called *almugávares* (Arabic=scouts) won a great reputation on Italian and Greek battlefields of the 13th century, and with many transformations in name and character appeared from time to time up to the Peninsular War. Castile, however, had a military system very different from the rest. The forces of the kingdom were composed of local contingents similar to the English *fyrd,* professional soldiers who were paid followers of the great lords, and the heavy cavalry of the military orders. The groups of cities called *Hermandades,* while they existed, also had permanent forces in their pay. At the union of Castile and Aragon the Castilian methods received a more general application. The new *Hermandad* was partly a light cavalry, partly a police, and was organized in the ratio of one soldier to every hundred families. In the conquest of Grenada (1482–92) *mesnadas* or contingents were furnished by the crown, the nobles and the cities, and permanently kept in the field. The *Hermandad* served throughout the war as a matter of course. From the veterans of this war was drawn the army which in the Italian wars won its reputation as the first army in Europe.

With the Italian wars of the early 16th century came the development of the regular army (*see* ARMY). Discipline, the feeling of comradeship and soldierly honour were the qualities which marked out the Spanish army as the model for others to follow, and for more than a century the Spanish army maintained its prestige as the first in Europe. The oldest regiments of the present Spanish army claiming descent from the *tercios* date from 1535. An officer whose regiment was reduced commonly took a pike in some other corps (*e.g.*, Tilly), the *señor soldado* was counted as a gentleman, and his wife and family received state allowances. Nor was this army open only to Spaniards. Walloons, Italians, Burgundians and other nationalities ruled over by the Habsburgs all contributed their quotas. But the career of the old army came to an end at Rocroi (1643), and after this the forces began more and more to conform to the French model.

There were never less than three Irish regiments in the army. In 1808 the *Irlanda, Ultonia* (=Ulster) and *Hibernia* regiments had come to consist largely of native soldiers. At that time the total forces numbered 137,000 men, but the part played by the Spanish standing army in the Peninsular War was certainly insignificant relatively to these figures. But the result of this war and the continued civil wars of the 19th century was the destruction of the old army, and the present army of Spain still bears traces of the confusion out of which it arose. In 1870, when conscription was introduced, and in 1872, universal service was proposed in its place. (X.)

Recruitment and Service.—Recruiting is on a national basis and military service, to which liability is universal, must be performed in person, with certain postponements for family, residential or educational reasons. Reduction of the period of service with the colours to nine months is permitted for those who can afford to pay for the privilege. The compulsory system is supplemented by volunteering between the ages of 18 and 21, the age at which compulsion is applied. Military service is for 18 years. Recruits spend two years with the colours. Of about 47,800 recruits in 1927, about 38,700 were posted to the combatant arms, including 830 to the air force.

Strength and Organization.—The budget effective strength of the army in 1927 numbered 113,434, including 13,434 officers. The organization in the peninsula is in 16 mixed divisions, and the Balearic and Canary Islands each have an infantry brigade with garrison troops of the other arms in addition. The largest cavalry formation is the brigade, of which there are five in the mixed divisions, which vary in their composition.

Forces in Africa.—Recruits in the peninsula and islands for service in Africa (Morocco) number about 11,500 annually. The budget effectives of the army in Africa in 1927 numbered about 88,300, including about 3,100 officers. There is a High Commissioner in chief command of the army in Morocco, with generals in command of the troops in Ceuta, Melilla, Larache and Tetuan. Auxiliary forces include civil guards, carabiniers, etc., in the towns of the Morocco Protectorate. The military air force in Morocco contains workshops, 3 groups of reconnaissance flights at Tetuan, Melilla and Larache, and a hydroplane base with two sea-plane flights at Melilla.

Higher Command.—The king is the supreme head of the army. He also presides over the council of national defence. The central administrative office of the army contains (a) a ministry of war with the usual departments and a special war archives office, (b) the general staff, responsible for training and preparation for war, (c) a supreme naval and military board, and (d) a central board (junta) to mobilize civil industries. Under captains-general or other senior army officers there are 7 military commands in the peninsula (1) Madrid (2) Seville (3) Valencia (4) Barcelona (5) Saragossa (6) Burgos and (7) Corunna. The garrisons of the Balearic Islands (headquarters Palma de Mallorca) and the Canary Islands (headquarters Santa Cruz, Teneriffe), each under a captain-general, form separate commands.

The training centres for officers include a staff college, central musketry school, riding school, army medical academy and schools for infantry, cavalry, artillery, engineers and administrative (supply and transport) officers. There is also a central physical training school. Non-commissioned officers of 3 years service are given special facilities for obtaining commissions through the military academies. Points for special notice are the embodiment of heavy tank units in the artillery, in Morocco (Ceuta and Melilla areas), the light tank units with the infantry (Larache and Melilla areas) and the employment of motor transport in Africa, specially in the engineer, transport and medical services, and for wireless telegraphy. Reliance is placed upon fortifications, mostly of old type, for defence of the principal harbours and naval bases.

Army Air Forces.—The army air forces include an independent flying branch and a branch attached to army units. A squadron contains 3 groups, each of 2 flights of 3 sections of 3 machines in flying condition. The total force includes 3 fighter groups (6 flights), 9 reconnaissance groups (18 flights) and 2 sea-plane groups (4 flights). The army air force is distributed in the peninsula in a training squadron, Madrid, Seville and Leon squadron and Granada group, and sea-plane group. The above-mentioned air force in Morocco is included in the total specified. In addition to the aeroplane and sea-plane units, there is a balloon branch with headquarters, regiment and balloon battalion.

See also the League of Nations *Armaments Year-Book* (Geneva, 1928). (G. G. A.)

Navy.—The Spanish navy is small, but contains representative types of ships to be found in the fleets of greater sea powers. These include:—2 "Dreadnought" battleships, the "Alfonso Trece" and the "Jamie Primero," armed with 8 12″ guns; 1 Aircraft carrier of 10,800 tons, attached to the Flying School for training purposes; 11 Cruisers and light cruisers, the most modern of which are the "Principe Alfonso," the "Almirante Cervera" and the "Miguel de Cervantes" of 7,850 tons, armed with eight 6″ and four 4″ guns and having a speed of 33 knots; 29 destroyers and torpedo boats; 12 submarines; 13 miscellaneous craft.

Three cruisers of about 10,000 tons are to be built to replace the old ships. The seagoing fleet was reorganised early in 1928 and placed under the command of a Vice Admiral. Personnel for the ships' companies is recruited by conscription.

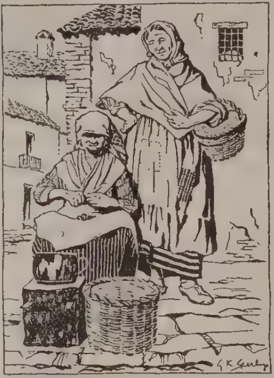
A Council of National Defence which includes a Minister of Marine and a newly-constituted General Directorate of Operations with a staff of naval officers under a vice admiral is responsible for the general direction of naval and military policy. *See Brassey's Naval and Shipping Annual;* F. Jane, *Jane's Fighting Ships* (annual) and H. W. Wilson, *Battleships in Action* (2 vols., 1926). (E. A.)

ECONOMIC AND INDUSTRIAL CONDITIONS

Economic Policy.—The most significant feature in the economic life of Spain is the marked movement towards nationalization. The beginning dates back to 1907, when a tentative step was taken towards the protection of national industries. A stronger and more purely Spanish colour was shown in the Law on taxation of profits, which gave the first legal definition of a Spanish company. This Law (of April 25, 1911) ruled that companies registered and domiciled in Spain were to be considered as foreign companies when: (a) a sufficient number of the directors to form a quorum, and take decisions by themselves, were not Spanish; (b) when the legal managers of the business depend upon a foreign corporation or firm, either as employees or by contract and agreement; (c) when either from the name of the company or its advertisements or business negotiations it may be recognized that it acts under the instructions of a foreign corporation; (d) when the Spanish Administration receives authentic information that sufficient of the shares are in the hands of a foreign corporation to enable this latter to impose its will upon general meetings of the shareholders and in the management of the company.

In 1917 another law for the protection of national industries was passed. In 1919 a revision of the Customs Tariff was ordered, and this began in 1920. The movement towards high tariff protection had commenced. In 1922 a new tariff was promulgated, which afforded very high protection indeed to Spanish industry.

A further move was made in 1924 by the Railroad Statute of July 13, which in some of its measures seems to be specifically directed against foreign companies. Under this Railroad Statute, transport rates are to receive the assent of the Superior Railway Council so that, in effect, the railroads now work under close Government supervision.



BY COURTESY OF GEERLINGS

A CHESTNUT VENDOR OF RONDA, AND A SPANISH GYPSY OF GRANADA

The march towards a more complete form of economic nationalization received a great impetus by the formation of the Primo de Rivera Government in Sept. 1923. This Government forged the nationalistic conceptions of the moment into a weapon for the nationalizing of industry in Spain. They received the willing aid of the industrial provinces, *i.e.*, Catalonia and Vizcaya, for Spanish economic nationalization is really a child of Catalonia and Vizcaya. Thus the present Government of Spain, by taking the lead in the nationalisation of industry and its protection by means of subsidies and high customs tariffs, has really applied a unifying force to the provinces to which more especially were attributed Separatist tendencies.

The Tariff Revision of 1928 is dictated by the same trend. To clear the way for a more complete revision the Spanish-British Commercial Treaty of 1922 was first amended, and by agreement between the two countries many consolidated customs schedules were abrogated.

The declared policy of the Government is to revise all existing commercial treaties which contain fixed or consolidated tariff rates, with the intention of replacing these rates by mutual most-favoured-nation clauses.

It is undoubted that the general policy formulated above has received the wholehearted support of the manufacturing and banking classes of the community. One instance where this satisfaction with the existing state of affairs is perhaps best evidenced is to be found in the prices of Government securities during the year 1927, the funds in general rising during the course of the year from 1 to 3 points.

Under a Decree of July 9, 1926, an Extraordinary Budget was instituted for public works, over a period of just over ten years, terminating at the end of 1936. The amount of money provided in this Extraordinary Budget was 3,538,000,000 of pesetas. Of this total 878,000,000 were to be devoted to naval constructional work, 632,000,000 to the Army, including aviation, while no less a sum than 1,600,000,000 pesetas was to be spent by the Ministry of Public Works on port and hydraulic works, roads and re-afforestation. The sum of 200,000,000 pesetas for expenditure on schools and other buildings was allotted to the Ministry of Education.

It must, therefore, be borne in mind in considering the public finances of Spain that, concurrently with the Ordinary Budget, there is going on an expenditure, over ten years, of 3,538,000,000 of pesetas on a public works constructional programme, while, in addition, there is in existence a five-year programme for the expenditure of sums up to 2,600,000,000 pesetas on railroads. This means that, if an average be cut across the two funds during the next five years after the institution of the Railway Fund, the sum of approximately 500,000,000 pesetas a year must be added for expenditure on railroads, and about 350,000,000 for expenditures on public works construction. Thus, during the first years, an extraordinary expenditure of 850,000,000 must be reckoned with, while after that date, and provided there is no extension to the railroad fund, an expenditure of about 350,000,000 pesetas yearly is provided under the Extraordinary Budget.

It is certainly the hope of the Spanish Government that these large sums will be provided by the Spanish money market on a low interest basis, and this expectation seems on the way to being realized. The successful issue of some thousands of millions of 3% tax-free bonds, at the price of 89 per hundred, made at the conversion of the Perpetual 4% Internal Loan in April, 1928, seems to show that the Spanish Government can secure money in Madrid for 4% and, so long as this is the case, it seems likely that the borrowing programme will be continued in order to provide for large expenditures on public works.

Conditions in Spain during the last few years have shown an improvement. Progress was helped by the political situation of the country, which evidenced a reaffirmation of assent to the present Government. The country has had the advantage of good crops in general, and the policy of industrial nationalisation has been carried a step further without any manifestation of ill effects. In 1927 the olive crop may perhaps be signalled as the best, and the wine output was very satisfactory.

Finance.—The conservatism of the Government in the matter of finances, in so far as regards the ordinary budget, coupled with the elasticity of the revenues, brought about a tremendous reduction in the deficit for the year 1927. The deficit was the very small one of approximately 24,000,000 pesetas, but it is the nearest approach to a balanced budget shown by Spain since the year 1909, and for that reason may be looked upon as a turning point in Spain's progress since the war.

The ordinary budget estimates for 1927 were as follows:

	Million pesetas
Total expenditure	3,139
Less revenue	3,073
Estimated deficit	66

The Minister of Finance, when publishing these estimates, admitted the possibility that the deficit on the ordinary budget might reach 200,000,000. The reality has proved to be much better than was expected, for, according to a provisional statement issued on April 8, 1928, the results were as follows:

	Million pesetas
Total revenue	3,218
Total expenditure on the ordinary budget	3,242
Deficit	24
Extraordinary expenditure	312·5
Total deficit for the year 1927	336·5

The reason for the excess of actual revenue over the estimates is to be found in the increases in taxation yield. The elasticity of the revenue from taxation is shown in the following table giving to the nearest million of pesetas the collections in 1925–26, the estimates for 1927, and the provisional returns of collections in 1927:

	Collected in 1925–26	Estimates 1927	Actual revenue 1927
Profits tax	358	357	394
Industrial tax	157	151	177
Royal dues	146	176	202
Land tax	285	313	336
Sugar	92	90	101
Stamp tax	251	300	313

The total revenue of 3,218,000,000 pesetas compares favourably with that of 2,964,000,000 pesetas for the completed year 1925–26. The expenditure of 3,242,000,000 pesetas is an excess of less than 3% over the estimates. This has been brought about partly by the decline in expenditure in Morocco, where only 74,000,000 pesetas were spent, in comparison with 176,500,000 pesetas in 1925–26.

The deficit for 1927 may be looked upon as a definite turn for the better in comparison with previous deficits, which were:—

	Million pesetas
1922–23	920
1923–24	576
1924–25	570
1925–26	608

Budget Estimates for 1928.—The expenditure was estimated at 3,257 million pesetas, made up of:—

	Million pesetas
Permanent services	3,035
Temporary services	216
Liabilities and accounts	6
	3,257

Revenue is estimated at 3,258,000,000 pesetas, which leaves an estimated surplus on the ordinary budget of 1,000,000 pesetas. This is an increase of only 40,000,000 pesetas over the revenues actually collected in 1927, so it seems probable that the 1928 estimates are on the conservative side. The expenditure of 3,258,000,000 pesetas is an increase of 16,000,000 over the amount spent during 1927 under ordinary budget headings.

Public Debt.—The following table gives the different categories of the Spanish National Debt after the recent conversion of 4% Perpetual Internal Debt:

In Millions of Pesetas, Nominal

	In circulation on April 12, 1928
Internal 4%	5,261
External 4%	911
Redeemable 4%, 1908	131
Redeemable 5%, 1917	965
Redeemable 5%, 1920	1,267
Redeemable 5%, 1926, tax-free	225
Redeemable 5%, 1927, tax-free	3,547
Redeemable 5%, 1927, subject to tax	2,071
Redeemable 4½%, 1928, tax-free	500
Redeemable 4%, 1928, tax-free	1,098
Redeemable 3%, 1928, tax-free	2,034
	18,010

The annual service of interest and sinking fund is estimated at 846,000,000. Taking the revenues as estimated for 1928 at 3,258,000,000, it will be seen that debt services absorb 26% of the revenues.

Note Circulation.—The following figures give the note circulation and reserves at the close of the last three years:—

Millions of Pesetas

	Note circulation	Gold reserve	Silver bullion and specie
1925	4,439·5	2,566·6	652·4
1926	4,339·2	2,592·0	675·1
1927	4,202·4	2,640·6	685·1

In the course of two years the notes in circulation have decreased by 237,000,000, while the gold and silver reserves have increased by 84,000,000 and 33,000,000 respectively. It is not surprising, therefore, that the peseta exchange showed improvement.

Bank Clearings.—The settlements effected through the Madrid Clearing House showed a large increase in 1927 over previous years. The figures in millions of pesetas are:—

1924	12,779	1926	18,119
1925	14,136	1927	54,494

The increase in the total clearings has not carried with it a wider diffusion of the system of payment by cheque. The number of cheques dealt with in 1927 was less than in 1926. The Clearing House Committee sees cause for regret in this fact, and appeals for concerted propaganda to convince commercial firms of the advantages of cheque payments.

Prices.—The general course of wholesale prices in 1927 was downwards, in agreement with the increase in the value of the peseta, as is shown in the following index numbers for foodstuffs and raw materials, compiled on a basis of 100 for the year 1913:

1927	172	1924	183
1926	181	1920	221
1925	188	1913	100

Spain's Foreign Trade.—Statistics published by the Council of National Economy show that the total volume of Spain's foreign trade during 1927 reached 4,481,000,000 pesetas, of which 2,586,000,000 are represented by imports and 1,895 millions by exports. The following table shows the relation to the trade of 1926 and 1925:—

Totals to Nearest Million of Pesetas

	1927	1926	1925
Imports	2,586	2,154	2,249
Exports	1,895	1,606	1,585
Total	4,481	3,760	3,834
Inc. or Decr. in total trade	+722	−74	..
Adverse trade balance	690	548	664

The imports of manufactured articles show by value and volume continuous increases over the three years, and an important increase is to be recorded in coal shipments to Spain, the bulk of the latter being of British origin.

Of the 6,247 tons of ferromanganese imported, Great Britain shipped 3,874 tons, followed by Norway with 2,244 tons. Scrap iron and steel entered Spain to the extent of over 100,000 tons, which compares with 57,000 and 94,000 tons in 1926 and 1925 respectively, Great Britain retaining the lead. Imports of fine carbon steels show a progressive increase since 1925, the 1927 figures being 1,721 tons, of which British firms supplied 610 tons. Seven thousand three hundred tons of tinplates, or double the amount of 1926, were absorbed by the Spanish market; the United Kingdom, as usual, shipped the bulk, viz.: 6,837 tons.

In the machine tool section Germany is again at the head of the suppliers, the imports from Great Britain being on the same level as those of the preceding year. Textile machinery shows a slight falling off, the figures being 3,568 tons in 1927, 3,715 tons in 1926, and 3,903 in 1925. Great Britain's share has dwindled from 1,540 tons in 1926 to 1,116 tons in 1927. In motor-cycles Great Britain retains the lead, with 128 tons, followed by France, with 97 tons. The total imports were 238 tons in 1927, 129 tons in 1926, and 94 tons in 1925, thus indicating a progressive improvement in the market for motor-cycles in Spain. In the motor-car section the United States and France continue to be the chief suppliers.

In comparison with previous years, the imports of cotton piece goods have slightly declined, although the United Kingdom retains the lead in their supply. The same remark applies to the other textiles made of vegetable fibres, and to woollen piece goods.

Exports of iron ore show an advance at 4,800,000 tons, as against 1,900,000 and 3,600,000 tons in 1926 and 1925 respectively. Great Britain absorbed 2,400,000 tons.

Transport.—In July 1925 a railroad fund of 2,600,000,000 pesetas was sanctioned. The railroads may secure advances from the State for the purpose of providing for capital expenditure. The advances made from the fund are a charge upon the earnings of the company in the sense that a part of the earnings proportionate to the amount of capital advanced by the State is returned as its participation.

The total extent of the Spanish railway lines at the end of 1926 was 16,200 km. of which 11,750 km. were broad gauge, 4,224 narrow gauge and 16 km. funicular railways.

The general advance in transport facilities in the interior of Spain is reflected in the following short table:—

Years	Locomotives	Wagons	Tonnage transported
1921	2,765	58,625	32,772,863
1922	3,220	67,766	39,910,285
1923	3,238	67,228	35,848,217
1924	3,325	69,760	43,302,632
1925	3,348	70,422	41,489,060
1926	3,519	72,792	41,869,668

Agriculture.—The agriculturally productive area of Spain is officially estimated at 94% of the total, but a large part of this is not cultivated. The area under cultivation is approximately 46% of the total, while about 48% is pasturage and mountain land. The remaining 6% is classified as unproductive for agricultural purposes.

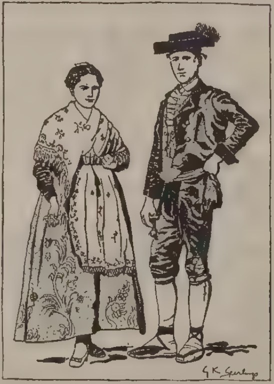
The crop taking the largest acreage is wheat, followed by barley and other cereals. These occupy about 20,000,000 acres, being approximately 16% of the total area. About 6% of the total area is devoted to olives and the vine.

The mainstay of Spain's economic existence is its agricultural production. This fact has not been lost sight of by the Government inaugurated in 1923 by General Primo de Rivera. A vast number of proposals for stimulating agricultural production have been brought forward and put into execution.

Some of the legislation is interesting. For instance, on May 4, 1926, a tax of 10 pesetas to 100 kg. was levied on all oil manufactured from ground nut and sesame seeds, while the previous month imports of these seeds had been limited to 40,000 tons. Later on in the year importation was prohibited altogether. The idea in this case was to protect Spanish olive oil.

Legislation in the same year (May 12–29) instituted a fund of 25,000,000 pesetas for credits to wheat growers. On July 6, a minimum price for wheat was fixed. This had already been done in 1925. These two measures having proved inadequate, on July 9, 1926, the importation of wheat was again prohibited.

As a consequence of the resolutions passed at a conference held in Oct., 1926, a Royal Order of Dec. 11, 1926, established an Orange Committee whose mission was to develop the orange-growing industry. Later on, in April 1928, an attempt was made to form a syndicate of all the orange producers and exporters, but the movement did not meet with anything like unanimous adherence, and at the moment the proposal is in the air. On Jan. 7, 1927, a Royal Order provided for the inspection of oranges prior to shipment. This was a valuable move in the attempt to standardize fruit shipments from Spain, and should undoubtedly lead to great benefits for growers and exporters if the system can be extended and applied to all shipments.



BY COURTESY OF YORK & SONS, LONDON

WELL-TO-DO CASTILIAN VILLAGERS IN FÊTE COSTUME

In October, 1926, a Royal Decree established a Silk Commission for the purpose of developing silk worm culture in Spain. Poultry farming also formed one of the objects of Government solicitude, and a Royal Order of January 18, 1927, promulgated measures for its development.

On Feb. 18, 1927, a Royal Order was published providing for the grant of credits against crops of wheat, oil, wine, rice and wool. The underlying intention of this Order was to facilitate credits to small growers, and the maximum amount of credit to be granted to any one grower was raised from 5,000 to 10,000 pesetas.

A Raisin Committee was formed in June, 1927, with a central office at Denia. The duties of this Chamber are to promote production, export, and consumption of Muscatel grapes and raisins. A Grape Committee was established at Almería, whose duties are the protection of the trade in fresh grapes.

Export bonuses were granted in June, 1927, on rice exported during any one year up to a quantity of 20,000 tons.

In this multitude of measures for the protection and development of agriculture, the wine trade was not forgotten, and a Decree-Law of May 7, 1928, authorised credits on Spanish wines at 5% interest, up to 60% of the value.

Cotton-growing is still in an experimental stage, but results have been most marked, the crop rising from 860 tons in 1924 to 5,364 tons in 1926. This increase also is partially due to the encouragement of the Government.

To this summary of the legislative and other measures taken for the protection of agriculture during the last three years may be added that the Spanish Government earmarked 100,000,000 pesetas for re-afforestation in the Extraordinary Budget of 1926, and has recently created an Institute of Agronomic and Forestry Research and Experiment.

The following table gives the totals of Spanish agricultural production, to the nearest thousand of metric tons and hectolitres, for the years indicated:—

SPANISH AGRICULTURAL PRODUCTION
(In thousands of metric tons or hectolitres)

	1913	1926	1927
Wheat, m.t.	3,059	3,990	3,942
Barley ,, . . .	1,497	2,096	2,008
Rye ,, . . .	709	597	674
Oats ,, . . .	368	547	569
Maize ,, . . .	639	437	663
Rice ,, . . .	223	320	309
Grapes ,, . . .	2,953	2,770	4,612
Wine, hectolitres . .	17,105	15,754	28,325
Olives, m.t. . . .	1,487	1,291	3,517
Oil, hectolitres . . .	2,654	2,301	6,656
Sugar, Beet, m.t. . .	149	251	219
,, Cane, ,, . .	13	7	11
Oranges, m.t. . . .	..	1,171	1,044

Mining and Minerals.—Second to agriculture is the mineral wealth of Spain which yields millions of tons of ore, principally for export.

Iron Ore output sank over 7,500,000 tons from 1913 to 1926, although the 1926 figures are hardly comparable because during that year the smelting works in Great Britain were obliged to reduce purchases. The general cause of the decrease in iron ore output is the gradual exhaustion of the principal mines yielding the better class of ores, whilst the industry in general is somewhat hampered by high costs of production.

The output of Copper shows a steady increase, the production in 1927 being nearly double the 1913 output.

The following table shows the Spanish Coal output in metric tons for the last few years, and a comparison is made with 1913, the year preceding the outbreak of the World War:—

(In Thousands of Metric Tons)

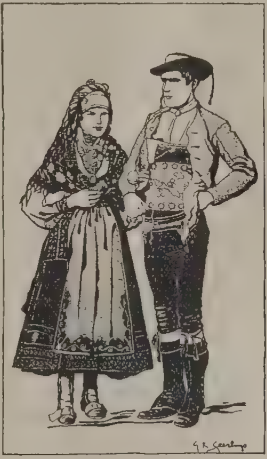
	1913	1923	1926
Anthracite	233	299	403
Pitcoal	3,783	5,672	6,133
Lignite	277	394	400
Total	4,293	6,365	6,936

The figures show an extremely rapid rise in production, the apex being attained in 1926, the year of the British coal strike.

In 1924 the Railway Statute was promulgated (July 12), and the Government took advantage of this law to revert to the subject of the consumption of Spanish coal. The policy of subsidies was codified and regularised in October, 1925. These somewhat tentative movements culminated in February, 1926, in legislation made with the idea of supporting the Spanish coal-mining industry, and helping it to expand still further by enforcing the use of Spanish coal up to a very high percentage of the total consumption on the railroads and in subsidized industries. The percentage to which Spanish coal must be used in the case of railroads running express passenger lines is 85% of the total consumption, whilst in the case of other railroads coming under the Railroad Statute the proportion is 90%. Industries have been classified in various ways, and upon them have been imposed certain proportions for the use of Spanish coal, which, however, do not reach the percentages enforced upon the railroads.

The annual average imports of British coal into Spain before 1925 was something over one and a half million tons. British exports in 1927 were very much in excess of that figure, and as a consequence of the coal stoppage in Great Britain the variation between the 1926 and 1927 figures was extremely great, the 1926 exports being 785,000 tons, whilst the 1927 figures were 2,361,000 tons. The agitation on the part of the Spanish coal owners in the early part of 1928 was directly due to the very large imports of 1927.

The output of lead ore has been affected by the drop in the price of the metal, but both miners and smelters have managed to maintain their production, and lead, on the basis of its value, occupies the second place in ore production. A Consortium of Lead Producers was created by a Royal Decree of March 9, 1928. The Consortium is composed of the Arrayanes Mine, the lead-mining Syndicates of Linares-Caroline and Cartagena-Mazarrón, and such other concerns engaged in the mining, smelting and working of lead as may apply for admission. It controls the purchase and sale in Spain of all the lead in bars, tubes and sheets required by the national market.



BY COURTESY OF YORK & SONS, LONDON

A MAN AND WOMAN OF THE PROVINCE OF LEON, SPAIN, IN CHARACTERISTIC DRESS

The production of copper ore and of ferro-cupreous pyrites has been steadily improving during the last three years, and the output of electrolytic copper and blister has likewise increased.

Zinc ore was produced in increased quantities in 1926, and the quantity of zinc smelted has increased. A similar movement in mercury and metallic quicksilver is also to be recorded.

The production of superphosphates is becoming more important in Spain, rising from 185,000 tons in 1913 to 828,000 tons in 1926. This increase in production marks the progressive rise in Spanish demand.

Hitherto the production of potassium salts in Spain has been insignificant, but in 1926 it occupied the sixth place, in so far as regards value, amongst all the minerals produced in Spain.

The Government has reserved for itself 378,335 hectares of land bearing these salts, some 93,675 having been registered by private individuals. Report states that the layers are from two to five metres thick. The production in 1926 was 80,598 tons.

There is an increasing tendency to legislate with a view to restricting the exploitation of the mineral wealth of the country to Spaniards.

Figures giving the ore output for the last three years available (1924–26), together with those for 1913 as a basis for comparison, are given below:—

A—ORE OUTPUT

(In thousands of metric tons)

Years	Coal including lignite	Lead including argentiferous	Copper and pyrites	Iron and pyrites	Zinc	Mercury	Sulphur	Manganese
1913	4,203	303	2,289	10,789	117	20	63	22
1924	6,539	109	1,000	5,222	117	15	65	21
1925	6,520	208	3,681	4,462	168	23	62	36
1926	6,936	216	3,937	3,195	201	30	65	45

B—MINERAL AND METAL OUTPUT

(In thousands of metric tons)

Years	Iron and steel	Lead	Coke and briquettes	Super phosphates	Copper	Cement	Zinc	Mercury
1913	667	199	1,081	186	31	512	6	1·0
1924	1,128	142	1,475	696	36	917	13	0·9
1925	1,159	154	1,549	723	39	1,136	15	1·0
1926	1,100	150	1,519	829	48	1,183	16	2·0

Industries.—Every department of Spain's economic life shows the effects of the World War period. Impetus was given to the formation of industries which were either non-existent before the war or in an embryonic state. These were put through a hothouse forcing period with the idea of supplying the Spanish market as well as the Allies.

With the return to conditions in which industry was obliged to compete in Spain itself with the foreign industries which had catered for Spain before the war, there spread a "malaise" which affected the whole industrial structure of the country, and manufacturers assisted in bringing into being a thorough-going campaign for the protection of industry.

Notwithstanding this campaign, many Spanish industries feel that they are not yet sufficiently secure from foreign competition in their own market, and there seems every likelihood that the protective movement will be carried even further.

The movement in the rate of exchange since the war has adversely affected the ability of local industry to compete, both at home and abroad. The fall in the value of the peseta, and its more recent return to a figure of about 29 pesetas to the pound sterling has increased the gold cost.

The above explains from the economic side the force of the campaign for higher customs duties in Spain today. It also shows that, upon the whole, there seems little likelihood of any slackening in the movement.

Hydro-electric Development.—A convention between Spain and Portugal, delimiting their respective rights in the falls of the River Douro, was signed on Aug. 11, 1927, and ratifications were exchanged in Lisbon on Aug. 22. A company called the "Sociedad Hispano-Portuguesa de Transportes Eléctricos" has been awarded the concession for the exploitation of the Falls.

No official Spanish statistics dealing with the production of electric energy are available, and it is therefore difficult to indicate with any degree of certainty the actual waterpower utilized. Nevertheless, it is possible to estimate the power derived from waterfalls in exploitation at about 1,300,000 h.p., and the production of electric energy at over 1,000,000 k.w., while according to expert opinion the total power latent in Spanish waterfalls is about 7,500,000 h.p.

The production of electric energy has extended to the whole of Spain, facilitating the conversion of steam-driven railways into lines worked by electricity. Small industries are springing up in villages where previously motive power was not available. It appears that in the near future a scheme of national distribution of electric energy is to be introduced.

Metallurgical.—No statistics are published with regard to industrial production, save in the case of the metallurgical industries. It is not, therefore, possible to make a detailed study of the general advance which is taking place in Spanish industry, but it is beyond doubt that such progress is constant.

The value of the output of the metallurgical industries in 1913 was 302,600,000 pesetas. In 1918, a year of prosperity and high prices, it reached the sum of 841,100,000, and in 1926 it attained 918,900,000 pesetas.

The manufacture of fine steels has improved considerably, and in 1927, with the collaboration of foreign experts, the production of certain alloys of special steels was begun.

The construction of rolling stock for railways has assumed larger proportions than previously in Spain, and this industry shows positive prosperity. Electrolytic copper and aluminium are also being produced in considerable quantities.

Chemical.—The manufacture of chemicals shows notable progress. Pharmaceutical specialities are placed on the market which compete with those from abroad, and dyestuffs of Spanish manufacture are every day more current.

Aeroplanes.—The branch of industry which perhaps has made the greatest progress is the building of aeroplanes and hydroplanes. The firms "La Hispano" of Guadalajara; "Construcciones Aeronauticas, S.A.," of Getafe and Cadiz; Loring of Carabanchel Bajo, and "La Hispano-Suiza" and "Elizalde" of Barcelona, hold licences for the construction in Spain of Aeroplanes and Hydroplanes, both metal and ordinary types, of the marks Breguet, Dornier, Fokker, DeHavilland, Hispano-Suiza, Loring, Lorraine, Neuport and Potern, and are capable of constructing more than 600 machines annually.

Labour.—The following table regarding strikes shows clearly the improvement in the industrial situation since the present Government came into power in September, 1923:

Strikes

Years	No. of strikes	Workers affected	Workers on strike	No. of days lost
1920 . .	1,060	264,080	244,684	7,261,762
1921 . .	373	98,615	23,691	2,802,299
1922 . .	484	167,123	119,417	2,672,567
1923 . .	465	159,784	120,568	3,027,026
1924 . .	165	40,639	28,744	604,512
1925 . .	181	71,323	60,120	839,934
1926 . .	96	31,508	21,851	247,223

The public works undertaken by the Government under the extraordinary budget have given rise to an unusual demand for road rollers, cranes, excavators, and other machinery, keeping the iron and steel industries and the cement works fully occupied. So long as the expenditure on public works of several hundred million pesetas annually continues, the prosperity of these branches of Spanish industry is assured.

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ARCHAEOLOGY

It is still impossible to introduce any accurate chronology into the prehistory of Spain. Before the Roman pacification in the 2nd century B.C. with its certain dates and events lie a couple of centuries of Punic penetration from Carthage; still earlier we know of the coasting voyages of Greek traders along the Mediterranean shore, and catch some glimpse of the Iberian civilization with which these Greeks came into contact; but all this brings us only into the 7th century B.C. Perhaps for several hundred years before the advent of the Greek ships there had been Phoenicians, mainly from Tyre and Sidon, who had maintained trading-posts along the southern shore of Spain and had sailed through the Gibraltar Straits to Cadiz on the Atlantic. Then the perspective of years lengthens out immeasurably and we step back, not by centuries but by thousands of years, through neolithic into palaeolithic times, when some type of men—we cannot guess what blood they were of or what form of language they knew—hunted the beasts of those early days and decorated with marvellously fine likenesses of these animals the inner walls and roofs of deep caverns.

Palaeolithic Spain.—These cave-paintings rank among our most impressive discoveries from the past. There can be no doubt of their vast antiquity, since they certainly represent animals of the late quaternary geological period and are engraved upon bones which are surely identifiable as those of animals now long extinct. Nor can there be much dispute about the extraordinary veracity and vivacity with which wild horse and bison, hind and stag, ibex and ox and boar are delineated with little save their outline and with no visible hesitation of stroke.

The best known of the Spanish caverns and one of the first to be discovered is Altamira near Santander. The publication of its contents by Cartailhac and the abbé Breuil (Monaco, 1906) is the best introduction to the study of palaeolithic Spanish archaeology. Other important sites are Hornos de la Peña, Pasiega, and Castillo in the province of Santander; Basondo in the province of Biscay; and Pindal, Buxu and La Peña in Asturias. Palaeolithic decorated caverns are largely confined to the small mountainous area in the north which extends from the westernmost Pyrenees through the coastal hills beyond Santander. They may therefore be justly termed Cantabrian. Elsewhere, however, beyond the Spanish border, the same type recurs, chiefly on the northern slopes of the Pyrenees and in the region of the Dordogne in south-western France. These three districts—the one in northern Spain, the two others in southern France—are inseparably allied and were products of contemporary cultures. In other parts of Spain, where caves are little more than open rock-shelters, there has been found a distinctively different art.

Prehistorians therefore speak of "cave art" and "rock-shelter art," and distinguish sharply between Cantabrian and East-Spanish palaeolithic. During the last 20 years there has been great activity in the exploration and elucidation of this second group. Except that the fauna of the paintings here implies a slightly warmer climate, much the same series of animals are rendered in much the same style; but intimately combined with them appear weirdly represented men and women—a subject almost completely neglected by the Cantabrian cave artists. Often the men are armed with bow and arrow and shown in pursuit of their quarry; but whereas the beasts are naturalistically correct in the surprising palaeolithic manner, some of the huntsmen with threadlike limbs more nearly resemble the praying mantis, while others with sudden protuberances of calf or thigh suggest unevenly inflated rubber toys. The women, in long flounced petticoats very remotely suggestive of the elegant ladies of Minoan Crete, seem to take part in dances and conversations, poorly visualized and crudely rendered. This striking combination of a naturalistic animal art with geometrically conventionalized, highly primitive human representations is a phenomenon of great significance, since the groupings and actions of the men and women are almost as clearly allied to palaeolithic rock-drawings in north Africa as the ibexes and stags, horses and oxen and bulls are allied to the cave-paintings of Cantabria. As in historic, so in prehistoric times, the destiny of Spain must have been a succession of invasions, now from the north, pouring round or over the Pyrenees, now from the south out of Morocco and Algeria. The most important sites of the East Spanish group are Cogul by Lerida, Valltorta in Castellón, Albarracin by Teruel, Alpera and Mortaja in Albacete, and Cantos de la Visera in Murcia—all characteristically within two or three days' journey afoot from the sea.

Neolithic and Bronze Age Spain.—The Neolithic Age in Spain testifies to a wholly different condition of mankind. Perhaps it is too ingeniously simple to ascribe the naturalism of palaeolithic art to a race of hunters and the geometric conventionalism of the neolithic to a race that tilled the soil. A fairly uniform culture spread over the entire peninsula; for the rock-shelters with neolithic drawings have a very wide distribution and show a striking similarity. They have almost no pictorial attraction and often more resemble picture script than actual illustration. The pottery finds are the great archaeological aid to neolithic chronology; and the occurrence of some of the conventionalized devices of the rock-paintings upon pottery which can with certainty be assigned to the transition from neolithic to the Early Bronze Age puts the general epoch of this culture beyond doubt.

A closer comparison of ceramic types shows that beneath this superficial uniformity there lies sufficient diversity to warrant many subdivisions. Chief among these is the clear distinction between the more indigenous central and the south-eastern or "Almeria" culture which was probably under African influence and may actually have been the nucleus from which the true Iberian culture developed. In late neolithic times the more extensive central culture exhibits a distinctive and striking bell-shaped (the so-called "campaniform") pottery. At this time it is likely that there was some exportation of copper and silver from Spain to the nearest of the Mediterranean islands, since there are ceramic affinities with finds of the "aëneolithic" period (or Stone-and-Copper Age, lasting in Spain from about 3000 to 2500 B.C.) in the Balearics and in Sardinia and Sicily. The peculiar megalithic structures in these parts, such as the *talayots* of the Balearics (*q.v.*), the *nuraghi* of Sardinia (*q.v.*), the underground chambers of Malta, are fairly well paralleled by megalithic grave structures in Portugal and Spain. But there is as yet no certain proof of intercourse between the eastern and the western basins of the Mediterranean for these early times.

Somewhat after 2500 B.C. the Bronze Age displaced the aëneolithic without apparent interruption; but still the Aegean influence, which can be proved to have reached Sicily and southern Italy, failed to extend as far as Spain. If anything, the Bronze Age marks a retrogression in the civilization of Spain, where there has yet been no archaeological discovery to indicate a powerful or wealthy Bronze Age culture even remotely comparable to that of Crete or the eastern Mediterranean lands.

Tartessos.—Herodotus (iv. 152) narrates the adventurous voyage of a Greek sailing-ship from Samos, which was driven by storm past the pillars of Herakles and "at last reached Tartessos. This trading-town was in those days a virgin port unfrequented by merchants, and the Samians in consequence made a greater profit than any Greeks before their day." This event supposedly took place about 630 B.C. During the century thereafter, Tartessos was certainly frequented by trading vessels of the Ionian Greeks of Phocaea in the Bay of Smyrna. It has been maintained that this rich Spanish city on the Atlantic was the Tarshish of the Old Testament, which "with silver, iron, tin and lead" traded in the fairs of Tyre (Ezekial xxvii. 12).

Yet the modern search for Tarshish-Tarsis-Tartessos has failed. The German archaeologist Adolf Schulten after several campaigns regretfully admitted in 1926 that the mysterious city must lie deep under river and below the groundwater level.

The Iberians.—The whole of the peninsula was sometimes called Iberia by ancient writers; but the true focus of the Iberian civilization was the south-eastern corner of the land. Here a stock out of north-east Africa (Oran?) and therefore probably Hamitic (Berber?) may have been infiltrating ever since the aëneolithic days of the Almeria culture (*c.* 3000 B.C.). They were probably racially akin to the Tartessians, who must therefore have also been African invaders. We become completely certain of their presence towards the end of the Bronze Age and, some centuries later, can trace the diffusion and inland penetration of their culture until it was finally absorbed by the Roman civilization almost as late as the time of Christ. Roman writers describe the typical Iberians as dark complexioned, with unkempt hair, small of face but with the cheekbones emphasized and the lower lip prominent, small-framed, alert and wiry. Iberian bronzes display them as riders of horses, and we know what their swords and daggers, spears and other weapons were like. The women are represented sometimes as wearing a singlepiece cloak drawn up over the head from the shoulders like a *mantilla* or shawl, and sometimes with a short, hooded garment which flares out below the waist and often has swallowtail sleeves. We may judge of their jewellery and their headdresses from the famous sculptured bust, the "Lady of Elche," now in the Louvre. Iberian art was rude but vigorous, with a leaning toward sculptured animals of stone and human figurines in bronze. The pottery was decorated with simple linear themes, artistically of no particular distinction, until Greek examples offered more sophisticated decorative motives to copy. The best Iberian art comes from the provinces of Murcia and Albacete in the south-east, where the Greek influence was strongest. The Iberians lived in walled towns. The cyclopean masonry in the bottom courses of the great walls of Tarragon is indubitably a remnant of an old Iberian stronghold. Tartessos and Massia (now Cartagena) were similarly enclosed; but the Carthaginians completely destroyed both of these cities, making Gades (now Cadiz) take the commercial place of the former and refounding the latter as Carthago Nova. Behind this seaboard fringe of Tartesso-Iberians the high-lying interior was in the possession of a variety of indigenous peoples of whom we have no clear knowledge except that, along with Catalonia, they passed through an Early Iron Age (or "Hallstadt" phase) and were at last completely submerged during the 6th century B.C. by an invasion of Celtic tribes who poured through the Pyrenees by the Pass of Roncesvalles and took possession of Castile. This Celtic invasion may with full justice be called an historical event. We can date its occurrence within a few decades, define its source, follow its spread, and perceive its results. In the extreme northern mountain lands the earlier inhabitants managed to preserve their individuality in the face of this Celtic irruption. It has even been argued that the Basques, who maintain customs and a language whose isolation is a mark of extreme antiquity, are ultimate descendants of the palaeolithic Cantabrian folk which produced the cave-art so many thousand years earlier. Elsewhere, during the pre-Roman times, we find Celtic tribes (Beribraces, Sefes, Cempsos) in possession of the land.

Such is the ethnic picture during the 6th and 5th centuries B.C. With such a Spain the Ionic Greek traders now came into contact, in rivalry with the Carthaginians who had fallen heirs to the century-old Phoenician exploitation of these western marts. Neither the Phoenicians nor the Carthaginians left any permanent mark upon the land, while the Greeks influenced it profoundly. Ships from Tyre and Sidon may have traded beyond the Straits and in Cadiz at least as early as the 9th century B.C.; yet modern archaeology, which has located and excavated Greek and Iberian and Roman towns, has not laid bare a single Phoenician settlement or found more important Phoenician remains than the odds and ends of trinkets and jewels and similar articles of barter. The inference is clear that, except perhaps at Cadiz, the Phoenicians built no towns, but had mere trading-posts and points of call.

The Greeks in Spain.—The Greeks, on the other hand, founded true colonies along the east and south coasts, where unmistakable traces of their settlements have survived. The sites of Hemeroskopeion (at the modern Calpe) and Mainake (at the mouth of the Rio de Velez near Malaga) have been identified, though not yet excavated; and Emporion (now Ampurias, on the Pyrenean east coast near the French frontier) has been systematically dug, revealing a fortified town with strong gates and walls, streets more or less at right angles, remains of houses, and a shrine of Asklepios with a cult statue of the god.

While there is almost nothing in Iberian art ascribable to Phoenician or Punic influence, the art of the Greeks had indisputably a revolutionary effect. A collection of sculptures found at Cerro de los Santos in the province of Murcia, and now in the Madrid Archaeological Museum, is a hybrid of archaic Greek and Iberian art. Fragments of Ibericized Ionic Greek architectural mouldings have been discovered in the same region; and the pottery from Elche and the surrounding districts is full of unmistakable borrowings from the ornamental repertoire of Greek vases. The earliest Iberian money was coined in direct imitation of Greek types of the 4th century B.C. Archaic Greek bronzes discovered in many parts of Murcia and Alicante, and the actual material traces of the Phocaean colonies tell us that the Greeks were once in this part of Spain.

Elsewhere in the Mediterranean this period is covered by the written chronicles of the ancient historians; but the records for Spain are extraordinarily meagre. We hear no more about Tartessos after the 6th century B.C. Instead, Greek sources of the 5th century begin to speak of the whole Tartesso-Iberian region as Iberia; and recent archaeological exploration has confirmed this emphasis upon the Iberians and established them as the great civilizing force of that time in ancient Spain.

Spain Under the Carthaginians.—During the 4th century B.C. the Carthaginian encroachment reached most of the Iberian homeland, the Greek contact was broken, and the Greco-Iberian culture in Murcia waned. But in recompense, and probably under the pressure of this Punic expansion, the Iberian penetration of the interior gathered great headway. During the 3rd century B.C. the most flourishing Iberian centre in Spain is the valley of the Ebro, where in the 5th century there had been no Iberian settlements whatever; and Greek writers of the time no longer refer to the Castilian uplands as Celtic but as "Celtiberian." Recent excavation has confirmed this gradual Iberianization of almost the whole of pre-Roman Spain. Particularly of Numantia, and largely as a result of the careful and systematic work of Prof. Schulten in laying bare the sites of the Roman and Celtiberian encampments there, an extensive insight into this Iberianized Celtic culture of the 3rd and 2nd centuries B.C. has been gained.

The Romanization of Spain.—When the Romans began their efforts to Latinize the land after the close of the Second Punic War (201 B.C.) they found not a Celtic civilization like that of Gaul, but an Iberian culture of the general type which the Greeks had encountered and influenced before them. The dramatic story of Scipio and the capture of Numantia in 133 B.C. indicates with how much bloodshed and violence this Roman pacification was attended. However, the archaeological in contrast to the historical evidence shows that the two civilizations must have endured side by side for more than a century and suggests a more tolerant penetration and absorption. The latest sculptures from Cerro de los Santos, though still Iberian in style, borrow Roman statuary motives. In other regions true Iberian pottery is often found mixed with thoroughly Roman ware (*terra sigillata*). Iberian jewellery and gold have been found amid Roman surroundings; and most of the coinage bearing in Iberian script the names of Iberian towns dates from after the Roman conquest.

The archaeological remains of fully Romanized Spain are abundant, but show the monotony of a provincial art which has nothing to stimulate it into new forms of its own. There is no obviously and distinctively "Spanish" flavour in the architecture and sculpture of these times. The spirit which seems to distinguish mediaeval or modern Spain from the rest of Europe may or may not contain a recrudescence of Tartessian or Iberian or Celtiberian mentality. With the final Romanization of the land these older cultures were supplanted completely.

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HISTORY TO A.D. 406

Primitive Inhabitants.—The origin and character of the early inhabitants of the Peninsula are obscure. We must await the result of further excavations of prehistoric sites and further inquiries into the native inscriptions before we can hope for much certainty. The Romans mention three races: Iberians (in the east, north and south), Celts (north-west) and Celtiberians (centre). The use to-day of the strange and ancient Basque tongue on the western slopes of the Pyrenees and in Vizcaya (Biscay) suggests that the Iberians may have been an older people than the Celts and alien from them in race. On the other hand, numerous place-names show that parts of the Peninsula were once held by the Celtic-speaking tribes who probably also inhabited the greater part of the area which is now France for several millenniums before the current era.

Earliest Historic Period.—The Phoenicians had possibly reached Spain by the 11th century B.C. One of their earlier foundations, Gades (now Cadiz), has been called the oldest town in the world (or in Europe) which has kept a continuity of life and name from its first origin. But their exploitation of the Peninsula dates principally from after the rise of Carthage (*q.v.*). Carthaginian "factories" were planted on many Spanish coasts: a Nova Carthago (New Carthage, mod. Cartagena) formed a Carthaginian fortress with the best harbour of south-eastern Spain. The expansion is attributed chiefly to the second half of the 3rd century B.C., and to the genius of Hamilcar Barca, who, seeing his country deprived by Rome of Sicily and Sardinia, used Spain, not only as a source of commercial wealth, but as an inexhaustible reservoir of recruits for the Carthaginian armies. But Rome too needed the Spanish men and mines, and, in the second Punic War, drove Carthage finally and completely out of the Peninsula (201 B.C.).

Roman Spain.—The Romans divided Spain into two *provinciae*, Hispania Citerior, that is, the northern districts which were nearer to Italy, and Hispania Ulterior, the south. To each province was sent yearly a governor, often with the title *proconsul.* The commands were full of military activity. The south, indeed, notably the fertile valley of Andalusia, the region of the Guadalquivir (*Baetis*), then called Baetica, was from the first fairly peaceful. Italian veterans or Spanish soldiers who had served for Rome were settled at Hispalis (Seville) and at Carteia near Gibraltar, and a beginning was made of a Romanized provincial population. But in the north, on the high plateau and amidst the hills, there was incessant fighting throughout the greater part of the 2nd century B.C., and indeed in some quarters right down to the establishment of the empire. In the long struggle many Roman armies were defeated, many commanders disgraced, many Spanish leaders won undying fame as patriot chiefs (*see* NUMANTIA). But the struggle could not be given up without risk to the lands already won. So the war went on to its inevitable issue. Numantia, the centre of the fiercest resistance, fell in 133 B.C. (*see* SCIPIO), and even northern Spain began to accept Roman rule and Roman civilization. When in 80–70 B.C. the Roman Sertorius (*q.v.*) attempted to make head in Spain against his political enemies in Rome, the Spaniards who supported him were already half Romanized.

There remained only small groups of unconquered tribes in the northern hills and on the western coast. Some of these were dealt with by Julius Caesar, governor here in 61 B.C. Others, especially the hill tribes of the Basque and Asturian mountains, were still unquiet under Augustus. By the days of Cicero and Caesar (70–44 B.C.) the southern districts, at least, had become practically Roman: their speech, their literature, their gods were wholly or almost wholly Italian. Gades was the first city outside of Italy which obtained a municipal charter as *municipium*, without the usual implantation of Roman citizens.

Imperial Spain.—Under Augustus (or possibly Tiberius) there was a reorganization. Henceforward there were three provinces: (*a*) the north and north-west, the central tableland and the east coast as far south as New Carthage, that is, all the thinly-populated and unquiet hill country, formed the province of Tarraconensis with a capital at Tarraco (Tarragona) under a *legatus Augusti pro praetore* with a legion (VII. *Gemina*) at Leon and some other troops at his disposal; (*b*) the fertile and peaceful west formed the province of Lusitania, very roughly the modern Portugal, also under a *legatus Augusti pro praetore*, but with very few troops; (*c*) the fertile and peaceful south formed the province of Baetica, under a pro-consul nominated by the senate, with no troops. These divisions (it will be observed) exactly coincide with the geographical features of the Peninsula. Substantially, they remained till the end of the empire, though Tarraconensis was broken up at different dates into smaller and more manageable areas. Augustus also accelerated the Romanization of the land by planting in it many municipalities (*coloniae*) of time-expired veterans (*e-meriti*) such as Augusta Emerita (mod. Mérida), which still possesses extensive Roman ruins. About this time imperial finance agents (*procuratores*) were appointed to control the revenues and look after the mines, which became Imperial property, while a special *praefectus* administered the Balearic Islands. The iron and also the copper, silver and lead of Spain were well known: it was also (according to the elder Pliny) the chief source whence the Roman world obtained its tin. Its olive-oil was superior to that of Italy. But commercial prosperity characterized many districts of the empire during the first two centuries of our era. Spain can boast that she supplied Rome with almost her whole literature in the silver age. The Augustan writers had been Italians. Their successors were Spaniards—the younger Seneca, Lucan, Martial, Quintilian, besides a host of lesser lights. By-and-by the impulse of the opening empire died away and with the 2nd century the great Roman-Spanish literature ceased. Of statesmen the Peninsula was less prolific. Though the emperor Trajan and his relative and successor Hadrian, were born in Spain, both were of Roman stock and Roman training. The 3rd and 4th centuries saw a decline in prosperity. The confiscations of Septimius Severus and the ravages of barbarians in the middle of the 3rd century have been adduced as causes. But, though we need not doubt that the decline occurred, we can hardly determine either its date or its intensity without careful examination of the Roman remains of Spain. While many of the best Roman ruins—such as the aqueduct of Segovia or the bridge of Alcantara—are older than 200 A.D. others are probably later, and indicate that prosperity continued here, as it did on the other side of the Pyrenees, till the later days of the 4th century—perhaps indeed till the fatal winter's night in 406–7 when the barbarians burst the Rhine frontier and flooded Gaul and even Spain with a deluge from which there was no recovery. (F. J. H.; G. M.)

FROM A.D. 406 TO THE CONQUEST OF GRANADA

The Barbarian Invasion.—With the irruption of the Vandals, the Suevi and the Alans, the history of Spain enters on a long period of division and confusion which did not end even with the union of the chief kingdoms by the marriage of Isabella and Ferdinand at the close of the 15th century. The function of the barbarians everywhere was to cut the communications of commerce, and the nerves of the imperial administration.

This function was effectually discharged in Spain by the Vandals and their associates, who plundered far and wide, and then by the Visigoths, who appeared as the *foederati*, or duly commissioned defenders of the Romans. The first-comers were not numerous enough to establish a rule of their own. When in 428 Gaiseric, king of the Vandals (*q.v.*), accepted the invitation of Bonifacius, the count of Africa, and passed out of Spain to found the Vandal kingdom of Carthage, his whole horde numbered only 80,000 persons, including old men, women and children, and runaway slaves who had joined him. There is probably some truth in the assertion of Salvian that many of the subjects of the empire preferred poverty among the barbarians to the tyranny of the imperial tax collectors. This would be pre-eminently the case with the smaller landowners who formed the *curiales*, and who were in reality serfs of the fisc, for on them fell the main weight of taxation, and they were confined to their position by oppressive laws. The great landowners who formed the *ordo senatorius* had almost as much to fear from the agrarian insurgents known as *bagaudae*, who are indeed found acting with the Suevi, as from the barbarians. In the north the Asturians and Basques, the least Romanized part of the population, appear from the beginning of the age of barbarization as acting for themselves. In the mountain country of Cuenca, Albacete, and the Sierra Nevada the natives known as the Orospedans were entirely independent in the middle of the 6th century. But if there lay in this revival of energy and character the germs of a vigorous national life, for the time being Spain was thrown back into the state of division from which it had been drawn by the Romans—with the vital difference that the race now possessed the tradition of the Roman law, the municipalities, and one great organization in the Christian Church.

No help was to be expected from the empire. Unable to aid itself it had recourse to the Visigoths (*see* GOTHS). Ataulphus (*q.v.*) the successor of Alaric, and husband of Placidia, daughter of the emperor Theodosius, whom he had married against the wish of her brother Honorius, entered Spain in 412, as the ally of the empire. He was murdered in 415, but after the speedily ensuing murder of his murderer and successor Sigeric, Wallia (415–419), who was elected to the kingdom, continued his work. He destroyed the Alans, and drove the Vandals and Suevi into the north-west. Then he handed Spain back to the imperial officials, that is to say, to weakness and corruption, and marched with all his people into the Second Aquitaine, the south-west of modern France, which had been assigned to them by Honorius as a home and a reward. From this date till the very end of the reign of Amalaric (511–531), the seat of the Visigothic kings was at Bordeaux, or Toulouse or Narbonne, and their main interests were in Gaul. Southern Spain was overrun and plundered by the Vandals before their departure for Africa. In 456 Theodoric II. (453–466) entered Spain as ally of Avitus, whom he had himself raised to the empire in Gaul. He defeated the Roman senators of the Tarraconensis and the Suevi, putting their king to death, and advanced as far as Mérida. Majorian (457–461), the last capable emperor of the West, proposed to make Spain the basis of his attack on the Vandals at Carthage till his fleet was destroyed by them in the harbour of Carthagena. The fratricidal murderer and successor of Theodoric, Euric (466–485), followed his brother's policy in Spain. With the extinction of the Western empire (476 or 479) the kings of the Visigoths became more and more the representatives of authority, which they exercised on Roman lines, and with an implied or formal deference to the distant emperor at Constantinople. After the defeat and death of Alaric II. (485–507) at Vouillé the shattered Visigoth power was preserved from destruction at the hands of the Frankish king Clovis (*q.v.*) by Theodoric, the Gothic king of Italy. But on his death the advance of the Franks began again. Amalaric (507–531) fled from Narbonne, to meet the usual violent end of a Visigothic king at Barcelona.

The Visigothic Kingdom.—The line of the Visigothic kings of Spain begins, strictly speaking, with his successor Theudis (531–548), an Ostrogoth appointed by Theodoric to act as guardian of Amalaric. He had acquired great possessions in the valley of the Ebro by marriage with a Roman lady. It was a Government, and not a people, which was established in Spain with Theudis. The Visigoths had been much Romanized during their establishment in Gaul. Their monarchy was elective. Until the death of Amalaric the choice was confined to one family, but he was the last of his line. The kings tried to make the Crown hereditary, and the nobles, Visigothic *seniores*, and Roman *senatores* seized every opportunity to keep it elective. Of the 23 kings between Theudis and Roderic five were certainly murdered, one was deposed, and three were tonsured by tricks or open force.

The administration which these kings of unstable authority had to direct was essentially the Roman system. The great owners, whether nominally Visigoth or nominally Roman—*seniores* or *senatores*—continued to enjoy all the privileges and exemptions of the *ordo senatorius* in the last days of the empire. They lived surrounded by multitudes of semi-servile *coloni*, or farmers, bound to the soil, of actual slaves, and of *buccelarei*, who were free swordsmen to whom they gave rations (*buccelatum*, soldiers' bread, or *buccella*, a portion). The *curiales* remained as before the victims of the fisc.

Theudis, who made his headquarters at Seville, endeavoured to complete his mastery of the diocese of Spain by occupying Mauritania Tingitana, but he was defeated by the imperial officers at Ceuta. He was in due course murdered at Seville by Theudigisel (548–549) who was himself promptly slain. The reigns of his two successors, Agila (549–554) and Athanagild (554–567), coincided with the reign of Justinian and the temporary revival of the Eastern empire. Athanagild called on the imperial officers to help him against Agila, and paid for their assistance by the surrender of the province of Baetica. On his death there was an obscure interregnum of five months, which ended by the election of Liuva (567–572), the governor of Narbonne, the surviving remnant of the Visigoth power to the north of the Pyrenees. Liuva did not come to Spain, but associated his brother Leovigild (567–586) with him. The reigns of Leovigild and of his son Reccared are the greatest in the list of the Visigoth kingdom in Spain. The father was the first Visigothic king who wore the crown, and it would appear that he threw off all pretence of allegiance to the empire. The series of the Visigothic gold coins begins with him, and it is to be noted that while the earliest are struck in the name of the emperor Justinian, the imperial superscription disappears in the later. Leovigild drove the imperial officers from Seville and Cordova, though they still retained control of the coast.

The reign of Reccared (586–601) is famous in Spanish history for the establishment of Catholicism as the religion of the State. He made the change at the Third Council of Toledo. If Reccared hoped to secure the perpetuance of his dynasty he was mistaken. His son Liuva II. (601–603) was murdered by an Arian reaction headed by Witteric (603–610). The Catholics regained power by his overthrow, but they could not give stability to the State. A succession of obscure "priests' kings," who are but names, followed: Gunthemar (610–612), Sisebut (612–620), Reccared II. (620–621), Swintilla, associated with his son Reccimer (621–631), Sisinand (631–636), Chintila (636–640), Tulga (640–641), Chindaswinth (641–652), Recceswinth (649–672). The growing weakness of the Merovingians saved them from serious attack, though not from occasional invasion on the north. The prostration of the empire in the East by Avar and Persian invasions enabled them to drive the imperial officers from the coast towns. But the kingdom was growing internally weaker. Wamba (672–680) is credited with an attempt to reform the State, but he was tonsured while unconscious from illness or poison, and disappeared into a religious house. His successors again are but names, Euric (680–687) and Egica (687–701). Witiza (697–710) has more substance. With Roderic, whose "tumultuous" election was the work of Witiza's enemies, the line of the Visigoth kings is considered to have ended.

The Mohammedan Conquest.—During the reign of Witiza the Muslim masters of northern Africa had pressed the town of Ceuta, the last remnant of the Byzantine possessions, very closely. It seems to be certain that Julian, the imperial count or governor of Ceuta, acting in concert with the family and faction of Witiza, who sought his help against Roderic, provided vessels to transport the Berber Tarik (Tāriq) across the straits. Tarik, the general of the caliph's governor in northern Africa, Mūsā b. Nosair, came with a small force, but with the certainty of finding allies, and on being joined by another detachment of Berbers marched inland. On July 19, 711, he met Roderic near the Lago de la Janda between Medina Sidonia and Vejér de la Frontera. He had perhaps already been joined by Spanish allies. It is at least certain that in the battle the enemies of Roderic passed over to the invader. The Visigoth king was routed and disappears from authentic history. There is some probability that he did not perish in the battle, but escaped to fall two years later, at Seguyjuela near Salamanca, in action with Merwan the son of Mūsā. Before the end of 711 Tarik had advanced as far north as Alcalá. Cordova fell to a detachment of his army. In 712 Mūsā joined his lieutenant, and the conquest of the south was completed. Mérida was the only town which offered an honourable resistance. During 713 and 714 the north was subdued to the foot of the mountains, and when Mūsā and Tarik were recalled to Damascus by the caliph the progress of the Muslims was not delayed. In 718 they crossed the Pyrenees, and continued their invasions of Gaul till they met the solid power of the Austrasian Franks at Poitiers 732 (*see* CHARLES MARTEL and CALIPHATE). The great landowners south of the Pyrenees, to whom patriotism was unknown and whose religious faith was tepid, were as ready to pay tribute to the caliph as to render service to one of their own body who had become king by violence or intrigue. On the part of the Arabs, who, though a small minority of the invaders, were the ruling element, there was a marked absence of proselytizing zeal. They treated the occupation of Spain as a financial speculation more than as a war for the faith. The Spanish Roman and Visigoth, accustomed as he was to compound with one master after another, saw nothing dishonourable in making such an arrangement. In Murcia the duke whom the Arabs knew as Tadmir became a tributary prince, and his family retained the principality for generations. The family of Witiza obtained possession of an immense stretch of the land of the State in Andalusia on condition of paying tribute. One of them, by name Ardabast, was deprived of his holding at a later date on the ground that he held more land than could be safely left in the hands of a Christian. Everywhere landowners made the bargain, and the monasteries and the cities followed their example. Many professed themselves converts to Mohammedanism. In the north one great Visigoth family not only accepted Islam, but founded a dynasty, with its capital at Saragossa, which played a stirring part in the 8th and 9th centuries, the Beni-Casi, or Beni-Lope. To the mass of the population the conquest was, for the present, a pure gain. The Jews, escaped from brutal persecution, were the eager allies of the Arabs. The serfs acquired personal freedom and relief from the Roman fiscal system. Add to this that a slave who professed Islam could secure his freedom, at least from slavery to a Christian master, that Arianism had not been quite rooted out, that the country districts were still largely pagan, and it will not appear wonderful that within a generation Mohammedan Spain was full of renegades. The Arabs at first were content to take a fifth of the land to constitute the public domain, or *khoms,* out of which fiefs held on military tenure were provided for the chiefs of the conquering army.

The invaders were a coalition of Arabs, Syrians and Berbers. The Arabs, incurably anarchical, with no political idea except the tribal one, looked down on the Syrian; they thought the Berber a lout and a plebeian, they scorned the renegade, and called him a slave and son of a slave. They fought out the old tribal rivalries of Arabia on the banks of the Guadalquivir and on the Vega of Granada. They planted the Berber down on the bleak, ill-watered and wind-swept central plateau. He revolted, and they strove to subdue him by the sword. He deserted his poor share of the conquered land, and in many cases returned to Africa. The conflict for the caliphate (*q.v.*) between Omayyad and Abbasid removed all shadow of control by the head of the Mohammedan world, and Spain was given up to mere anarchy. The treaties made with the Christians were soon violated, and it seemed as if Islam would destroy itself. From that fate it was preserved by the arrival in Spain of Abdurrahman (Abdarrahman b. Moawiya) the Omayyad (758), one of the few princes of his house who escaped massacre at the hands of the Abbasides. With the help of his clansmen among the Arabs, and to a large extent of the renegades who counted as his clients, by craft, by the sword, by keeping down the fanatical Berber element, and by forming a mercenary army of African negroes, and after 30 years of blood and battle, Abdurrahman founded the independent amirate, which in the 10th century became the caliphate of Cordova. The real basis of its power was the slave army of negroes, or of Christian slaves, largely Slavonians sold by their German captors to the Jew slave traders of Verdun, and by them brought to Spain. These janissaries at first gave them victory, and then destroyed them.

Christian States of the North.—The Christian enemies of the Mohammedans were for long weak and no less anarchical than themselves, but they were never altogether wanting, and they had, what the Arab and Berber had not, a tradition of law and a capacity for forming an organized polity and a State. In the centre were the Basques, dwelling on both sides of the Pyrenees, who kept against the Mohammedan the independence they had vindicated against the Visigoth. On the east were the roots of the kingdom of Navarre, of Sobrarbe and Aragon. In the earliest times their most pressing foe was not the Arab or Berber so much as the Carolingian. It was at their hands that Charlemagne (*q.v.*), while returning from his expedition to Saragossa, suffered that disaster to his rearguard at Roncesvalles which is more famous in poetry than important in history. With the aid of the Spanish Muslim Beni-Casi the Basques drove off the counts and wardens of the marches of the Carolingians. On the eastern extremity of the Pyrenees the Franks found no native free population. Here, mainly under the leadership of Louis the Pious, they formed the Marca Hispanica, where Frankish counts and wardens of the marches gradually gained ground. By the reign of Charles the Fat a principality had been founded. Wilfred the Hairy—the *Comes Vellosus*, so called because his countship was poor and covered with scrub wood—became the founder of the countship of Barcelona.

The greatest destiny was reserved for the Christian remnant which stood out to the west of the Basques, in the mountains of Asturias. Pelayo, whom they chose for king, and his victory of Covadonga, are legendary and obscure. It is with the warning that the dates can only be given as probably correct that the three first Christian kings can be said to have reigned from 718 to 757. Pelayo (718–737), his brother Favila (737–739)—of whom we only know that he is said to have been killed by a bear while hunting—and Alphonso I., the Catholic (739–757), stand as little more than names. While the Muslim invasion of Gaul was still going on, Manuza, the chief of the Berbers settled in north-western Spain, had revolted against the caliph's lieutenants. In 740 came the great general revolt of the Berbers. In 750 plague, following on drought and famine, swept away thousands of conquered and conquerors alike. Amid the general desolation Alphonso I., duke of Cantabria and son-in-law of Pelayo, constituted the kingdom which the Arabs called Galicia. It answered closely to the old Roman province of the same name—extending from the Bay of Biscay to the line of the Duero, from the ocean to the foot of the mountains of Navarre. Alphonso swept all through that region, already more than half depopulated, slaying the lingering remnants of the Berbers, and carrying back the surviving Christians to the north. Behind that shield of waste the Christian kingdom developed; from the death of Alphonso I. to the reign of Ramiro II. (931–950) it was subject to no serious attack, though raids on the frontier never ceased. Norse pirates appeared on the coast in the 9th century, but made no permanent settlements. As the population grew, it pushed down to the plain of Leon and Castile. The advance is marked by the removals of the capital forward from Cangas de Oña to Oviedo, from Oviedo to Leon, and by the settlement of adventurous frontier men in the ancient Bardulia, which from their "peels," and towers of strength, gained the name of Castilla—the castles. Burgos became its centre. The Montaña (hill country) of Burgos, and in particular the district called the Alfoz of Lara, was the cradle of the heroes of the Castilian share in the reconquest. As the Marca Hispanica on the east became the county of Barcelona, so the chiefs of Bardulia became the counts of Castile, then the count of Castile, the rival of the king at Leon, and in time the king of Castile, and head of Christian Spain.

There is much in the internal history of that kingdom which stands apart from the general development of western Europe, from which it was shut out. In all the long period from Pelayo to Ramiro II. only one event occurred which had much tendency to bring the Christians of the north-west into close relations with their neighbours of the same faith north of the Pyrenees. This was the discovery of the body of St. James the Apostle in the reign of Alphonso II. the Chaste (789–842). The shrine at Santiago in Galicia attracted pilgrims, who brought trade. The chief who had to "people" a new and exposed township had to tempt men by freedom and secure rights to follow his banner. The influences which by the 13th century had abolished serfdom in western Spain were all at work before the reign of Ramiro II. In spite of revolts and of fratricidal struggles a State was formed. To the east of it, the Navarrese, having rid themselves of the Carolingian counts and marchers, had made a kingdom in their mountains, and beyond them the little free territories of the central Pyrenees were advancing, in subordination to the Navarrese king at Pamplona. The Arab called them the Christians of Al Frank, and distinguished them from the Galicians.

The Mohammedan Amirate.—The 10th century and the first years of the 11th saw a great set-back of the Christian revival. Dissensions among themselves coincided with an energetic rally of the Muslim power. From the foundation of the amirate by Abdurrahman I. (758–790) to the beginning of the reign of Abdurrahman III. (912–961) Mohammedan Spain had shared the usual fortunes of an oriental monarchy. A strong amir, such as Abdurrahman I. or his grandson Hakam I. (796–822), could enforce obedience by arms, or by murder. On the upper frontier, which is now Aragon, the "Visigoth" Beni-Casi ruled, doing homage and paying tribute intermittently, supported by a loyal population of native Mohammedans, whose Christian or nominally Christian fathers had been their followers before the conquest. The "Moors," so called, who afterwards filled the kingdom of Aragon, were of native blood. Toledo, relying on the immense military strength of its position, was more often in rebellion than in subordination. The massacre which Hakam I. effected by a lavish use of fraud cowed it only for a time. Abdurrahman III. found it independent again when he came to the throne, and had to besiege it for two years before it yielded. The renegades grew in numbers, and in faith. Under the influence of orthodox Berber teachers their fanaticism was turned against the amir himself. Hakam, a winebibber much suspected of heterodoxy, had to expel thousands from his capital. Part went to people the town of Fez, newly founded in Morocco by the Idrisites; part wandered eastward to found a Mohammedan State in Crete. Under the stimulus of Berber fanaticism the toleration first shown to the Christians was turned to persecution. A counter fanaticism was aroused in them, and for years the "Martyrs of Cordova" continued to force the often reluctant cadis to behead them, by blaspheming the Prophet. Under Abdurrahman II. (822–852), who spent his life listening to a favourite and highly accomplished Persian tenor and in the company of dancing girls, and under Mohammed I. (852–886), the niggardly Mondhir (886–888), whose time was short, and Abdalla (888–912), who was feeble, the amirate was torn to fragments.

From this state of anarchy the amirate was saved by Abdurrahman III. (912–961), the Akbar of his race. He came to the throne when half a century of war and murder had produced exhaustion. The country was swarming with brigands, and the communications were so dangerous that seven years had been known to pass during which no caravan travelled from Cordova to Saragossa. Abdurrahman III., an oriental ruler of the great type, industrious, resolute, capable of justice, magnificent, and free-handed without profusion, was eminently qualified to give all that his people wanted. The splendour of his reign is a commonplace. He restored order even in the Sierra de Ronda, and then he took the field against the Christians.

Hakam II. (961–976), Abdurrahman's son, ascended the throne in mature years, and continued his father's policy. A lover of books, he gave protection to writers and thinkers who were not strictly orthodox. The anarchy which broke out in the north-west, the kingdom now called Leon, on the death of Ramiro II.—whose sons fought among themselves—and the endless conflicts between Leon and Castile, rendered the only formidable Christian kingdom powerless. In Hakam's old age, one of his wives Sobh (the Daybreak), a Basque, bore him the first son born in his harem, who became Hishām II. and in all his long life was nothing but a puppet. The administration of his chamberlain or *hajib*, Mohammed ben Abdallah, who took the royal name al-Mansur Billah ("the victorious through God") and is generally known as Mansur (*q.v.*), is counted among the glories of the caliphate of Cordova. It was the rule of a strong man who made, and kept under his own control, a janissary army of slaves from all nations, Christian mercenaries from the north, Berbers and negroes from Africa. With that host he made 50 invasions into the Christian territory, but he left his enemies in a position to regain all they had lost. It mattered little that he desolated in 997 the shrine of

St. James at Santiago da Compostela, the monastery of Cardeña in Castile, took Leon, Pamplona and Barcelona, if at the end he left the roots of the Christian States firm in the soil, and to his son and successor as *hajib* only a mercenary army without loyalty. He died in 1002 undefeated, but racked by anxiety for the permanence of the prosperity of his house. His son Mozaffar kept the authority as *hajib,* always in the name of Hishām II., who was hidden away in a second palace suburb of Cordova, Zahira. But Mozaffar lasted for a short time, and then died, poisoned, as it was said, by his brother Abdurrahman, called Sanchol, the son of Mansur by a Christian lady. Abdurrahman Sanchol was vain and feather-headed. He extorted from the feeble caliph the title of successor, thereby deeply offending the princes of the Omayyad house and the populace of Cordova. He lost his hold on his slaves and mercenaries, whose chiefs had begun to think it would be more to their interest to divide the country among themselves. A palace revolution, headed by Mohammed, of the Omayyad family, who called himself Al Mahdi Billah (guided by God), and a street riot, upset the power of the *hajib* at Cordova while he was absent on a raid against Castile. His soldiers deserted him, and he was speedily slaughtered. Then in the twinkling of an eye the whole edifice went into ruin. The end of Hishām II. is unknown, and the other princes perished in a frantic scramble for the throne in which they were the puppets of military adventurers. A score of shifting principalities, each ready to help the Christians to destroy the others, took the place of the caliphate.

Development of the Christian Kingdoms.—The fundamental difference between the Muslim, who know only the despot and the Koran, and a Christian people who have the Church, a body of law and a Latin speech, was well seen in the contrast between the end of the greatness of Mansur, and the end of the weakness of his Christian contemporaries. The first left no trace. The second attained, after much fratricidal strife, to the foundation of a kingdom and of institutions. The interval between the death of Ramiro II. in 950 and the establishment of the kingdom of Castile by Fernando I. in 1037 is on the surface as anarchical as the Mohammedan confusion of any time. The personages are not anywise heroic, even when like Alphonso V. (999–1027) they were loyal to their duty. Sancho the Fat, and Bermudo II. the Gouty, with their shameless feuds in the presence of the common enemy, and their appeals to the caliph, were miserable enough. But the emancipation of the serfs made progress. Charters began to be given to the towns, and a class of burghers, endowed with rights and armed to defend them, was formed; while the council of the magnates was beginning to develop into a *cortes.* The council over which Alphonso V. of Leon and his wife Geloria (*i.e.,* Elvira) presided in 1020, conferred the great model charter of Leon, and passed laws for the whole kingdom. The monarchy became thoroughly hereditary, and one main source of anarchy was closed. By the beginning of the 11th century the leading place among the Christian kings had been taken by Sancho El Mayor (the Great) of Navarre. He was married to a sister of Garcia, the last count of Castile. Garcia was murdered by the sons of Count Vela of Alava whom he had despoiled, and Sancho took possession of Castile, giving the government of it to his son Fernando (Ferdinand I.), with the title of king, and taking the name of "king of the Spains" for himself. Fernando was married to a daughter of Alphonso V. of Leon. Her brother Bermudo, the last of his line, could not live in peace with the new king, and lost his life in the battle of Tamaron, in a war which he had himself provoked. Fernando now united all the north-west of Spain into the kingdom of Castile and Leon with Galicia. Navarre was left by Sancho to another son, Garcia, while the small Christian States of the central Pyrenees, Aragon and Sobrarbe with the Ribagorza went to his other sons, Ramiro Sanchez and Gonzalo. Fernando, as the elder, called himself emperor, and asserted a general superiority over his brothers. When he had united his kingdom, he took the field against the Mohammedans; and the period of the great reconquest began.

Beginning of the Christian Reconquest.—The Christians advanced to the banks of the Tagus in the south, and into Valencia on the south-east. They began to close round Toledo, the shield of Andalusia. The feeble Andalusian princes were terrified into paying tribute, and Fernando reached the very gates of Seville without finding an enemy to meet him in the field. His death in 1065 brought about a pause for a time. He left his three kingdoms to his three sons Sancho, Alphonso and Garcia. Alphonso, to whom Leon had fallen as his share, remained master after the murder of Sancho at Zamora, which he was endeavouring to take from his sister, and the imprisonment of Garcia of Galicia. The reign of Alphonso VI., which lasted till 1109, is one of the fullest in the annals of Spain. His marriage with Constance, daughter of Robert, duke of Burgundy, brought a powerful foreign influence into play in Castile. Constance favoured the monks of Cluny, and obtained her husband's favour for them. Under their leadership measures were taken to reform the Church. Castile ceased to be an isolated kingdom, and became an advance guard of Europe in not the least vital part of the crusades. Alphonso, who during his exile owed some good services to the Mohammedan king of Toledo, spared that city while his friend lived. In 1082 he swept all through the valley of the Guadalquivir to Tarifa, where he rode his horse into the sea and claimed possession of the "last land in Spain." In 1086, his friend being dead, he made himself master of Toledo. The fall of the city resounded throughout Islam, and the Mohammedan princes of Andalusia began to look to Africa, where Yusuf ben Techufin was ruling the newly founded empire of the Almorávides. Al-Motamid, amir of Seville, a brilliant cavalier, an accomplished Arab poet, and one of the most amiably spendthrift of princes, thought it better to lead camels in Africa than to tend pigs in Castile. Yusuf came, and in 1086 inflicted a terrible defeat on Alphonso VI. at Zalaca near Badajoz. The immediate results of the stricken field were, however, but small. Yusuf was called back to Africa, and in his absence the Christians resumed the advance. When he returned he was chiefly employed in suppressing the Mohammedan princes. Alphonso was compelled to withdraw a garrison he had placed in Murcia, and Valencia was, by his decision, given up by the widow of the Cid (*q.v.*). But he kept his hold on Toledo, and though his last days were darkened by the death of his only son in the lost battle of Ucles (1108), he died in 1109 with the security that his work would last.

The Almorávides.—The Almorávides, who were Berbers and were largely mingled with pure negroes, added to corruption a dull bigotry and a hatred of thought and knowledge from which the Arab, anarchical and politically incapable as he was, was free. In Aragon the successors of Ramiro Sanchez had begun to press close on Saragossa when the Almorávide invasion took place. The battle of Zalaca gave pause to the Aragonese, as it did for a short space to the Castilians. The interval of advance in the reconquest would have been shorter than it was but for the results of a most unfortunate attempt on the part of Alphonso VI. to unite the Crowns of Aragon and Castile by the marriage of Alphonso I. (1104–34) of Aragon with his daughter Urraca. Urraca (the name is a form of Maria) was dissolute and Alphonso was arbitrary. They came to open war, in which he claimed to be king of Castile by right of his marriage and his election by the nobles. The confusion was increased by the fact that Alphonso, Urraca's son by her first marriage with Raymond of Burgundy, was recognized as king in Galicia, was bred up there by the able bishop Diego Gelmirez, and took an active part in the feuds of his mother and stepfather. The death of Urraca in 1126 allowed her son to reunite the dominions of his grandfather. In the meantime his quarrels with Urraca had not deterred Alphonso, who is surnamed the Battler in Aragonese history, from taking Saragossa in 1118, and from defeating the Almorávides at the decisive battle of Cutanda in 1120. In 1125 he carried out a great raid through Mohammedan Spain, camping in its midst for months, and returning with many thousands of the Christian *rayahs,* who, under the name of Mozárabes, had hitherto continued to live under Muslim rule. After his death his brother, Ramiro, having been first exclaustrated by the pope, married Agnes of Aquitaine, and on the birth of his daughter Petronilla affianced her to Ramon Berenguer (Raymond Berenger), count of Barcelona, and then retired to his cell at Narbonne. This marriage united Aragon and Catalonia for ever, and marks a great step forward in the constitution of a national unity in Spain. Navarre, indeed, which had been united with Aragon since the fratricidal murder of its king Sancho in 1076, preferred to remain independent under a new ruler of its choice. It was henceforth a small State lying across the Pyrenees, dependent on France, and doomed inevitably to be partitioned between its great neighbours to north and south.

Alphonso VII., the son of Urraca, was, during the 20 years between his mother's death and his own in 1157, the dominating sovereign of Spain. In 1135 he was crowned at Leon, in the presence of the new king of Navarre, of the counts of Barcelona and Toulouse, and of other princes, Christian and Mohammedan, "emperor in Spain, and king of the men of the two religions." He took Cordova and conquered as far as Almeria, but left vassal Muslim princes in possession. At his death Sancho, his eldest son, succeeded him in Castile and Fernando in Leon. Portugal had already become a semi-independent State.

The Almohádes.—Alphonso VIII. married Leonora, daughter of Henry II. of England, who, as duke of Aquitaine, by right of his marriage with the duchess Eleanor, had a strong direct interest in Spanish politics. In Andalusia the downfall of the Almorávides had opened the way to the Almohádes, or followers of the Mahdi, an even more bigoted religious sect. Alphonso had conquered Cuenca, in the hill country between Castile and Valencia, in 1177, with the help of the king of Aragon, also an Alphonso, the son of Petronilla and of Ramon Berenguer of Barcelona, and rewarded his ally by resigning all claim to feudal superiority over Aragon. At a later period the two kingdoms defined their respective spheres of influence by a treaty. Aragon was left free to conquer the Balearic islands and Valencia, while Murcia and Andalusia were to fall to Castile. The Almohádes took the field against Alphonso in force, and as his fellow Christian sovereigns failed him in the hour of need, he was defeated at Alarcos (1195). To this age belongs the formation of the great monastic military orders of Calatrava, Santiago and Alcántara. They supplied the Crown with a strong force of well-disciplined and well-appointed cavalry. To tighten the bond with Leon, Alphonso of Castile married his daughter Berengaria to its king Alphonso (1188–1230), the son of his uncle Fernando. The marriage was dissolved by the pope as being within the prohibited degrees, but the son born of it was recognized as legitimate. Berengaria, a woman of very noble character and eminent ability, deserved a better husband than her cousin of Leon, who was nicknamed El Baboso—the Slobberer—and who appears to have been epileptic. In 1212 the king of Castile reaped the reward of long years of patience. The Almohádes threatened an invasion in force, and he organized a crusade against them. Aragon was represented by its king Peter II., Navarre by its king Sancho, and Portugal by a strong contingent of Templars and other knights. At Las Navas de Tolosa, just south of the Sierra Morena, the Almohádes received (1212) the final overthrow which laid Mohammedan Spain at the feet of the Christians. Alphonso died in 1214. His son Enrique (Henry) was killed by the fall of a tile three years later; and Berengaria, to whom the Crown came, sent to Leon for her son Fernando, and abdicated in his favour.

Reconquest of Spain Except Granada.—Fernando (Ferdinand III.) continued the advance into Andalusia. The Almohádes were in swifter decline than the Almorávides. One of them, al-Mamun, even sought Fernando's help to regain his throne in Morocco, and ceded a suburb of the city to his Christian allies. In 1230 the death of Alphonso of Leon opened the way to a final union of the Crowns of Castile and Leon. The work of the reconquest was now completed with swift steps. In 1236 Cordova was conquered, and Seville fell in 1248 with the help of a fleet from the Basque coast and of the Moorish king of Granada, who was Fernando's vassal, paying tribute and attending *cortes* when summoned. Fernando died in May 1252. The Aragonese share of the reconquest was completed by James the Conqueror (1213–76). He conquered the Balearic islands in 1229 and Valencia in 1238. Mohammedan Spain was reduced to Granada and a line of ports round to Cadiz.

The close of the period of the great reconquest, five centuries of struggle, left Spain divided between two States of different character. On the west of the Iberian range and south of the Guadarrama was the kingdom called, for short, Castile and Leon. In fact its sovereign was also king of Galicia, Asturias, Extremadura, Jaen, Cordova and Seville.

On the eastern slope of the Iberian hills and the great central table-land was the kingdom called, again for short, Aragon. Its king was also a ruler of many titles—king in Aragon, in Valencia and the Balearic Isles (with one interval of separation), count of Barcelona, and in Provence. Marriage and inheritance had given him territorial rights in the south-east of France. Thus he came in contact with the crusaders of Simon de Montfort and the expansion of the French monarchy. Another marriage, that of Peter, the son and successor of James the Conqueror, with Costanza, the daughter of Manfred of Beneventum, gave him claims on the Neapolitan and Sicilian inheritance of the Hohenstaufen. From the date of the Sicilian Vespers (1283) Aragon is found mixed in the politics of Italy. The commercial activity of Barcelona brought it into collision with Genoa and alliance with Venice. The curious double position of the king of Aragon is fully illustrated by the career of that king Peter who was the father of James the Conqueror. He fought as a crusader at Las Navas de Tolosa, he went to Rome to be crowned, and did voluntary homage to the pope. Yet his interests as a prince of southern France compelled him to draw the sword in defence of the Albigenses, and, orthodox as he was in creed, he fell fighting for them at Muret in 1213.

The distinction of classes was far sharper in Aragon than in non-feudal Castile and Leon. Predial slavery, which had disappeared in Castile and Leon in the 13th century, existed unmodified in Aragon, and in its worst form, down to the Bourbon dynasty. Freedom was confined to the citizens of the towns which had charters—called in Aragon the Universidades—the nobles, the gentry and the Church. The Catalans attained emancipation from feudal subjection by a succession of savage peasant revolts in the 15th and 16th centuries. In Valencia emancipation was finally brought by a measure which in itself was cruel—the expulsion of the Moriscos in the 17th century. The landlords were compelled to replace them by free tenants. The prevalence of predial slavery in Aragon and Valencia can be largely explained by the number of Mudéjares, that is Mohammedans living under Christian rule, and of Moriscos—converted Mohammedans.

Christianization of Spain.—The Jews, who had suffered cruelly from the brutal fanaticism of the Almohádes, had done a great deal to forward the conquest of Andalusia. They were repaid by the confidence of the king, and the period which includes the reign of Fernando and lasts till the end of the 14th century was the golden age of their history in Spain. In 1391 the preaching of a priest of Seville, Fernando Martinez, led to the first general massacre of the Jews, who were envied for their prosperity and hated because they were the king's tax collectors. But the history of the persecution and expulsion of the Jews is the same everywhere except in date. The story of the Mudéjares and Moriscos is peculiarly Spanish. Forced conversion prepared the way for expulsion, which came in the reign of Philip III. (1598–1621). In the majority of cases the conversion had occurred so long ago that the memory of the time when they were Mohammedans was lost, and multitudes of the children of Mudéjares remained. The Mozárabes again—the Christians who had always lived under Mohammedan rule—were an element of importance in mediaeval Spain. They had learnt to write in Arabic, and used Arabic letters even when writing Latin, or the corrupt dialect of Latin which they spoke. The Mozárabes were treated under the kings of the reconquest as separate bodies with their own judges and law, which they had been allowed to keep by the Muslim rulers. That code was the *forum judicum* of the Visigoths, the *fuero juzgo,* as it was called in the "romance" of later times and in Castilian. The Mozárabes brought in the large Arabic element, which is one of the features of the Castilian language.

Problem of the Unification of Spain.—The work of political unification was essentially more difficult than the christianization of Spain. The Galician who spoke, and still speaks, a language of his own, was profoundly separated from the Andalusian. The Basque, who till much later times practically included the Navarrese, was a man of another nationality and another speech from the Castilian. And what is true of Castile and Leon applies equally to Aragon. Aragonese, Catalans and Valencians were as different as Galicians, Basques, Castilians and Andalusians. Aragon spoke a dialect of Castilian. Catalonia and Valencia, together with the Balearic islands, spoke, and speak, dialects of the southern French, the so-called Limosé, though it was not the language of the Limousin. High mountain barriers and deep river courses had separated the Spaniards locally. They were more subtly and incurably separated by traditional and legal status. Under the Crown of Castile all the territory was either *abadengo, realengo, salariego, behetria,* or it belonged to some town, big or little, which had its *carta pueblo* or town charter, its own *fuero* (forum) or law. *Abadengo* was land of the Church, *realengo* domain of the Crown, *salariego* land of the nobles. *Behetria* is less easy to translate. The word is the romance form of *benefactoria.* Behetrias, called "plebian lordships," were districts and townships of peasants who were bound to have a lord, and to make him payments in money or in kind, but who had a varying freedom of choice in electing their lord. Some were described as "from sea to sea, and seven times a day," that is to say they could take him anywhere in the king's dominions from the Bay of Biscay to the Straits of Gibraltar, and change him as often as they pleased. Others were *de linage,* that is to say, bound to take their lord from certain lineages. Their origin must probably be sought in the action of communities of Mozárabes, Christians living under Muslim rule as *rayahs,* who put themselves under Christian chiefs of the early days of the reconquest for the *benefice* of their protection. They were mainly in old Castile. By the end of the middle ages they had disappeared. The chartered towns, in Spain east and west, were practically republics living under their own *carta pueblo* with their own *fuero* or law. All charters were not granted by the king. Many of them were given by nobles or ecclesiastics, but required the confirmation of the king. And in this country, where all was local law usage and privilege, where uniformity was unknown, all charters were not held by towns. In many cases the serfs in the course of their struggle for freedom extorted charters and *fueros.* The greater chartered towns had their surrounding *comarcas,* answering to the "county" of an Italian city, over which they exercised jurisdiction. In time the villages dependent on a chartered city, as they grew to be towns themselves, fought for, and in many cases won, emancipation, which they then sought to have confirmed by the king and proceeded to symbolize by setting up their own gallows in the market-place. The Church had won exemption from the payment of taxes by no general law, but by particular privilege to this or that chapter, bishopric or monastery. The nobles claimed, and were allowed, exemption from taxation. Church and nobles alike were for ever extending their borders by purchase, or trying to do so by force. They conferred their exemptions on the land they acquired, thus throwing the burden of taxation on the towns and the non-nobles with increasing weight. But there was in reality no sharp division except in the smaller and feudal portion—called Aragon for convenience—and save as between Christian and non-Christian, noble and non-noble. The necessities of the reconquest made it obligatory that all the dwellers on the frontier should be garrison. Hence they were not only encouraged but required to possess arms. Those of them who could provide themselves with a charger, a mail shirt, a spear and sword were ranked as *milites*—and the *miles* was a *caballero.*

The Kings of Castile.—Alphonso X. of Castile (1252–84) was a writer, and a man of keen intelligent interest in science and law. As a ruler he was at once weak, unstable and obstinate. He wasted much time and great sums of money in endeavouring to secure his election as emperor—not in Spain, but in the Holy Roman empire. He did indeed add the town of Cadiz to his possessions with the help of his vassal, the Moorish king of Granada, but his reign is filled with quarrels between himself and his nobles. He ended his life in a war with his son Sancho, who claimed the succession in preference to the children of his elder brother, Fernando de la Cerda, in virtue of a doctrine that the younger son, being nearer to the father than the grandson, had a right to succeed in preference to the children of an elder brother who had died before the succession was open. Alphonso, after first accepting Sancho's claim, repudiated it, and made a will by which he not only left the Crown of Castile to the eldest son of Fernando de la Cerda, but cut vassal kingdoms out of the southern parts of Spain for Sancho's younger brothers. The reign of Sancho IV., surnamed El Bravo, or the Fierce (1284–96), was one constant struggle with the very nobles who had helped him against his father, with his younger brothers, and with the sons of Fernando de la Cerda. Murder and massacre were his familiar methods. He was succeeded by his infant son Fernando (Ferdinand IV.) whose long minority was an anarchy, tempered by the courage and the tact of his mother, Maria de Molina. Fernando, ungrateful to his mother and incapable as a king, died in 1312, leaving a son of less than a year old, Alphonso XI. (1312–50). After another minority of confusion, Alphonso, surnamed "of the Rio Salado," from the great victory he won over an invading host from Africa, ruled with energy and real political capacity. He did something to found the judicial and administrative unity of the country. His death at the age of 38, during the great plague, and while he was besieging Gibraltar, was a misfortune to Spain.

His successor, Peter, called the Cruel (1350–68) was destined to show the Castilians exactly what the constant use by "the prince" of the reserved rights of the sovereign authority could be made to mean, when they were exercised by a passionate man maddened by suspicion of all about him. Administering the civil side of his Government through Jewish tax-gatherers and farmers of the taxes, and surrounded by the Mudéjar guard, who were the executors of his justice, his path is marked by one long succession of murders. With all his appearance of energy, he shrank from action at the critical moment of his wars out of utter want of trust in all about him. His expulsion by his brother, Henry of Trastamara, the eldest son of Leonora de Guzman, his restoration by the Black Prince (*q.v.*), his treachery to him, and his final defeat and murder at Montiel, are famous episodes. Henry of Trastamara, the beginner of the "new kings" (1368–79), reigned by election. In his reign and those of his immediate successors the *cortes* flourished, although it failed to establish checks on the absolute power of the king. Henry was on the whole a successful ruler. He forced his neighbours of Portugal to make peace, his fleet defeated an English squadron off Rochelle, and he restored internal order. The civic *hermandades,* or brotherhoods, enforced respect from the nobles. John I. (1379–90), Henry's son and successor, had to contend with John of Gaunt, son of Edward III. of England, who had married the eldest daughter of Peter the Cruel, and claimed the Crown of Castile in her name. John averted the danger by arranging a marriage between his son Henry and Constance, the eldest daughter of John of Gaunt, an alliance which united the two equally illegitimate lines representing Alphonso XI., and so closed the dispute as to the succession. He was less fortunate in his efforts to vindicate the rights of his wife Beatriz to the throne of Portugal. The defeat of the Castilians at the battle of Aljubarrota (1385) compelled the king to renounce his pretensions. The minority of his son, Henry III. (1390–1406) was long, and his effective reign short, but in the brief space allowed him the king, a weakly man surnamed El Doliente (the sufferer) did something to establish order. He recovered all the immense grants of Crown lands and rents, impounded by the nobles during his minority. The first years of the minority of his infant son, John II. (1406–54), were by a rare exception peaceful. The young king's uncle Ferdinand acted as regent. Ferdinand was able and honest. His succession to the throne of Aragon is an event of capital importance.

The Kings of Aragon.—The kings of Aragon from the death of James the Conqueror in 1276 to the death of Martin I. in 1410 were so largely concerned in the struggle with the Angevin Party in Naples and Sicily, that their history belongs rather to Italy than to their Peninsular kingdom. They were six in number: Peter III. (1276–85), Alphonso III. (1285–91), James II. (1291–1327), Alphonso IV. (1327–36), Peter IV. (1336–87), John I.

(1387–95), and Martin I. (1395–1410). Their double task was to reunite the Balearic islands and Roussillon, which James the Conqueror had left by will to a younger son, to the Crown of Aragon, and to reduce their turbulent barons, in Aragon, Catalonia and Valencia alike, to the position of obedient subjects. In both tasks Peter IV. ultimately achieved success. The barons of Aragon and Valencia had extorted from his weak father the charter known as the "Union," an instrument which was incompatible with the monarchical or any other form of government. The object of the life of Peter IV. was to force the barons to surrender their charter. After years of struggle and preliminary failures, Peter IV. defeated the "Union" utterly at the decisive battle of Epila (1348). He was a typical king of the 15th century, immeasurably false, and unspeakably ferocious, but he was not a mere bloodthirsty sultan like his enemy, Peter the Cruel of Castile. When he won he took, indeed, a brutal vengeance on individuals, and he extorted the surrender of the charter and destroyed it with his dagger in the presence of the *cortes* at Saragossa. He cut his hand in his eagerness, and declared that the blood of a king was well shed in securing the destruction of such an instrument—whence his popular nickname of Peter of the Dagger (*del Punyalet*). But his use of the victory was statesmanlike. He fully confirmed the right of the nobles to trial by law and security against arbitrary punishment; he left the franchises of the city untouched, and respected the independence of the *justicia*. The result of his victory was to give Aragon and his other dominions a measure of internal peace unknown in Castile. The reigns of his sons and successors, John and Martin, were insignificant and tranquil. The death of Martin without children in 1410 left the succession open. The *cortes* was able to administer in peace, and the question of the succession was debated as if it had been in a suit between private persons. The judges finally decided in favour of Ferdinand, on the ground that his mother, Eleanor, was the daughter of Peter IV., and that though a woman could not reign as a "proprietary queen" in Aragon, she could convey the right to her husband or transmit it to her son.

The years 1412–79 marked a growing approximation between the two States whose interests touched one another so closely. In Castile John II. (1406–54), a man of amiable but indolent character and of literary tastes, was governed by his favourite, Álvaro de Luna, and harassed by his nobles. At the end of his life he sacrificed his favourite at the instigation of his second wife. Of his son, Henry IV. (1454–74) it is enough to say that he was called "the Impotent," and that there is every reason to believe that he deserved the description in all the senses of the word. His reign was an inferior copy of his father's. As the legitimacy of his alleged daughter Juana was disputed, his sister Isabella claimed the succession, and married her cousin, Ferdinand of Aragon, son of John I., in 1469 in defiance of her brother. In Aragon, Ferdinand I. "of Antequera" (1412–16) was succeeded by Alphonso V. (1416–58) the Magnanimous, whose brilliant life belongs to Italy. In Aragon he was represented by his brother John, who administered as lieutenant-general, and who reigned in his own right (1458–79) when Alphonso V. died without legitimate heirs, leaving Naples by will to a bastard son. John I., a man of indomitable energy and considerable capacity, spent most of his life in endeavouring to enforce his claims to the kingdom of Navarre as the husband and heir of its queen Blanche. His conflict with his son by his first marriage, Charles, prince of Viana, was settled in his favour by the death of the prince. A national revolt was suppressed in Catalonia. At the age of over 80, the blind old king transmitted his kingdom to Ferdinand, his son by his second marriage, with Juana Enriquez, of the family of the hereditary admirals of Castile. Navarre went to a daughter, and Roussillon was somewhat fraudulently retained by Louis XI. as security for a debt. Ferdinand conquered the Spanish half of Navarre later, and recovered Roussillon from Charles VIII., the successor of Louis XI.

With the death of John I. of Aragon in 1479 the history of Spain enters on an entirely new period. Hitherto it has been the story of a national development. The process did not cease, but, during the reign of Isabella the Catholic (1474–1504) until the death of her husband Ferdinand in 1516, was carried, not to completion, but to the stopping place at which it was destined to rest for two centuries. The voyage of Columbus in 1492, and the intervention of Ferdinand in the great conflict of France, the empire and the papacy for predominance in Italy, had, simultaneously, the effect of opening to her the world of conquest and adventure in America, and of committing her to incessant wars in the Italian peninsula. The death of John, the only son of Ferdinand and Isabella, the worst misfortune which ever happened to Spain, opened the succession to all the crowns and coronets worn by the Catholic sovereigns to Charles of Habsburg—the emperor Charles V. From that day Spain became a part—the leader, then the paymaster, then the dupe—of the international monarchical confederation called "the illustrious House of Austria." The Spaniard became the swordsman and executioner of the counter-Reformation, because the power of the House of Austria depended on the imposition of religious unity in Europe. The decision of Charles V., king of Spain and emperor, to leave the Netherlands to his son Philip II., committed the Spaniards to conflict on the sea with England, and to the insane attempt to secure a safe road for their armies across Europe from the shores of the Mediterranean to the North sea. Meanwhile the Spaniards were endeavouring to check the advance of the Turks in the Mediterranean, and to exclude all Europe from the waters of the New World.

Ferdinand and Isabella.—Ferdinand and Isabella were proclaimed king and queen of Castile together, although the Crown was hers alone, and although she never consented to part with her sovereign authority. In the purely internal affairs of Castile it was always she who decided on questions of administration. They immediately began the work of establishing order and obedience in their dominions. The line of policy followed by the Catholic sovereigns was to keep the old forms, but draw the substance of power to themselves. This course was followed with the *cortes*. It continued to be summoned by the Catholic sovereigns and their successors of the Habsburg line, but it was needed only to grant money. The nobles and the clergy, who as exempt from taxation had no vote, became purely ornamental parts of the *cortes*. The representatives of the third estate were confined by the indifference of the Castilians to 18 towns, whose procurators were named by the councils either from among themselves in rotation, or from particular families. The Catholic sovereigns provided themselves with a revenue by the customary wholesale resumptions of grants made during the reigns of John II. and Henry IV., and by the suppression or reduction of the pensions they had granted with profusion. Encouragement of industry was not wanting; the State undertook to develop the herds of merino sheep, by issuing prohibitions against inclosures, which proved the ruin of agriculture, and gave premiums for large merchant ships, which ruined the owners of small vessels and reduced the merchant navy of Spain to a handful of galleons. *Tasas*, fixed prices, were placed on everything. The weaver, the fuller, the armourer, the potter, the shoemaker were told exactly how to do their own work. All this did not bear its full fruit during the reign of the Catholic sovereigns, but by the end of the 16th century it had reduced Spain to a state of Byzantine regulation in which every kind of work had to be done under the eye and subject to the interference of a vast swarm of Government officials, all ill paid, and often not paid, all corrupt. All this also did not bear its full fruit till later times, but by the 17th century it had made Spain one of the two "most beggarly nations in Europe"—the other being Portugal.

The Spanish Inquisition.—The policy of the Catholic sovereigns towards the Church was of essentially the same character as their treatment of the nobles or the cities. They aimed at using it as an instrument of government. One of the first measures adopted by them in Castile, before the union with Aragon, was to stop the nomination of foreigners to Spanish benefices by the pope. But the most characteristic part of their ecclesiastical policy was the establishment of the Spanish Inquisition (*q.v.*). By the bull of Sixtus IV. of 1578 they obtained authority to appoint three inquisitors, whom they were empowered to remove or replace, and who were independent of, and superior to, the inquisitorial courts of the bishops. The Inquisition was at first established (in 1480) in the dominions of Castile only, but it was extended in 1486 to Catalonia and in 1487 to Aragon, in spite of strong protests. The first duties of the Inquisition were to deal with the converted Jews and Mohammedans, respectively known as Marranos and Moriscos. Professed Jews were expelled in 1492, and the Mohammedans or Mudéjares in 1502. Both were industrious classes, and the loss of their services was disastrous to Spain—the first of a long series of similar measures which culminated in the final expulsion of the Moriscos in 1610. The converted Jews and Mohammedans presented greater difficulties to the Inquisition. Many of the higher ecclesiastics and of the nobility were of Jewish, or partially Jewish, descent.

Conquest of Granada.—Between 1481 and 1492 the Catholic sovereigns completed the work of the reconquest by subjugating the one surviving Mohammedan State of Granada. Their task was materially facilitated by dissensions among the Moors. The surrender of Granada on Jan. 2, 1492, was partly secured by promises of toleration, which were soon violated. A revolt had to be suppressed in 1501. Having secured the unity of their territory in the peninsula, the Catholic sovereigns were free to begin the work of expansion. In 1492 Columbus (*q.v.*) sailed on his first voyage to the west. In 1493 Ferdinand secured the restoration of Roussillon from Charles VIII. of France by the fallacious treaty in which he undertook to remain neutral during the king's expedition to Italy. The voyage of Columbus had unforeseen consequences which led to diplomatic difficulties with Portugal, and the Treaty of Tordesillas in 1494, which defined the respective spheres of influence of the two Powers in the New World and in Asia. In 1497 Ferdinand, with the support of his wife, entered on those wars of Italy in which the Spanish regular soldiers first gained their reputation, and which made Spain for a time the dominant Power in the Italian peninsula (*see* CORDOBA, GONZALO F. DE). They endeavoured to strengthen themselves against France by marriages with the royal family of England (*see* CATHERINE OF ARAGON) and the Habsburgs. The marriage of Juana, called the Mad, with Philip of Habsburg, son of the emperor Maximilian (*q.v.*), brought a new dynasty to Spain. On the death of Queen Isabella in 1504 her son-in-law claimed the regency, and was supported by the Castilian nobles. His death in 1506 and the insanity of his widow left the Castilians no choice but to restore Ferdinand as regent. During the next ten years Ferdinand governed with the very able assistance of the archbishop of Toledo, Jimenez de Cisneros (*q.v.*). He annexed the southern part of Navarre, which was held by the representatives of his half-sister. The archbishop organized and directed the expedition which conquered Oran, Tripoli and other points on the African coast. Here beyond all doubt lay the proper field for the expansion of Spain. She was drawn from it on the death of Ferdinand in 1516. He was succeeded by his grandson Charles of Habsburg, and when Charles was elected to the empire in 1519 Spain was dragged into the wars and politics of Central Europe.

(A. E. Ho.; A. B.)

THE AUSTRIAN HOUSE

The Emperor Charles V.—Only the smaller part of the reign of Charles was spent in Spain. He came to it from Flanders, where he had received his education, unable to speak the Spanish language and surrounded by Flemish favourites. Furthermore, and this was the chief cause of his misunderstandings with the Spaniards, his mind was mainly preoccupied with the international policy of the house of Burgundy and the empire, a foreign policy which could arouse no interest and was not even understood in Spain. Charles knew nothing either of Spanish ideas or of the national tradition of the new States to which he had succeeded. To him and his favourites the new country was only a source of supply from which money was to be obtained in order to bribe the German electors.

European Policy of Charles V.—The conquest of Mexico by Hernan Cortes (*q.v.*) and of Peru by Francisco Pizarro (*q.v.*) belong to this reign. These conquests and the incessant wars into which Spain was drawn by the Aragonese claims in Italy, and its connection with the empire, gave to the nation a great European position and to the Spanish soldiers of the time many opportunities to win renown. The capture of the French king (Francis I.) at Pavia and his imprisonment at Madrid gratified for a moment the pride of the Spaniards, and did much to reconcile some of them to the sacrifices which the policy of the emperor imposed on them. But the *cortes* begged Charles many times to make an end of the European wars, as did the nobles assembled in 1538. Except in the case of the successful attack on Tunis in 1535, and the attempt to take Algiers in 1541, the actions of Charles were not inspired by any regard for the interests of his Spanish kingdoms. He treated them simply as instruments to promote the grandeur of his house. His indifference to their good, or his utter inability to see where it lay, was conspicuously shown when, on his abdication in 1556, he left his hereditary Flemish possessions to his son Philip, and not to his brother Ferdinand.

Philip II.—In foreign policy the reign of Philip II. (1556–98) was a prolongation of the reign of his father, and in it the vices of this policy were displayed to the fullest extent. Philip's marriage with Mary Tudor in 1554 having proved barren, and her death in 1558 having placed Elizabeth on the throne of England, he was left without the support against France which this union was meant to secure. At the same time his inheritance of the Netherlands brought him into collision with their inhabitants, who feared his absolutist tendencies, and with the Reformation (*q.v.*). The revolt in the Low Countries was inevitably favoured by both France and England. Philip was consequently drawn into intervention in the religious wars of France (*q.v.*) and into war with England, which culminated in the great Armada (*q.v.*) of 1588. His relations with England were further complicated by the extension of English maritime enterprise to the New World (*see* HAWKINS, JOHN; and DRAKE, FRANCIS). In the Mediterranean he was equally forced by his position and the tradition of the Crown of Castile to take part in resisting the Turks (*see* MALTA; and LEPANTO, BATTLE OF). But his relations with his Flemish subjects formed the centre of his policy. With his absolutist tendencies, which did not however differ from those of other European monarchs, he was bound to wish to govern them as he did Castile, and the principle of religious toleration, which was not understood by any prince in Europe with the exception of the prince of Orange, William I., the Silent (*q.v.*), was peculiarly impossible for him. His reign was therefore one long struggle with forces which he was unable to master.

The burden of the struggle fell with crushing effect on his Spanish dominions and particularly on Castile. Aragon, which was poor and tenacious of its rights, would give little; Catalonia and Valencia afforded small help. The Flemish revenue was destroyed by the revolt. The Italian states barely paid their expenses. Resources for the incessant wars of the reign had been sought in the taxation of Castile and the revenue from the mines of America. They were wholly inadequate, and the result of the attempt to dominate all western Europe was to produce bankruptcy and exhaustion. In his internal government Philip was fully absolute, but he was at the same time careful to ensure good administration, public integrity and justice.

Foreign Policy of Philip II.—The first years of the reign of Philip II. were occupied in concluding the last of his father's wars with France, to which was added a very unwelcome quarrel with the pope, arising out of his position as duke of Milan. He was unable to avoid sending an army under Alva against Paul IV., and was glad to avail himself of the services of Venice to patch up a peace. On the Flemish frontier, with the help of an English contingent and by the good generalship of Philibert of Savoy he defeated a French army at St. Quentin on Aug. 10, 1557, and again at Gravelines on July 13, 1558. But he did not follow up his successes, and the war was ended by the signing of the peace of Cateau Cambrésis on April 2, 1559. The exhaustion of his resources made peace necessary to him, and it was no less desirable to the French Government. Philip's marriage with Elizabeth, the daughter of Henry II. and of Catherine de' Medici, together with their common fear of the Reformation, bound him to the French royal house, but for a brief period only.

By 1567 the revolt in the Netherlands was flagrant, and the duke of Alva was sent with a picked army, and at the expense of Spain, to put it down. In the same year, a decree of the king, which repeated the terms of another decree of Charles (1526) regarding the Catholic education of Moriscoes and the prohibition of the use of Arabic, led to a revolt which desolated Granada from 1568 to 1570. The Moriscoes had looked for help from the Turks, who were engaged in conquering Cyprus from Venice. The danger to Spain and to the Spanish possessions in Italy stimulated the king to join in the Holy League formed by the pope and Venice against the Turks; and Spanish ships and soldiers had a great share in the splendid victory at Lepanto.

In 1581 Philip annexed Portugal, as heir to King Henry, the aged successor of Dom Sebastian. Philip endeavoured to placate the Portuguese by the fullest recognition of their constitutional rights, and in particular by favouring the *fidalgos* or gentry. The duke of Braganza, whose claims were better than Philip's, was bought off by immense grants. Outwardly at the zenith of its powers, the country in reality was internally exhausted, and its weakness was shown when open war began with England in 1585.

While a vast armament was being slowly collected for the invasion of England, Drake swept the West Indies, and in 1587 burnt a number of Spanish ships in their own harbour of Cadiz. The ruinous failure of the great Armada in 1588 demonstrated the incapacity of Spain to maintain her pretensions. In 1591 the support given by the Aragonese to Antonio Perez (*q.v.*) led to the invasion of their country by a Castilian army. The constitutional rights of Aragon were not entirely suppressed, but they were diminished, and the kingdom was reduced to a greater measure of submission. In his later years Philip added to all his other burdens a costly intervention in France to support the League and resist the succession of Henry IV. to the throne. He was compelled to acknowledge himself beaten before his death on Sept. 13, 1598. He left the war with England and with the Netherlands as an inheritance to his son.

Philip III. 1598–1621.—The period of 102 years covered by the reigns of Philip III., Philip IV. and Charles II., was one of gradual decadence, mainly in the spheres of politics and economics. On the other hand and until the end of the reign of Philip IV. it was the golden age of Spanish literature, art and science. The dynasty continued to make the maintenance of the rights and interests of the house of Austria its main object. The policy of James I. of England, the civil wars of Charles I., the assassination of Henry IV. of France, the troubles of the minority and reign of Louis XIII. and the Fronde (*q.v.*), preserved Spain from concerted and persistent foreign attack. After a futile attempt to injure England by giving support to the earl of Tyrone in Ireland (*see* TYRONE, EARLS OF) peace was made between the powers in 1604. In 1609 a 12 years' truce was made with the Dutch. But the temporary cessation of foreign wars brought no real peace to Spain.

Philip IV. 1621–65.—The death of Philip III. (March 21, 1621) brought no real change. His son, Philip IV., was an abler man and even gave indications of a wish to qualify himself to discharge his duties as king. But he was young, pleasure-loving, and wanted the strength of will to make his good intentions effective. For 20 years the administration was really directed by his favourite the count of Olivares (*q.v.*) and the duke of San Lucar, known as the "Conde-Duque," the count-duke. Olivares possessed the sense of the national unity of Spain as opposed to the particularism of the old kingdoms, which was a source of certain weakness in international disputes. But he could only keep his place by supplying his master with the means of dissipation and by conforming to his dynastic sentiments. The truce concluded in 1609 with Holland ended in 1621, and was not renewed. The commercial classes, particularly in Portugal, complained that it subjected them to Dutch competition. War was renewed, and the Dutch invaded Brazil. As their fleets made it dangerous to send troops by sea to Flanders, Spain had to secure a safe road overland. Therefore she endeavoured to obtain full control of the Valtellina, the valley leading from Lombardy to Tirol, and from thence to the German ecclesiastical states, which allowed a free passage to the Spanish troops. War with France ensued. The failure of the treaty of marriage with England (*see* BUCKINGHAM, GEORGE VILLIERS, first duke of) also led to war, for the English court was offended by the Spanish refusal to aid in the restoration of the count palatine, son-in-law of James I., to his dominions. In Flanders the town of Breda was taken after a famous siege. The French conducted their campaign badly. The Dutch were expelled from Bahia in Brazil, which they had seized. An English attack on Cadiz in 1625 was repulsed.

Decadence of the Spanish Empire.—But by 1640 the feebleness of the political power of the Spanish European empire was notorious. In that year Portugal fell away without needing to strike a blow. Then followed the revolt of Naples (*see* MASANIELLO) and of the Catalans, who were bitterly angered by the excesses of the troops sent to operate against the French in Roussillon. They called in the French, and the Spanish Government was compelled to neglect Portugal. Olivares, who was denounced by the nation as the cause of all its misfortunes, was dismissed, and the king made a brief effort to rule for himself. But he soon fell back under the control of less capable favourites than Olivares. In 1643 the prestige of the Spanish infantry was ruined by the battle of Rocroy. At the Peace of Münster, which ended the Thirty Years' War in 1648, Spain was cynically thrown over by the German Habsburgs for whom she had sacrificed so much. Aided by the disorders in the minority of Louis XIV., she struggled on till the Peace of the Pyrenees in 1659, by which Roussillon was ceded to France. An attempt was now made to subdue Portugal, but the battle of Montesclaros in 1665 proved the futility of the effort. The news of the disaster was followed by the death of the king on Sept. 17, 1665. Catalonia was saved by the reaction produced by excesses of the French troops, and in Naples the revolt had collapsed; but Portugal was lost forever.

Charles II. 1665–1700.—During the whole of the reign of Charles II., the son of the second marriage of Philip IV. with his niece Mariana of Austria, the Spanish monarchy was saved from dismemberment only by the intervention of England and Holland. The wars of 1667–68, 1672–78, 1683–84, and the war of the League of Augsburg, 1689–96, were some of them fought wholly, and all of them partly, because the French king wished to obtain one or another portion of the dominions of the Spanish Habsburgs. But Spain took a subordinate and often a merely passive part in these wars. The king was imbecile. During his minority the Government was directed by his mother and her successive favourites, the German Jesuit Nithard and the Granadine adventurer Fernando de Valenzuela. In 1677 the king's bastard brother, the younger Don John of Austria, defeated the queen's faction, which was entirely Austrian in sentiment, and obtained power for a short time. By him the king was married in 1679 to Marie Louise of Orleans, in the interest of France. When she died in 1689, he was married by the Austrian party to Mariana of Neuburg. At last the French party, which hoped to save the monarchy from partition by securing the support of France, persuaded the dying king to leave his kingdom by will to the duke of Anjou, the grandson of Louis XIV., and of Maria Teresa, daughter of Philip IV. by his first marriage. On the death of Charles II., on Nov. 1, 1700, the duke of Anjou became king.

THE BOURBON DYNASTY

The decision of Louis XIV. to accept the inheritance left to his grandson by Charles II. led to a war (*see* SPANISH SUCCESSION, WAR OF THE), which was only ended in 1713 by the peace of Utrecht, and resulted in the loss of Gibraltar and the island of Minorca, which remained in the hands of England, and of all the Spanish dominions in Italy and Flanders.

Philip V. 1700–46.—In internal affairs the years of the war were of capital importance in Spanish history. The general political and administrative nullity of the upper Spanish class of this generation and the political views of the French monarchy led to the assumption of all real power by the French or Italian servants and advisers of the king. Under their direction important financial and administrative reforms were begun. The absolutist and centralizing nature of some of these innovations revived the separatist tendencies of the eastern portion of the peninsula which had embraced the cause of the Austrian party against the Bourbon dynasty. Philip V. was forced to reduce Aragon, Catalonia and Valencia by arms. Barcelona was only taken in 1714, the year after the signing of the Treaty of Utrecht. Most of the privileges of these once independent kingdoms, which had with rare exceptions been respected by the Austrian kings, disappeared.

Elizabeth Farnese and Alberoni.—On the death of Philip V.'s wife, Maria Luisa Gabriella of Savoy, in 1714, the king was married at once to Elizabeth Farnese of Parma, who ruled him and used her whole influence to drag Spain into a series of adventures in order to obtain Italian dominions for her sons. Her first agent was the Italian priest Alberoni (*q.v.*), whose favour lasted from 1714 to 1719. Alberoni could not, and perhaps did not, sincerely wish to prevent the queen and king from plunging into an attempt to recover Sardinia and Sicily, which provoked the armed intervention of France and England and led to the destruction of the rising Spanish navy off Cape Pássaro (*see* TORRINGTON, GEORGE BYNG, VISCOUNT). In 1731 Elizabeth secured the succession of her eldest son, Charles, afterwards Charles III. of Spain, to the duchy of Parma, by arrangement with England and the empire. Apart from the Italian intrigues, the most important foreign affairs of the reign were connected with the relations of Spain with England. A feeble attempt to regain Gibraltar was made in 1733, and a serious war was only averted by the resolute peace policy of Walpole. The king, who had become almost entirely mad, died on July 9, 1746.

Ferdinand VI. 1746–59.—His successor, Ferdinand VI., the second son of his first marriage, was a retiring and modest man, who adopted a policy of peace with England. His ministers were mainly Spaniards, well qualified for political and administrative tasks (which indicates a very rapid recovery), intermingled with a few foreigners: the most notable of the Spaniards was Zenon de Somadevila, marquis of Ensenada, and of the foreigners, Richard Wall, an Irish Jacobite. The advance of the country in material prosperity was considerable.

Charles III. 1759–88.—Charles III. was one of the most sincere, and the most successful, of the "enlightened despots" of the 18th century. He had had a long apprenticeship in Naples, and was a man of 43 when he came to Spain in 1759. Until his death he laboured to advance the material prosperity of Spain. His foreign policy was less wise. He had a deep dislike of England, not only because of the late wars in Europe, but also because of the covetous eyes which England turned on America; and a strong and justified desire to recover Minorca and Gibraltar. All this added to a natural family feeling, induced him to enter into the "Family Compact" with his French cousins. In 1770 he came to the verge of war with England over the Falkland islands. In 1778 he joined France in supporting the insurgent English colonists in America. The most statesmanlike of his foreign enterprises, the attempt to take the piratical city of Algiers in 1775, was made with insufficient forces and ended in defeat. Yet he was able to recover Minorca and Florida in the War of American Independence, and he finally extorted a treaty with Algiers which put a stop to piratical raids on the Spanish coast.

The king's domestic policy was almost wholly fruitful of good. Under his direction many useful public works were carried out—roads, bridges and large schemes of drainage. The first reforms undertaken had provoked a disturbance in Madrid directed against the king's favourite minister, the Sicilian marquis of Squillacci. Charles, who believed that the Jesuits had promoted the outbreak, and also that they had organized a murder plot against him, allowed his minister Aranda (*q.v.*), the correspondent of Voltaire, to expel the order in 1766, and exerted his whole influence to secure its entire suppression. The new spirit was also shown by the restrictions imposed on the numbers of the religious orders and on the Inquisition. On the other hand the shipping and the industry of Spain increased greatly. The population made a considerable advance, and, under the enlightened bureaucratic rule of Florida-blanca, the sloth and ignorance which had settled on Spain in the end of the 17th century was lifted.

Charles IV. 1788–1808.—Charles III. was succeeded in 1788 by his son Charles IV. The father, though "enlightened," had been a thorough despot; the son was sluggish and stupid to the verge of imbecility, but the despotism remained. The new king was much under the influence of his wife, Maria Luisa of Parma, a coarse, passionate and narrow-minded woman; but he continued to repose confidence in his father's ministers. Floridablanca was, however, unable to continue his earlier policy, in view of the contemporaneous outbreak of the Revolution in France. The revival of Spain depended on the restoration of her colonial and naval ascendancy at the expense of Great Britain, and for this the support of France was needed. But the "Family Compact," on which the French alliance depended, ceased to exist when Louis XVI. was deprived of power by his subjects. Of this conclusive evidence was given in 1791. Some English merchants had violated the claim of Spain to the whole west coast of America by founding a settlement at Nootka Sound. The Spanish Government lodged a vigorous protest, but the French National Assembly refused to lend any assistance, and Floridablanca was forced to conclude a humiliating treaty and give up all hope of opposing the progress of Great Britain.

The French Revolution.—This failure was attributed by the minister to the Revolution, of which he became the uncompromising opponent. He opened negotiations with the *émigrés,* urged the European Powers to a crusade on behalf of legitimacy, and paraded the devotion of Charles IV. to the head of his family. This bellicose policy, however, brought him into collision with the queen with the result that Floridablanca and his friends, and shortly afterwards the veteran Aranda also, were set aside and the favourite Emmanuel Godoy obtained the direction of affairs. Godoy, who had recently received the title of duke of Alcudia, and who was at once the queen's lover and the personal favourite of the king, had no experience of the routine of office, and no settled policy: but the course to be pursued was decided for him. The execution of Louis XVI. (Jan. 21, 1793) made a profound impression in Spain. Charles IV. was roused to demand vengeance for the insult to his family, and the Spanish monarchy became an enthusiastic member of the first coalition against France. But the campaign undertaken mainly in Roussillon was a failure; the Spaniards were driven from the strong fortresses that guarded the Pyrenees, whilst the French advanced almost to the Ebro.

The queen and Godoy hastened to follow the example set by Prussia, and concluded the Treaty of Basle with France (1795). But the moderation of this treaty was only a flimsy disguise of the disgrace that it involved. Spain found herself tied hand and foot to the French republic. Godoy had to satisfy his allies by the encouragement of reforms which both he and his mistress loathed, and in 1796 the veil was removed by the conclusion of the Treaty of San Ildefonso. This was a virtual renewal of the "Family Compact" of 1761, but with terms far more disadvantageous to Spain. The real object of the treaty was cynically avowed in the 18th article, by which, during the present war, the Spanish obligations were only to apply to the quarrel between Great Britain and France. A scheme was prepared for a joint attack on the English coast, but it was foiled by the battle of St. Vincent (*q.v.*), in which Jervis and Nelson forced the Spanish fleet to retire to Cadiz. Great Britain seized the opportunity to encourage discontent in the Spanish colonies.

It was in vain that Godoy sought to secure the friendship of the reforming party by giving office to two of its most prominent members, Jovellanos and Saavedra. Spanish pride and religious sentiment were offended by the French occupation of Rome and the erection of a republic in the place of the papal Government. The treatment of the duke of Parma by the Directory was keenly resented by the queen. Godoy found himself between two parties who agreed only in their hatred of him, and in March 1798 he was compelled to resign his office. Godoy's office was entrusted to Saavedra, but the reformers did not obtain the advantages which they expected from the change. During Napoleon's absence in Egypt the second coalition gained successes in 1799 which had seemed impossible since 1793.

Napoleon and Spain.—But the return of Bonaparte, followed as it was by the fall of the directory and the establishment of the consulate, commenced a new epoch for Spain. As soon as the first consul had time to turn his attention to the peninsula, he determined to restore Godoy, who had already regained the affection of the queen, and to make him the tool of his policy. Maria Luisa was easily gained over by playing on her devotion to the house of Parma, and on Oct. 1, 1800 a secret treaty was concluded at San Ildefonso. Spain undertook to cede Louisiana and to aid France in all her wars, while Bonaparte promised to raise the duke of Parma to the rank of king and to increase his territories by the addition either of Tuscany or of the Roman legations. This was followed by Godoy's return to power. Spain was now more servile to France than ever, and in 1801 was compelled to attack Portugal in the French interests. The Spanish invasion, commanded by Godoy in person, met with no resistance, and the prince ventured to conclude a peace on his own authority by which Portugal promised to observe a strict neutrality on condition that its territories were left undiminished. But Bonaparte resented this show of independence, and compelled Charles IV. to refuse his ratification of the treaty. In the preliminary treaty with Great Britain, Bonaparte ceded the Spanish colony of Trinidad without even consulting the court of Madrid, while he sold Louisiana to the United States in spite of his promise not to alienate it except to Spain. As soon as he saw himself involved in a new war with England, he turned to Spain for assistance and extorted a new treaty (Oct. 9, 1803), which was more burdensome still than that of 1796. Spain had to pay a monthly subsidy of 6,000,000 fr., and to enforce strict neutrality upon Portugal, this involving war with England. The last remnants of its maritime power were shattered in the battles of Cape Finisterre and Trafalgar, and the English seized Buenos Aires.

Treaty of Fontainebleau.—In Oct. 1807 Spain accepted the Treaty of Fontainebleau. The treaty was hardly concluded when a French army under Junot marched through Spain to Portugal and the royal family of that country fled to Brazil. Ferdinand, whose wife had died in 1806, determined to imitate his rival Godoy by bidding for French support. He entered into secret relations with Eugène Beauharnais, Napoleon's envoy at Madrid, and went so far as to demand the hand of a Bonaparte princess. Godoy, who discovered the intrigue, induced Charles IV. to order his son's arrest (Oct. 27, 1807), on the charge of plotting to dethrone his father and to murder his mother and Godoy. The prince indeed was soon released and solemnly pardoned; but, meanwhile, Napoleon had seized the opportunity afforded by this public scandal in lowering the prestige of the royal family to pour his troops into Spain, under pretext of reinforcing Junot in Portugal. Even this excuse was soon dropped, and by Jan. and Feb., 1808 the French invasion had become clearly revealed as one of conquest. Charles IV. and his minister determined to fight. The news of this intention, however, excited a rising at Aranjuez, whither the king and the queen had gone from Madrid. A raging mob, instigated by highly placed people, surrounded the palace, clamouring for Godoy's head; and the favourite's life was only saved by Charles IV.'s announcement of his abdication in favour of Ferdinand (March 17). Murat, however, who commanded the French, refused to be turned aside by this change of circumstances. He obtained from Charles IV. a declaration that his abdication had been involuntary, and occupied Madrid (March 23, 1808).

Napoleon Attacks Spain.—Meanwhile Napoleon had advanced to Bayonne on the frontier, whither, at his orders, Murat despatched the old king and queen and their favourite Godoy. The emperor had already made up his mind to place one of his brothers on the Spanish throne; but in order to achieve this it was necessary to cajole the young king Ferdinand VII. and get him into his power. Ferdinand, instead of retiring to Andalusia and making himself the rallying point of national resistance, had gone to Madrid, where he was at the mercy of Murat's troops and whence he wrote grovelling letters to Napoleon. It was no difficult matter for the emperor's envoy, General Savary, to lure him by specious promises to the frontier, and across to Bayonne, where he was confronted with his parents and Godoy in a scene of pitiful degradation. Struck and otherwise insulted, he was forced to restore the crown to his father, who laid it at the feet of Napoleon. The old king and queen, pensioned by the French Government, retired to Rome; Ferdinand was kept for six years under strict military guard at Talleyrand's château of Valençay (*see* FERDINAND VII., King of Spain). On May 13 Murat announced to an improvised "junta of regency" at Madrid that Napoleon desired them to accept Joseph Bonaparte as their king.

The War of Independence.—But Spanish loyalty and sentiments of independence were too profound to be daunted. For the first time Napoleon found himself confronted, not by terrified and selfish rulers, but by an infuriated people who rose against the French on that memorable day, May 2, 1808. The rising in Spain began the movement which ultimately proved fatal to Napoleon's power. At first he treated the novel phenomenon with contempt, and thought it sufficient to send his less prominent generals against the rebels. Madrid was easily taken, but the Spaniards showed great capacity for the guerrilla warfare (*q.v.*) in the provinces. The French were repulsed from Valencia; and Dupont, who had advanced into the heart of Andalusia, was compelled, by a force entirely composed of Spanish troops and volunteers, to retreat and ultimately to capitulate with all his army at Baylen (July 10). The Spaniards now advanced upon Madrid, and drove Joseph from the capital, which he had just entered.

The Spanish nation, deprived of its kings and former statesmen and even of the support of a large part of the higher nobility, sought to build up a provisional political organization based on the old provincial and regional committees (*juntas*). It was a remarkable effort, and in spite of its many defects the admirable *bourgeoisie* and the provincial yeomanry succeeded in creating a system which proved capable of resisting French domination. The military superiority of the French was so great that an immediate victory was impossible; but Napoleon himself was compelled to come to Spain to direct operations. In less than a week the Spanish army was broken through and scattered, and Napoleon restored his brother in Madrid. Sir John Moore, who had advanced with an English army to the relief of the capital, retired when he found he was too late, and an obstinate battle, in which the gallant general lost his life, had to be fought before the troops could secure their embarkation at Corunna. Napoleon, thinking the work accomplished, had quitted the peninsula, and Soult and Victor were left to complete the reduction of the provinces. The capture of Seville resulted in the dissolution of the central junta, but the patriots took refuge in Cadiz, which became the capital of independent Spain. The peninsula was only saved from final submission by the obstinate resistance of Wellington in Portugal, the heroic conduct of many Spanish towns, such as Saragossa and Gerona, the continuous activity of the *guerrillas,* and by dissensions among the French.

The Cortes of 1810 and the Constitution of 1812.—The Spanish *cortes* had never been so entirely suspended as the States-General of France. They had been encouraged to a certain extent during the 18th century to play a more important political rôle. The reformist patriots of Cadiz, influenced by the ideas of revolutionary France, then conceived the plan of re-establishing the old Spanish parliaments on a more democratic and national basis. In 1810 the new *cortes* in which the colonies were represented was convened. The third estate of the commons secured 184 representatives, who were sufficient to swamp the nobles and the clergy. In theory the members of the third estate had been chosen by a process of double election. In fact, however, since much of the country was held by the French, they were often returned by such natives of the regions so occupied as happened to be present in Cadiz at the time. The suppression of the Inquisition and other measures relating to the privileges of the Church and the aristocracy passed together with much else. But even before the new constitution was published and sworn, on March 19, 1812, large numbers of Spaniards had made up their minds that after the invaders were driven out the *cortes* must be suppressed.

Expulsion of the French.—Spain, in achieving her liberation from the military domination of France, owed very much to the assistance of Great Britain (*see* PENINSULAR WAR). In 1812 Wellington determined on a great effort. He secured his base of operations by the capture of Ciudad Rodrigo and Badajoz, and at Salamanca he completely routed the opposing army of Marmont. This victory enabled the English general to enter Madrid (Aug. 12), and Joseph retreated to Valencia. But further advance was prevented by the concentration of the French forces in the east, and Wellington found it advisable to retire for the third time to winter quarters on the Portuguese frontier. It was during this winter that Napoleon suffered his first and greatest reverse in the retreat from Moscow and the destruction of his grand army. The "war of liberation" in Germany followed, and French troops had to be withdrawn from Spain to central Europe. For the first time Wellington found himself opposed by fairly equal forces. In the spring of 1813 he advanced from Ciudad Rodrigo and defeated Jourdan at Vittoria, the battle which finally decided the Peninsular War. Joseph retired altogether from his kingdom, and Wellington, eager to take his part in the great European contest, fought his way through the Pyrenees into France. Napoleon, who had suffered a crushing defeat at Leipzig, hastened to recognize the impossibility of retaining Spain by releasing Ferdinand VII., who returned to Madrid in March 1814.

Restoration of Ferdinand VII.—Before entering Spain Ferdinand had undertaken to maintain the constitution of 1812, and when on March 22, 1814 he reached Figueras, he was met by a demand on the part of the *cortes* that he must accept all the terms of the constitution as a condition of his recognition as a king. But Ferdinand had convincing proof of the true temper of the nation. He refused to recognize the constitution, and was supported in his refusal not only by the army and the Church, but by the masses. There can be no doubt that Ferdinand VII. could have ruled despotically if he had been able to govern well. But, although possessed of some sardonic humour and a large measure of cunning, he was base, and had no real capacity. He changed his ministers incessantly, and on mere caprice. Governed by a *camarilla* of low favourites, he was by nature cruel as well as cowardly, and the persecution of the *"liberales"* was ferocious.

Revolution of 1820.—Partial revolts took place, but were easily crushed. The revolt which overpowered him in 1820 began by a military mutiny. During the war the American colonies had rebelled, and soldiers had been sent to suppress them. No progress had been made, the service was dreadfully costly in life, and it became intensely unpopular among the troops. Meanwhile the brutality of the king and his ministers had begun to produce a reaction. Not a few of the officers held Liberal opinions, especially those who had been prisoners in France during the war and had been inoculated with foreign doctrines. These men, of whom the most conspicuous was Colonel Rafael Riego, worked on the discontent of the soldiers, and in Jan. 1820 brought about a mutiny at Cadiz, which became a revolution. Until 1823 the king was a prisoner in the hands of a section of his subjects, who restored the constitution of 1812 and had the support of the army. But the Liberals were divided into sub-sections; any sign of moderation on the part of the ministers chosen from one of them was enough to secure him the name of *"Servile"* from the others. The *"Serviles"* or absolutists proper took up arms in the north. Ferdinand appealed for help to the monarchies of the Holy Alliance. As early as 1820 the Emperor Alexander I. of Russia had suggested a joint intervention of the powers of the Grand Alliance to restore order in the peninsula, and had offered to place his own army at their disposal for the purpose. The project had come to nothing owing to the opposition of the British Government and the strenuous objection of Prince Metternich to a course which would have involved the march of a powerful Russian force through the Austrian dominions. In 1822 the question was again raised at the congress assembled at Verona (*see* VERONA, CONGRESS OF). The French Government asked to be allowed to march into Spain, as Austria had marched into Naples.

French Intervention, 1823.—In spite of the vigorous protest of Great Britain, which saw in this demand only a pretext for reviving the traditional Bourbon ambitions in the peninsula, the mandate was granted by the majority of the powers; and on April 7, 1823 the duke of Angoulême, at the head of a powerful army, crossed the Bidassoa. The result was a startling proof of the flimsy structure of Spanish Liberalism. What the genius of Napoleon had failed to accomplish in years, Angoulême seemed to have achieved in a few weeks. But the difference of their task was fundamental. Napoleon had sought to impose upon Spain an alien dynasty; Angoulême came to restore the Spanish king "to his own," and found the active support of some Spaniards and the tacit co-operation of the majority. The *cortes*, carrying the king with it, fled to Cadiz, and after a siege, surrendered with no conditions save that of an amnesty, to which Ferdinand solemnly swore before he was sent over into the French lines. As was to be expected, an oath taken "under compulsion" by such a man was little binding; and the French troops were compelled to witness, with helpless indignation, the orgy of cruel reaction which immediately began under the protection of their bayonets.

The Spanish Colonies.—If anything could have recalled the distracted country to harmony and order, it would have been the object-lesson presented by the loss of all its colonies on the continent of America, just as at an earlier date England had lost a great part of her American dominions. Some of them had already become *de facto* independent after 1810 and many more in the ten years following, and the recognition of their independence *de jure* was, for Great Britain at least, merely a question of time. When the Angoulême invasion of Spain was seen to be inevitable, Canning had informed the French Government that Great Britain would not tolerate the subjugation of the Spanish colonies by foreign force. A disposition of the powers of the Grand Alliance to come to the aid of Spain in this matter was countered by the famous message of President Monroe (Dec. 2, 1823, *see* MONROE DOCTRINE), laying the veto of the United States on any interference of concerted Europe in the affairs of the American continent. The republics of Mexico and Colombia were recognized by Great Britain in the following year; the recognition of the other states was only postponed until they should have given proof of their stability.

The Succession Question.—In Spain itself, tutored by misfortune, the efforts of the king's ministers, in the latter part of his reign, were directed to restoring order in the finances and reviving agriculture and industry in the country. The king's chief difficulties lay in the attitude of the extreme monarchists (*Apostólicos*) who found leaders in the king's brother Don Carlos and his wife Maria Francisca of Braganza. Yet the absolute monarchy would probably have lasted for long if a dispute on the succession had not thrown one of the monarchical parties on the support of the Liberals. The king had no surviving children by his first three marriages. By his fourth marriage (1829) with Maria Cristina of Naples he had two daughters. According to the ancient law of Castile and Leon women could rule in their own right, as is shown by the examples of Urraca, Berengaria and Isabella the Catholic. When he died on Sept. 29, 1833, his daughter Isabella II. was proclaimed queen, with her mother Maria Cristina as regent.

The Regency of Cristina.—Maria Cristina would have ruled despotically if she could, and began by announcing that material changes would not be made in the method of government. But the Conservatives preferred to support the late king's brother Don Carlos, and they had the active aid of the Basques, who feared for their local franchises, and of the mountaineers of Navarre, Aragon, Catalonia and Valencia. Maria Cristina had the support of the army, and the control of the machinery of government. The regent soon found that this was not enough to enable her to resist the active hostility of the Carlists and the intrigues of their clerical allies. She was eventually driven by the necessities of her position to accept parliamentary institutions.

The Carlist Wars.—The first civil war, which for the Crown was a dynastic war, and for the nation a struggle between two opposed political principles, was terminated in Aug. 1839 by the convention (*convenio*) of Vergara between the Carlist general Maroto and the Liberal general Espartero. The Carlist general Cabrera, the most famous of the *guerrilleros* of his party, left the country. The political struggle was then for some years confined to Government circles; but already a part of the common people had been won over to the cause of Liberalism. In 1841 a crisis arose, the immediate cause of which was a law depriving the towns of a great part of their autonomy. Queen Cristina resigned and fled to France, and General Espartero was declared regent. He held office till 1843, during an agitated period, in which the Carlists reappeared in the north, mutinies were common, and an unsuccessful attempt was made on the part of the enemies of Espartero to kidnap the young queen in her palace on the night of Oct. 7, 1841. In 1843 Espartero, a man of much personal courage and of fitful energy, but of no political capacity, was expelled by a military rising, promoted by a combination of discontented Liberals and the Moderates. The queen, though only 13 years old, was declared of age.

Isabella II.—The reign of Queen Isabella, from 1843 till her expulsion in 1868, was no more than a prolongation of her mother's regency. It was a confused conflict between the attempts of the court to rule despotically, with a mere pretence of a *cortes*, and the growing wish of the Spaniards for a parliamentary Government, or at least the honest and capable Government which they hoped that a parliament would give them. During this period a series of political changes, revolutions and amendments to the constitution took place, a detailed account of which is unnecessary. The party leaders were almost always generals: Espartero, Narvaez (leader of the Moderates, who were conservatives of almost absolutist ideas), O'Donnell and Prim. The only event which diverted public interest from questions of domestic politics was the war in Morocco in 1859, in which the armies of Spain were victorious, but which led to but meagre results in North Africa owing to the intrigues of other European Powers whose interests were involved. Another event of international importance was the queen's marriage in 1846. Louis Philippe, perceiving a chance of reviving the family alliance between Bourbon France and Bourbon Spain, with the aid of the queen-mother succeeded in forcing Isabella to accept the hand of Don Francisco d'Assisi, her cousin, who was notoriously incapable of having heirs; and on the same day the younger sister was married to the duke of Montpensier, son of Louis Philippe. Palmerston had agreed to this union—but not until an heir to the Spanish Crown should have obviated the possibility of the French prince again inheriting the throne of Spain. The affair broke the entente between France and England, and was a contributory cause of the downfall of Louis Philippe.

In Sept. 1868 the squadron at Cadiz under the command of Admiral Topete mutinied, and its action was the signal for a general secession. One gallant fight was made for the queen at the bridge of Alcolea in Andalusia by General Pavia, but it was an exception. Gonzales Brabo deserted her in a panic. She went into exile, and her reign ended. The revolution of 1868 was the first openly and avowedly directed against the dynasty. It became a familiar saying that the "spurious race of Bourbon" had disappeared forever, and the country was called upon to make a new and a better Government.

Contending Parties.—The mass of the Spaniards, however, were not prepared for a republic. There were also the various monarchical parties: the *Alfonsins* who wished for the restoration of the queen's son with a regency; the partisans of the widower king consort of Portugal; those of the duke of Montpensier; the Carlists; and a few purely fantastic dreamers who would have given the crown to the aged Espartero. The real power was in the hands of the military politicians, Francisco Serrano (*q.v.*) and Juan Prim (*q.v.*), who kept order by means of the army. A constituent *cortes* was assembled in 1869, and decided in favour of a monarchy. The constitution of 1869 was the first in the constitutional history of Spain since 1812, which clearly set forth the entire programme of the liberalism of the period. Serrano was declared regent until a king could be found.

Amadeo of Savoy.—At last, in Aug. 1870, Prince Amadeo of Savoy, second son of Victor Emmanuel II., consented to become candidate. He was elected on Nov. 3. On Dec. 27, 1870, the day on which the new king reached Carthagena, Prim was murdered by assassins who were never discovered. The nominal reign of Amadeo lasted till Feb. 1873. It was a pitiful episode. He had put himself into a false position. Intriguing politicians sought to use him as a tool, and every man of honest principles, royalist or republican, looked upon him as an intruder. The Carlists began to collect in the mountains. Republican agitation went on in the towns. At last a dispute in regard to the officering of the artillery gave the king an honourable excuse for resigning the throne.

Republican Interlude.—The Republicans entered the place he left vacant simply because there was nobody to oppose them. Until Jan. 1874 the country was given up to anarchy. The Carlists increased rapidly, and were joined by many Royalists, who looked upon them as the last resource. A new *cortes* was collected and a new constitution discussed. Three presidents succeeded one another within a year, Pi y Margall, Salmeron and Castelar: ministries changed every few days. As the republic was to be federal when finally organized, many parts of Spain proceeded to act independently. One party went beyond federalism and proposed to split Spain into cantons. The Cantonalists seized the important harbour of Carthagena and the ships in it. The ships were taken out of their hands by the British and German squadrons. The spectacle of anarchy, and the stoppage in payment of taxes frightened the Republican deputies into some approach to sanity. Salmeron allowed General Pavia to restore order in Andalusia. When he gave place to Castelar, the eloquent Republican deputy threw all his most eagerly avowed principles to the wind, raised a great conscription, and provided the means of reducing Carthagena and pushing the war against the Carlists with vigour. When the *cortes* met again in Jan. 1874, the extreme parties voted against Castelar on the 3rd of the month. Hereupon General Pavia, the governor of Madrid, turned the *cortes* into the streets. Serrano was appointed as head of the executive, and was mainly employed during the year in efforts to save Bilbao from falling into the hands of the Carlists. It had now become clear that the restoration of the Bourbons in the person of Don Alphonso, Isabella's son, was the only way of securing a final settlement. On Dec. 29, 1874, General Martinez Campos caused him to be proclaimed king at Murviedro (Sagunto) by a brigade of troops, and the example there set was followed everywhere. Don Alphonso XII. landed in Barcelona on Jan. 10, 1875.

THE RESTORED MONARCHY

Alphonso XII.—The first act of Alphonso was a royal decree confirming the appointment of Cánovas del Castillo (the most prominent leader of the *Alfonsins*) as prime minister. A strong administration was formed, which gave its attention for 15 months to the pacification of the peninsula, adopting a Conservative and Catholic policy which contributed quite as much as the great display of military resources to lose the Carlists adherents and prestige. The Church, the nobility and the middle classes soon pronounced for the new state of things. The Alphonsist armies, led by Marshals Campos and Jovellar, swept the Carlist bands from the right bank of the Ebro to the Pyrenees, and took their last strongholds in the east of Spain, Cantavieja and Seo de Urgel. Some of the Carlist leaders accepted bribes to go abroad, and others put their swords at the disposal of the Government for employment against the Cuban rebels. Then all the forces of King Alphonso under Marshal Quesada closed round the remainder of the Carlist army in Navarre and in the Basque Provinces at the beginning of 1876. That was the end of the Carlist Wars.

The Cuban Insurrection.—Directly this internal strife was over, the government used part of the large army at its disposal to reinforce the troops which had been fighting the Cuban insurgents since 1869. Marshal Jovellar was sent out to Havana as governor-general, with Marshal Martinez Campos as commander-in-chief of the forces. In about 18 months they managed to drive the rebels into the eastern districts of the island, Puerto Principe and Santiago de Cuba, and induced all but a few irreconcilable chiefs to accept a convention that became famous under the name of the Peace Treaty of Zanjon. Marshal Campos, who succeeded Jovellar as governor-general, held out to the loyalists of the island the prospect of reforms, fairer treatment at the hands of the mother country, a more liberal tariff to promote their trade, and self-government as the crowning stage of the new policy.

Internal Changes.—Though much of his time and energies had been devoted to the re-establishment of peace at home and in the colonies from 1875 to 1880, Cánovas had displayed considerable activity and resolution in the reorganization of the monarchy. Until he felt sure of the early termination of the struggle, he ruled in a dictatorial manner without the assistance of parliament. Royal decrees set aside most of the legislation and reforms of the Spanish revolution. Universal suffrage alone was respected for a while and used to call into existence the first *cortes* of the Restoration in 1876. The principal result of this parliament was the constitution of 1876, which was a compromise between the constitution of 1845 in the reign of Isabella and the principles of the democratic constitution of the revolution in 1869. Cánovas, who was endowed with great political qualities, sought at the same time to win over to the new régime some of the old Liberals of the Revolution, and the least recalcitrant of the old Carlists. The latter (including Don Alejandro Pidal and his followers) eventually joined the ranks of the Conservative Party adding to it a leaven which, however, was not always in harmony with the views of the prime minister. The Liberals succeeded in forming a dynastic Liberal Party whose name of *Fusionista* was indicative of the great heterogeneity of its component elements.

After a short-lived marriage with his cousin Mercedes, third daughter of the duke of Montpensier, Alphonso listened to the advice of his council and married the Austrian archduchess Maria Cristina of Habsburg.

The Liberal Government.—In 1881 the *Fusionista* Party, swelled by the addition of a number of Liberal and Conservative generals who disapproved of Cánovas' policy, showed unmistakable signs of agitation. Cánovas himself thought that the time had come to slacken somewhat the reins of conservative hegemony and to allow effective expression to the support given to the dynasty by the so called Liberal Party whose leader was Sagasta, the former minister of King Amadeo. In this way the latter party came into power. The policy of Sagasta in domestic affairs resembled that of Cánovas. Several treaties of commerce were concluded with European and Spanish American Governments. They reformed the tariff in harmony with the treaties, and with a view to the reduction of the import duties by quinquennial stages to a fiscal maximum of 15% *ad valorem.* A general conversion of the consolidated external and internal debts was promoted by a considerable reduction of capital and interest, to which the bondholders assented. The floating debt proper was consolidated in the shape of a 4% stock redeemable in 40 years, of which £70,000,000 was issued in 1882 by Señor Camacho, the greatest Spanish financier of the period. Sagasta was not so fortunate in his dealings with the anti-dynastic parties, and the Republicans gave him much trouble in Aug. 1883. This had the effect of gaining him the support of many Democrats and Radicals who broke away from Ruiz Zorrilla the leader of the revolutionary republicans. But Sagasta himself had to abandon the premiership. A new cabinet formed by members of the "Fusionist" left wing did not last long. In 1884 Cánovas returned to power.

The last Conservative cabinet of this reign was neither popular nor successful. In the *cortes* the tension in the relations between the Government and the Opposition was growing daily more serious. Outside, the Republicans and Carlists were getting troublesome, and the tone of their press vied with that of the Liberals in their attacks on the Conservative cabinet.

Regency of Queen Cristina.—The declining health of the king had been kept as secret as possible, and in the ten months before his death the Conservative cabinet displayed unprecedented rigour against the newspapers of every shade: in 60 days 1,260 prosecutions were ordered against Madrid and provincial papers. But at last, on Nov. 24, 1885, the truth had to be admitted and on the morning of the 25th the end came. It was no wonder that the death of the king should have made Spaniards and foreigners extremely anxious about the prospects of the monarchy. Alphonso XII. left no male issue. He had two daughters; the princess of the Asturias, born in 1880 and the Infanta Maria Theresa, born in 1882. At the time of his death it had not been officially intimated that the queen was *enceinte.* The *Official Gazette* did not announce that fact until three months after the demise of the sovereign. On May 17, 1886, six months after the death of Alphonso XII., his posthumous son, Alphonso XIII. was born at the palace of Madrid. The political situation was difficult. Cánovas assured the queen-regent that he was ready to undertake the Government if it was thought wise to continue the Conservative policy of the late king, but in the circumstances he frankly advised that Señor Sagasta should be asked to take the reins of government, with a view to inaugurating the regency under a progressive and conciliatory policy.

Sagasta.—Sagasta took for colleagues for the first Liberal cabinet some of the strongest and most popular statesmen of the party, virtually representing the three important groups of men of the Revolution united under his leadership—veteran Liberals like Camacho and Venancio Gonzalez; Moderates like Alonzo Martinez, Gamazo and Marshal Jovellar; and Democrats like Moret, Montero Rios and Admiral Beranger. The new cabinet convoked the *cortes* elected under the administration of Cánovas in 1884; and supplies and other bills were voted to enable the government to be carried on until another parliament could be elected in the following year, 1886.

The field was thus fairly clear for an accentuation of the Catholic policy which the queen mother had at heart. She became regent when Spain had felt the consequences of the expulsion of the Jesuits and other religious orders from France after the famous Jules Ferry laws, which aimed at placing these orders once more under State control, to which they declined to submit. They selected Spain as an excellent field of enterprise; and all the Governments of the regency showed so much indulgence towards the Catholic revival thus started, that in less than a decade the kingdom was studded with convents and monasteries.

Progress.—The prime minister conducted the first general election in 1886 much after the usual precedents. The long parliament of the regency was composed of considerable Liberal majorities in both houses, though Sagasta had allowed a larger share than Cánovas was wont to do to the minorities; on the Opposition benches Republicans of various shades were represented by their most eminent leaders, the Carlists had a respectable group, and the Conservatives a strong muster, flanked by a group of dissentients. The first *cortes* of the regency in five sessions did really good and substantial work. A civil code was carefully drawn up by Alonzo Martinez, in order to consolidate the heterogeneous ancient legislation of the monarchy, especially in the old kingdom of Castile; while at the same time measures were taken to ensure respect for the local civil laws of many provinces, especially Catalonia, Aragon, Valencia, Navarre and the Basque territory. Trial by jury was re-established for most crimes and offences. The laws regulating the rights of association and public meeting, the liberty of the press and other rights of the subject were reformed on liberal and more tolerant lines.

Republican Movement Fails.—In these circumstances, a Republican movement which was suddenly launched in Sept. 1886 by the partisans of Ruiz Zorrilla collapsed at its very outset. Very shortly afterwards the war minister, General Castillo, attempted to strike at the root of military insubordination, and simultaneously in every garrison of the kingdom the senior sergeants, more than 1,000 in all, were given their discharge and ordered to their homes at once. No trace of revolutionary work is visible among non-commissioned officers after 1886. As time wore on, Sagasta found it difficult to maintain discipline in the ranks of the Liberal Party. Señor Martos and the Democrats almost brought about a political crisis in 1889. Sagasta cleverly affected to resign and stand aside, but without him a Liberal Government was impossible. On his return to power, Sagasta reconstructed his ministry for the last time, and announced his intention to make the re-establishment of universal suffrage the crowning act of the Liberal policy, knowing very well that he would thus rally round him all the Liberals, Democrats and most of the Republicans in the last session of the long parliament. The suffrage bill was carried through the senate and congress in the spring of 1890 after protracted debates, in which the Conservatives and many military politicians did their best to obstruct the measure. The increasingly violent opposition of the Conservatives was supported by the regency and accordingly Sagasta, after having secured the promulgation of the law of universal suffrage, resigned at the first hint given him by the queen (July 1890).

A Protectionist Regime.—Cánovas once more returned to power and gathered round him most of the prominent Conservative and Catholic statesmen. The first step of the new cabinet was to adopt protection. Sagasta to please Señor Gamazo and the Liberal representatives of agricultural interests, had allowed his parliament to empower the Government to revise and increase all tariff duties not covered by the then existing treaties of commerce. This touched most of the products of agriculture and live stock, so Cánovas and his finance minister, by royal decree, enormously increased the duties on these imports, and particularly on breadstuffs. Then, in 1891, they denounced all the treaties of commerce which contained clauses stipulating most-favoured-nation treatment, and put in force in Feb. 1892 a protectionist tariff which completely reversed the moderate free-trade policy which had been so beneficial to the foreign commerce of Spain from 1868 to 1892. The effects of this policy verging upon prohibition were soon sharply felt. Foreign exchanges rose, exports decreased, the railway traffic declined, and the commercial classes and consumers of foreign goods and products were loud in their protests. Industrial interests alone benefited, and imported more raw materials, chemicals and coal and coke, which naturally influenced the exchanges adversely. But political divisions also began to show themselves in an acute form within the Conservative Party, chiefly owing to the rivalry between Cánovas' two lieutenants, Romero Robledo and Silvela (Francisco). Once more Cánovas had to resign and Sagasta, with great reluctance, succeeded him.

The two most important events of this new period of "fusionist" Government took place outside the peninsula. The scene of one was the Spanish zone in Morocco bordering the Riff, the tribes inhabiting which had never submitted to the authority of the sultan and had always been very bad neighbours. An incursion by these tribes into Spanish territory and an attack upon Spanish troops resulted in the defeat of the latter and the death of General Margallo who was in command. Public opinion was instantly fired, and the press called so loudly for revenge that the Government sent to Melilla no less a personage than Marshal Campos, at the head of 29 generals and 25,000 men. The sultan of Morocco lost no time in censuring the behaviour of the Riff tribes, and in promising that he would chastise them. Marshal Campos was sent to Fez to make a treaty, in which he obtained ample redress and the promise of an indemnity of £800,000 which Morocco punctually paid.

The Cuban Question.—Colonial affairs gave Sagasta much to do. Señor Antonio Maura, the colonial minister, and Señor Gamazo, the finance minister, two moderate Liberals, attempted together to grapple with colonial questions, which in 1894 had assumed a very serious aspect. Marshal Campos, on returning from Cuba in 1870, had advocated some concessions to satisfy the legitimate aspirations of the majority of the colonists. In 1886, in the first parliament of the regency, Cuban autonomist deputies (who had issued their first political programme in Aug. 1878) divided the house on a motion in favour of home rule and of an extension of the franchise in Cuba. This motion was negatived by all the Conservatives, by most of the Dynastic Liberals and by some of the Republicans. The majority of Spaniards were prevented by the Government and the press from learning of the disaffection in Cuba, so that they were loath to listen to the few men, courageous enough to raise the note of alarm during the ten years before the final catastrophe. For no other reason did Maura, in 1893, fail to convince the *cortes*, and even the Liberal Party, that his very moderate Cuban Home Rule bill was indispensable.

In succession to Maura, Señor Abarzuza framed a Cuban Reform bill (1895) so much short of what his predecessor had thought an irreducible minimum of concessions, that it was censured in Havana by all the colonial Liberals and home rulers, and by their representatives in Madrid. The latter at the last moment recorded their votes in favour of the Abarzuza bill when they perceived that a strange sort of eleventh-hour presentiment was about to make all the Spanish parties vote this insufficient reform. Before it could be promulgated, the tidings came of a separatist rising in the old haunts of Creole disaffection near Santiago de Cuba (1895). Sagasta then sent about 12,000 men to reinforce the 15,000 soldiers in Cuba under General Calleja, and was preparing more when a sudden attack made by officers of the Madrid garrison upon the offices of the radical paper *El Resumen* raised a question of discipline with which the authorities were unable to deal in the manner required by law. The impotence of the authorities on this occasion, which was the forerunner of many others, resulted in the return to power of the Conservatives.

Cánovas devoted his attention to the Cuban question, and sent out General Martinez Campos who had been so successful in 1878. He allowed him much liberty of action, but dissented on the expediency of offering the loyalists of Cuba as much home rule as would not clash with the supremacy of Spain. The prime minister declared that the Cubans must submit first, and then the mother country would be generous. This policy rendered inevitable the failure of the efforts of Campos, who took an entirely different view of the question.

Weyler in Cuba.—Cánovas then sent to the island General Weyler, who favoured purely military measures, sternly and harshly applied. He certainly cleared two-thirds of the island of Creole bands, and stamped out disaffection by vigorous military operations and by obliging all the non-combatants who sympathized with the rebels in arms to elect between joining them in the bush (*la Manigua*) or residing within the Spanish lines. This system, which was disavowed in Spain by most Liberals, might probably have succeeded if American supplies had not reached the rebels in considerable quantities, and if American diplomacy had not again and again made representations against Weyler's ruthless policy of repression in the island.

Cánovas so fully comprehended the necessity of averting American intervention that he listened to the pressing demands of secretary Olney and of the American minister in Madrid, Hannis Taylor, and laid before the *cortes* a bill introducing home rule in Cuba on a more liberal scale than Maura, Abarzuza and Sagasta had dared to suggest two years before. Cánovas did not live to see his scheme put into practice, as he was assassinated by an anarchist at the baths of Santa Agueda, in the Basque Provinces, on Aug. 9, 1897. The queen-regent appointed General Azcárraga, the war minister, as successor to Cánovas; and a few weeks later President McKinley sent General Woodford as representative of the United States at the court of Madrid. At the end of Sept. 1897 the American minister placed on record, in a note handed by him at San Sebastian to the minister for foreign affairs, the duke of Tetuan, a strongly-worded protest against the state of things in Cuba, and demanded in substance that a stop should be put to Weyler's proceedings, and some measures taken to pacify the island and prevent disturbances which, he said, grievously affected American interests. Less than a fortnight after this note had been delivered, the Conservative cabinet resigned, and the queen-regent asked Sagasta to form a new administration.

Weyler Recalled.—The Liberal Government recalled Weyler, and sent out, as governor-general of Cuba, Marshal Blanco, a conciliatory and prudent officer who agreed to carry out the home-rule policy, concerted by Señor Moret and by Sagasta. Had things not already gone too far in Cuba, and if public opinion in the United States had not exercised irresistible pressure on both Congress and President, the Moret Home-Rule Act (Nov. 1897) would probably have sufficed. All through the winter of 1897–98 the Madrid Government took steps to propitiate the United States, even offering a treaty of commerce which would have allowed American commerce to compete on equal terms with Spanish imports in the West Indies and defeat all European competition. But the blowing up of the American cruiser "Maine" in the port of Havana added fuel to the agitation in the United

States against Spanish rule in Cuba, and war followed. When Congress met in Washington the final crisis was hurried on. Spain appealed to European mediation, to the pope, to courts and Governments, but none were disposed to go beyond purely platonic representations at Washington.

War with the United States.—At last, on April 20, 1898, when the Spanish Government learned that the United States minister, General Woodford, had been instructed by telegraph to present an ultimatum demanding the cessation of hostilities in Cuba, with a view to prepare for the evacuation of the island by the Spanish forces, Sagasta decided to give General Woodford his passports and to break off official relations with the United States. It was an open secret that this grave decision was not taken at the cabinet council presided over by the queen without a solemn protest by Moret and the ministers of war and marine that the resources of Spain were totally inadequate for a struggle with the United States. These protests were overruled by the majority of the ministers, who invoked dynastic and monarchical considerations in favour of a desperate stand, in defence of the last remnants of the colonial empire of Spain.

The sequel is soon told. The Spanish fleet in the Far East was defeated in Manila bay by Admiral Dewey. Admiral Cervera's squadron was destroyed outside the bay of Santiago de Cuba by the United States fleet under Admirals Sampson and Schley. All communication between Spain and her colonies was thus cut off. A U.S. expedition landed near Santiago, and the Spanish garrison surrendered after a fortnight's show of resistance. Shortly afterwards, at the end of July, Spain sued for peace through the mediation of French diplomacy.

End of New World Rule.—The agreement of Aug. 9, signed by M. Cambon, the French ambassador in Washington, in the name of Spain, clearly stipulated that her rule in the New World must be considered at an end, and that the fate of the Philippines would be settled at the Paris negotiations. Spain could not help assenting to a treaty by which she renounced unconditionally all her rights of sovereignty over Cuba and Porto Rico and ceded the Philippine islands and Sulu islands and the largest of the Marianne islands in consideration of the payment of twenty million dollars by America. Thus ended a struggle which only left Spain the Carolines and a few other islands in the Pacific, which she sold to Germany in 1899 for £800,000, and a couple of islands omitted in the delimitation made by the Paris peace treaty of Dec. 12, 1898, and purchased by the United States in 1900.

After the War.—The Liberal Government was held responsible for the *débâcle,* but the seeds had been sown long before by many and widely diffused mistakes and by hostile influences outside Spain; the cabinet of 1898, moreover, had sought to avert it by every means in its power. The result was that a call was again made upon the Conservatives, then led by Silvela, who was far from possessing the qualities necessary to control the situation and to stem the pessimism which overwhelmed the majority of Spaniards. His one real success was achieved for him by the economic policy of his minister of finance, Villaverde, who succeeded in less than 18 months in giving a decisive and vigorous impulse to the reorganization of the budget, and of the home and colonial debts. He resolutely reformed all existing taxation, as well as the system of assessment and collection, and before he left office he was able to record an increase of close upon three millions sterling in the ordinary sources of revenue. His reorganization of the national debt was very complete; in fact, he exacted even more sacrifices from the bondholders than from other taxpayers. The amortization of the home and colonial debts was suppressed, and the redeemable debts of both classes were converted into 4% internal consols. The interest on all colonial debts ceased to be paid in gold, and was paid only in pesetas, like the rest of the internal debts, and like the external debt held by Spaniards. Alone, the external debt held by foreigners continued to enjoy exemption from taxation, and its coupons were paid in gold; but the Government consented to a conversion of the 4% external debt into a 3½% stock redeemable in 61 years. (A. E. Ho.; R. Al.)

Growth of Religious Orders.—The failure of Silvela compelled the queen once more to summon Sagasta (March 1901). He was at once faced with two problems, very opposite in their nature, which were destined to play a very conspicuous part in Spanish politics. The first was that presented by the growth of the religious orders and congregations, which continued to increase in number and power and had ignored the law of associations of June 1887, which ordered congregations to register their members, and required all except three orders admitted under the concordat to apply for authorization. The queen-regent, on July 19, 1901, issued a decree, countersigned by Sagasta, for enforcing the law.

Industrial Unrest.—Meanwhile, however, a second and more pressing peril distracted the attention of the Government. The industrial unrest, fomented by Socialist agitation, culminated in Jan. 1902 in serious riots at Barcelona and Saragossa, and on Feb. 16 in the proclamation of a general strike in the former city. The government sent General Weyler to deal with the situation; and order was restored. The methods by which this result had been achieved were the subject of violent attacks on the Government in the *cortes,* and on March 13 Sagasta resigned, but only to resume office five days later. He now returned to the question of the religious orders, and on April 9 issued a decree proclaiming his intention of enforcing that of July 19, 1901. The attitude of the Church was practically one of defiance. The nuncio, indeed, announced that the papacy would be prepared to discuss the question of authorization, but only on condition that all demands for such authorization should be granted. To avoid a crisis at the time when the young king was about to come of age, the Government yielded; and on May 20, Sagasta announced that a *modus vivendi* had been established.

Alphonso XIII.—King Alphonso XIII., whose enthronement took place with all the antique ceremonial on May 17 was himself at the outset under clerical and reactionary influences, and his contemptuous treatment of ministers—who at the ceremonial functions were placed wholly in the background—seemed to argue an intention of ruling personally under the advice of the court *camarilla.* This impression, due doubtless to the king's youth and inexperience, was belied in the event; but it served still further to discredit the Liberal Government. On Nov. 7 Sagasta resigned, resumed office temporarily on the 14th, and handed in his final resignation on Dec. 3. On Dec. 6 a Conservative cabinet was formed under Silvela, the portfolio of finance being taken by Villaverde.

The first years of the new reign saw a renewal of the rivalries between the leaders of both parties, Conservative and Liberal alike, the latter temporarily breaking up when, on Jan. 5, 1903, Sagasta died. The result was a period of frequent changes of Government: the conservative Governments of Villaverde and Maura, and the clerical-conservative Government of Azcarraga, in 1904, the Liberal Governments of Montero Rios and Moret in 1905. The country meanwhile was in a ferment, the old antagonisms, due to the conflict of interests between the industrial north and the agricultural south and to the traditional regional, social and religious conflicts, being now complicated by socialist and anarchist agitation.

The king's marriage with Princess Victoria Eugénie, which took place on May 31, was in many respects significant. In spite of the young queen's "conversion" and the singular distinction conferred on her by the papal gift of the golden rose, the "Protestant" alliance marked a further stage in Alphonso XIII.'s emancipation from the tutelage of the Clerical-Conservative court, which looked with disfavour on the marriage. The king was, indeed, showing an increasing tendency to think and act for himself, which, though not as yet overstepping constitutional limits, was disconcerting to all parties.

Ecclesiastical Controversies.—The political situation soon assumed a serious aspect when the new cabinet presided over by General Lopez Dominguez, a democrat, obtained the king's signature to an ordinance giving, in conformity with the spirit of the law, legal validity to the civil marriages of Catholics. This aroused a furious agitation among the clergy, to which bounds were only set by the threat of the Government to prosecute the bishop of Tuy and the chapter of Cordova. In the session 1906–07 the most burning subject of debate was the new Associations Law, drawn up by the minister Señor Davila. Even in the Liberal ranks the question aroused furious differences of opinion; Señor Montero Rios, the president of the senate, denounced the "infamous attacks on the church"; the Government itself showed a wavering temper in entering on long and futile negotiations with the Vatican; while in Jan. 1907 the cardinal archbishop of Toledo presented a united protest of the Spanish episcopate against the proposed law. This and other issues produced complete disunion in the Liberal party. Already, on Nov. 27, Lopez Dominguez had resigned; his successor, Moret, had at once suffered defeat in the house and been succeeded in his turn on Dec. 4 by the marquis de la Vega de Armijo. The question was now mooted in the cabinet of dropping the Associations Law; but on Jan. 21, 1907 Señor Canalejas, president of the lower house, who was credited with having inspired the bill, publicly declared that in that event he would cease to support the Government. By the 24th the cabinet resigned, and a Conservative Government was in office under Señor Maura as premier.

Maura's Ministry 1907–1909.—During his second period of political power Maura gave a clear indication of his qualities and aims, which were to exercise a powerful influence upon affairs. Though a sincere Catholic, he was no Clerical, as was proved by his refusal to withdraw the ordinance on civil marriage. The main objects that he set before himself were, firstly, the maintenance of order; secondly, the reform of local government, so as to destroy the power of the *caciques* and educate the people in their privileges and responsibilities. The local administration reform bill was submitted to the *cortes* in Oct. 1907. It contained 429 clauses, largely increased the responsibility of the local elected bodies, made it compulsory for every elector to vote, and did away with official interference at the polls. The bill met with strenuous opposition, and on Dec. 23, 1907 the *cortes* adjourned without its having been advanced.

Political Tension Renewed.—But in the following year the struggle between the antagonistic forces in Spain once more produced a perilous crisis. The Local Administration bill, after being debated for two sessions, passed the lower house on Feb. 13, 1909, having at the last moment received the support of the Liberal Señor Moret, though the Radicals as a whole opposed it as a sop to Señor Cambò, the Regionalist leader, and tending to disintegration. It was however evident that the method of Señor Maura, who ruled in the spirit of an enlightened despotism rather than in that of a constitutional government, could not meet with the approval of Liberals: at all events it was inevitable that he should incur unpopularity in many quarters. His efforts to reconstruct the Spanish navy were attacked both by the apostles of retrenchment and by those who saw in the shipbuilding contracts an undue favouring of the foreigner; the Marine Industries Protection Act was denounced as favouring the large shipowners and exporters at the expense of the smaller men. The cabinet's ecclesiastical policy also exposed him to the fate of those who take the middle way; the Liberals denounced the minister of education, Don F. Rodriguez San Pedro, for making concessions to the teaching orders, while the archbishops of Burgos and Santiago de Compostella fulminated against the Government for daring to tax the congregations. In his reforming work Maura had an active and efficient lieutenant in the minister of the interior, Señor La Cierva. Under his auspices laws were passed reforming and strengthening the police force, instituting industrial tribunals, regulating the work of women and children, introducing Sunday rest, early closing and other reforms. In short, the position of the Government, when the *cortes* adjourned on June 6, 1909, seemed to be assured.

Morocco Crisis and the Barcelona Rising.—Its downfall was ultimately due to the development of the crisis in Morocco (*q.v.*). It is only here proposed to outline the effects of its reaction upon the internal affairs of Spain. The trouble, long brewing, broke out in July, with the attack by the Riff tribesmen upon the workmen engaged on the railway being built to connect Melilla with the mines in the hills, held by Spanish *concessionares.* The necessity for strengthening the Spanish forces in Africa had for some time been apparent; but Maura had not dared to face the *cortes* with a demand for the necessary estimates, for which, now that the crisis had become acute, he had to rely on the authorization of the council of State. The spark was put to the powder by the action of the war minister, General Linares, in proposing to organize a new field force by calling out the reserves. This summoned up too vivid memories of the useless miseries of former over-sea expeditions. On July 26 a general strike was proclaimed at Barcelona, and a movement directed at first against "conscription" rapidly developed into a revolutionary attack on the established order in Church and State. The city, a *colluvies gentium,* was seething with dangerous elements, its native proletariat being reinforced by a cosmopolitan company of refugees from other lands. The mob, directed by the revolutionary elements, attacked more especially the convents and churches. From the city the revolutionary movement spread to the whole province. In Barcelona the rising was suppressed after three days' street fighting (July 27–29). On the 28th martial law was proclaimed throughout Spain, and a military reign of terror continued until the end of September. In the fortress of Monjuich in Barcelona were collected, not only rioters caught red-handed, but many others—notably journalists—whose opinions were disliked. The greatest sensation was caused by the arrest on Aug. 31 of Señor Ferrer, a theoretical anarchist well known in many countries for his anti-clerical educational work and in Spain especially as the founder of "lay schools." Señor Ferrer was tried by court martial (Oct. 11–13), and shot. This tragedy, which rightly or wrongly aroused the most widespread indignation throughout Europe, produced a ministerial crisis in Spain. The opening of the October session of the *cortes* was signalized by a furious attack by Moret on Maura and La Cierva, who were accused of having sacrificed Ferrer to the resentment of their clerical task-masters. The Government had been already weakened by the news of Marshal Marina's reverse in Morocco (Sept. 30); to this new attack it succumbed, Señor Maura resigning on Oct. 21, 1909.

Moret Ministry, 1909–10.—On the 22nd the formation of a new cabinet under Señor Moret was announced. It sent General Weyler to keep Barcelona in order, caused the release of most of the prisoners in Monjuich, reduced the forces in Morocco, reopened negotiations with Rome for a modification of the concordat, and on Dec. 31, the end of the financial year, was responsible for the issue of a royal decree stating that the budget would remain in force until the *cortes* could pass a new one. But, meanwhile, the municipal elections, under the new Local Administration law, had resulted in a triumph of the Liberals (Dec. 12). Moret therefore considered the time ripe for a dissolution; the king, however, refused to consent, and on Feb. 9, 1910 the ministry resigned. The new cabinet, with the radical Señor Canalejas as president of the council, included members of the various Liberal and Radical groups.

Canalejas Ministry, 1910–12.—Señor Canalejas was regarded as a sincere Liberal who was determined to carry out the programme of the Left, especially with regard to the so-called clerical question and that of the *latifundia* of certain parts of Spain. There was, however, in some quarters a doubt as to whether he had force of character enough to overcome his difficulties. This doubt was dispelled. In the course of 1910 and 1911 certain indications showed that his policy might be successful.

The Clerical Question.—As regards the clerical question, it was not long before the Government showed that it was in earnest. On May 31 the official *Gaceta* published a decree setting forth the rules to which the religious associations would have to submit. It was pointed out that, in conformity with the decree of April 9, 1902, it had become necessary to coerce those congregations and associations which had not fulfilled the formalities prescribed by the law of 1887, and also those engaged in commerce and industry which had not taken out patents with a view to their taxation.

In the speech from the throne at the opening of the new *cortes* (June 16) the king declared that his Government would "strive to give expression to the public aspirations for the reduction and control of the excessive number of orders and religious orders, without impairing their independence in spiritual matters," and in introducing a bill for the amendment of the law of 1887. Señor Canalejas declared that the Government, "inspired by the universal spirit of liberty of conscience," had given to article xi. of the constitution "the full sense of its text."

Religious Toleration.—"Liberty of conscience," a principle condemned by the Syllabus of 1864 and discountenanced by the encyclical *Pascendi gregis* of 1905, was hardly a phrase calculated to conciliate the Spanish clergy, still less the Vatican. A cry went up that to allow dissident Churches to announce their presence was to insult and persecute the Catholic Church; at Rome the decree was attacked as unconstitutional, and as a breach of diplomatic propriety all the more reprehensible since negotiations for a revision of the concordat were actually pending. A violent clerical agitation, encouraged by the Vatican, was started, 72 Spanish archbishops and bishops presenting a joint protest to the Government. Fuel was added to the fire by the introduction of a bill—known as the "Cadena's bill"—forbidding the settlement of further congregations in Spain until the negotiations with the Vatican should have been completed. This was denounced at Rome as a unilateral assertion on the part of the Spanish Government of an authority which, under the concordat, belonged to the Holy See as well. As a preliminary to negotiation, the Government was required to rescind all the obnoxious measures.

This demand broke the patience of the prime minister, and on July 30, Señor de Ojeda, Spanish ambassador at the Vatican, was instructed to hand in his papers. In Vatican circles dark hints began to be dropped of a possible *rapprochement* with Don Jaime, who had succeeded his father Don Carlos, on July 18, 1909, as the representative of Spanish legitimacy and Catholic orthodoxy. The pretender, indeed, disclaimed any intention of stirring up civil war in Spain; his mission would be to restore order when the country should have wearied of the republican régime whose speedy advent he foresaw. The fulfilment of the first part of this prophecy seemed to some to be brought a step nearer by the overthrow of the monarchy in Portugal on Oct. 5, 1910. For Spain its immediate effect was to threaten a great increase of the difficulties of the Government, by the immigration of the whole mass of religious congregations expelled from Portugal by one of the first acts of the new régime.

(W. A. P.; R. Al.)

Morocco.—At the close of the year 1910 Señor Canalejas resigned in order to reconstruct his cabinet. This second ministry lasted till April 3, 1911, when it fell on the occasion of a debate on the Ferrer case.

The attention of parliament was diverted towards Moroccan affairs. The French were preparing their advance on Fez, and Spain was forced to an active policy, the first signs of which were received with ill-humour by the French press. The Government, in the teeth of popular opposition, were sending troops to Morocco, and on June 9 a Spanish force landed at Larache. France was prevented from taking strong action by the Agadir incident (*see* Morocco; Europe, etc.), but a certain tension prevailed between France and Spain during the summer.

The Moroccan operation prepared as a consequence of the disembarkation in Larache began successfully on Dec. 6, but collapsed a few days later after a gallant attempt to force the passage of the River Kert, not without leaving behind an atmosphere of ill-feeling due to the belief, current in the Spanish army, that the Moorish troops were provided with French arms and ammunition. Under such unfavourable conditions began the negotiations for a Franco-Spanish agreement following upon the Franco-German treaty on Morocco. After a reshuffling of his cabinet (March 11) Canalejas adjourned parliament until May 1.

With the summer a period of strikes, culminating in a grave railway strike, set in. Canalejas met it by applying article 221 of the Recruiting Law allowing the drafting into military service of all men of military age working in industries of public importance in cases of danger or abnormal circumstances. On Oct. 14 the autumn session began with a fresh discussion of the bill *de Mancomunidades*, but the session was brought to a close by the murder of Canalejas on Nov. 12, 1912 by a fanatical anarchist, an event which ended all the hopes placed in a statesman who, in less than three years and in spite of all the difficulties which had arisen, had given politics a distinctly liberal trend.

The Romanones Ministry.—Señor Canalejas was succeeded by Count de Romanones, one of his ministers, but the discipline of the Liberal Party, which had been maintained by the strong hand of the murdered premier, subsequently relaxed. Señor Maura, who had hoped to be asked to form a government, protested against the continuation in power of the Liberals. This was the first sign of a determined opposition. Señor Alvarez, on the other hand, took the opportunity to accentuate his evolution towards the monarchy, helped by the king, who, at the moment, was seeking the advice of several prominent men known for their advanced views. Count Romanones took a good share of whatever merit there was in this policy, as well as in the success of the king's official visit to Paris on the conclusion of the Franco-Spanish treaty (May 6–9). He resigned on May 31, after a strong speech of opposition from Maura who restated his position of "implacable hostility" to a policy of co-operation with the parties of the anti-dynastic Left. The next day the king asked Romanones to return once more, after the crisis caused by a split in the Liberal Party on the question of the bill *de Mancomunidades* then before the Senate (June 11). But this time it was generally realized that this step was simply an expedient necessitated by the coming visit of the French president to Madrid.

The latent Liberal crisis broke out as soon as M. Poincaré left Spanish soil. On Oct. 25 the cabinet resigned, and the king, after attempting in vain to reconcile the parties, realized that the Liberal policy which he had constantly followed since 1909 was at an end. He first summoned Maura but found his views on policy so dangerous that he turned to Señor Dato (Oct. 27), a choice which initiated the disintegration of the Conservative party. The new Government granted a decree giving validity of law to the bill *de Mancomunidades*, dissolved the *cortes* (Dec. 31, 1913), and came back after a general election with a sufficient majority in both houses. It met with considerable opposition owing to several royal decisions which were interpreted as acts of personal power in military matters. But its internal difficulties were soon to be merged into the all-absorbing preoccupation of the World War.

THE WORLD WAR AND AFTER

The international situation of Spain at the outbreak of war was defined by two sets of circumstances: official, and national or popular. The official situation was ruled by an agreement between Spain, France and England, made at Cartagena in 1907, and confirmed by the conversations held there in 1913 between M. Poincaré and Count Romanones, which stipulated that "should new circumstances arise tending to alter the territorial *status quo*" in the Mediterranean or in the European and African coasts of the Atlantic, the three Powers concerned would "enter into communication" in order to take any measures that might be necessary. The war was obviously a "circumstance" within the limits of the above definition, yet France and England, the two Powers most interested, made no sign. Señor Dato promptly declared for an absolute neutrality. Spain was the only European nation which had no stake in the war; the nation was divided in its feelings. The working classes, most of the intellectuals and the trading communities, were pro-Ally. The clergy, most of the army and of the bureaucracy and the "idle rich," were pro-German. The division cut across the parties. On one definite point everybody agreed. Spain was to keep out of the war.

A "committee of initiative" was created for the study and co-ordination of efforts to deal with war problems. Parliament resumed its sittings on Oct. 30, 1914 and unanimously endorsed the foreign policy of the Government.

A crisis caused by difficulties in connection with the launching of a loan brought about the resignation of the Government (June 22) quickly followed by a reinstatement of the same cabinet. The situation of the Treasury was by no means flourishing. At the end of the year revenue remained at 1,202,000,000 pesetas while expenses, not including Government purchases of foodstuffs, rose to 1,556,000,000 pesetas. The Government had to fall back on Treasury bonds negotiated through the Bank of Spain. Yet the work of the country was in full swing under the stimulus of war orders. Profits in shipping rose high and sinkings by German torpedo boats increased accordingly. Señor Dato's Government fell on a debate on the Military Reform bills (Dec. 6, 1915). The crisis ended in the formation of a united Liberal ministry under Count Romanones.

Count Romanones wore his neutrality with a difference, and did little to conceal his pro-Ally views. By Sept. 1916, Spain had lost more than 30,000 tons of shipping by torpedoing, and more than 50,000 in circumstances which were, to say the least, obscure. The shipping interests asked for Government help. On Jan. 31 Germany sent in a note establishing an "absolute blockade" of the Allied coasts. Count Romanones sent a firm answer on Feb. 6. But he realized that his firmness meant nothing unless backed with the will to fight if necessary and that public opinion would not follow him so far. He resolved to leave the Government there and then, at the top of the wave of his own policy.

Committees of Defence.—In resigning (April 19) he took the easiest path. His fall, however, cost him the leadership of his party. The new ministry, under the premiership of Señor Garcia Prieto, was frankly neutralist. It had moreover to concentrate on the situation created by the so-called committees of defence. Towards the middle of 1916, a system of infantry committees of defence appeared, which soon evinced a tendency to interfere with the Government in such a manner that, towards the end of the year, Count Romanones, then in office, insisted on their dissolution. General Aguilera, the war secretary in Garcia Prieto's administration, ordered the leaders to be arrested but, probably owing to royal hints, the order was cancelled, the army officers having meanwhile faced the Government with an ultimatum (June 1). The Government resigned. Dato, called to office, capitulated before the juntas. This victory of a movement which, in its essence, was revolutionary, stimulated the revolutionary ferment at work in the country. Political manifestos asking for a renovation in government and constitution followed each other (Socialists June 12, Catalanists June 16, Left-Coalition June 16).

In the teeth of Government opposition, an assembly of senators and deputies met, voted resolutions asking for a reform of the constitution, and set up three commissions to prepare reports on reforms to be submitted to a second meeting to take place later. These men might have taken the lead of the revolutionary spirit stirred by the army. But the mass of the assembly was too dull, and no real leader manifested himself. Thus two attempts, one military, one middle-class, both directed against the evils of the old régime, failed through lack of co-ordination and mutual understanding. A third failure was still to come. On Aug. 10 the railwaymen of the Northern railway went on strike. On the 13th, a general strike, clearly revolutionary, was suddenly launched in the whole country.

A state of war was declared, and the military crushed the rebellion with a ruthless hand. By Aug. 19 the situation was well in hand. The net result was to prove that the only real force in the country was the army committee system. On Aug. 10, the council of ministers passed a special credit for military expenses. The committees attempted to deliver a message into the hands of the king. Dato had to resign on a "perfectly constitutional" hint by the king. In point of fact he was expelled by the army committees. The crisis was long and laborious, and in the midst of it, the parliamentary assembly met in Madrid (Oct. 30) in its second session. The cabinet was at last formed by Garcia Prieto. It was a coalition ministry composed of Maurists, Liberals and Catalanists, in which, in order to give satisfaction to the new demand for an impartial general election, a non-political judge was given the post of home secretary. Señor La Cierva, who took the war office, was the real head of the cabinet. His policy consisted of ingratiating himself with the committees of defence, so as to become their leader and representative. But soon after the general election (Feb. 24) the Government fell on a grave crisis brought about by a strike of telegraph officials. All possible combinations were tried and failed, until on March 21 at midnight, at a meeting of ex-prime-ministers called by the king in his study, King Alfonso, after, it is said, having threatened his abdication, succeeded in forming a "ministry of all the talents." It was but short-lived (resigned Nov. 6). The new Government, presided over by Garcia Prieto, was formed amid the sensation caused by the news of the Kaiser's flight. It fell on Dec. 3, 1918, and Count Romanones formed a stop-gap cabinet. His first important act was his visit to President Wilson, then in Paris.

The successive Governments which ruled Spain during this period had succeeded in steering clear of obstacles, home and foreign, overburdened as they were with home problems and foreign advice not always disinterested. Unwelcome visits of German submarines (1917), and the requirements of trade (Anglo-Spanish agreement Dec. 6) gradually brought Spain to apply to Germany the claim of ton for ton. Germany had agreed to the ton-for-ton indemnity when the end of the war came. The Spanish merchant marine had lost 65 ships representing 140,000 tons. From the material point of view, the neutral attitude adopted by Spain contributed to accelerate the progress which was observable in her economic development in the pre-war years.

Decay of the Party System.—A mixture of two political currents, a democratic, constitutional agitation, born of the Allied victory, and a revolutionary agitation traceable to the effect of the juntas' *pronunciamentos,* brought about a violent conflict between the military and the civil authorities of Barcelona. The Government resigned, the military having expelled the civil authorities from the town. Maura took office on April 15, asked for a decree dissolving the *cortes,* and to the consternation of all parties, obtained it. This amounted almost to a *coup d'état* on the part of the king.

Maura, despite most objectionable methods, failed to bring to the new *cortes* more than about one-eighth of its total membership under his banner. His Government fell (July 20), and Señor Sanchez de Toca (Dato being ill) formed a Conservative cabinet. Two short-lived cabinets followed and a period of deep unrest, murders and mutinies (Saragossa, Valencia, Santander). The king called Dato to power. But the general election at the end of 1920 showed that the mainspring of the old system—the docility of the electorate to any kind of Government—could no longer be counted upon. Dato failed to obtain a working majority, his supporters numbering 177 members out of 405. All his efforts were accordingly bent towards the reconciliation of the several factions within the Conservative party. While engaged in this task he was assassinated by anarchists on March 8, 1921.

This murder accelerated the disintegration of the system of rotation of the two political parties, which, as arranged by Cánovas and Sagasta at the death of Alfonso XII., had stood the monarchy in good stead as a substitute for a real constitutional practice on the lines of the English monarchy. While the old system deteriorated day by day owing to its own internal weakness, it was attacked from the outside by forces of three different kinds: first, the anti-dynastic elements, once heaped together under the common name of republicans, now moving towards Socialism on the one hand and on the other towards different varieties of social revolutionaries such as syndicalists, anarchists and even professional agitators without any political or philosophic bias; secondly, the Catalan home-rulers, gradually evolving from autonomy to separatism; finally the movement of what might be called military syndicalism embodied in the *juntas de defensa.* A Conservative Government under Allendesalazar took office at Dato's death.

Morocco.—The military disaster which the Spanish troops met in Morocco in July 1921, beginning with the fall of the advanced post of Anual, entailed the withdrawal at heavy cost of the Spanish troops from all the zone previously occupied by the commanding officer in Melilla, the suicide of General Silvestre, and considerable moral effects both in Spain and in the Rif. It swept away the Allendesalazar Government. A stronger Conservative Government was constituted under Maura who, backed by public opinion, sent 140,000 men to the rescue of the troops in Morocco. But an energetic demand for an inquiry made itself heard. As a set-off against this current of civilian opinion, the *juntas de defensa* began a campaign of threats and accusations against parliament, which they held responsible for the general disorganization leading to the Moroccan crisis. Injudiciously met by the Government at first, this demand had to be satisfied, and the Government decided to appoint General Picasso as an official investigator. General Picasso carried out his task with a high sense of duty and impartiality, and his report was received by all parties alike as a fine example of patriotism.

But this display of energy on the part of the Government increased the opposition of the military *juntas de defensa.* The cabinet sought a clumsy solution of this problem by a so-called "disbandment" of the *juntas* and their replacement by *juntas informativas* publicly and legally recognized and placed, at least in theory, under the authority of the war minister. This solution satisfied nobody. Señor Maura resigned in Jan. 1922, and though he continued in office by express wish of the king, had finally to disappear in March of the same year, leaving office to another Conservative cabinet under the leadership of Sánchez Guerra.

The Juntas.—The new prime minister, an energetic man, strongly opposed to the *juntas,* took office at a time when parliament was exceedingly weak. The *juntas de defensa* of the infantry officers, authorized by the previous war minister, adopted a number of resolutions, two of which are an indication of their general attitude: (1) Every infantry officer to be bound to affiliate to the *juntas,* or otherwise to be prosecuted before a tribunal of his brother officers; (2) No promotion to be authorized in the army save by seniority. The army officers had thus set up a form of military syndicalism which, owing to the material strength that it wielded, was a State within the State, while in parliament the opposition grew more critical of military inefficiency. The Picasso report was submitted to a parliamentary commission on which all the parties were represented. Parliament and public opinion grew more insistent in their demands for a condign punishment of the Moroccan setback and the Government collapsed.

Liberals and Morocco.—The Liberal coalition which, created in April of the same year, then took office (Dec. 1922) made it clear that it would uphold the parliamentary procedure adopted in regard to the conduct of the Moroccan campaign. Popular feeling backed the new Government.

The election held in April 1923 led to a Liberal-Reformist majority, but its sensational feature was the success of five out of eight Socialist candidates in securing election in the capital, attributed by the Socialist party to the strong line which they had taken against the war in Morocco.

The burden which the Moroccan question imposed on the Treasury was aggravated by other problems which the nation was unable to put aside. The railways were face to face with a severe crisis. The economic situation had somewhat improved since 1920–21, when the tension between owners and men was at its highest, particularly in Catalonia, where professional agitators victimized both owners and men to such an extent that in the year 1921 there were in Catalonia alone 145 attempts on human life causing 90 deaths.

Primo de Rivera.—In Sept. 1923, the report of the parliamentary commission on the disaster of 1921 was ready. Several politicians were stated to be deeply involved, some because they had accorded too much unconstitutional initiative to the king: other difficulties were raised owing to the ill-feeling with which the army received any parliamentary or civilian criticism of its action in Morocco. While the nation was anxiously awaiting the next development, a dramatic stroke brought suddenly to an end the system under which the country had lived since 1875. The captain-general of Catalonia, Don Miguel Primo de Rivera (Marqués de Estella) rebelled against the Government, threatened its members with gaol, and seized power first and office afterwards. He had already once or twice appeared in the limelight owing to declarations on such questions as the surrender of Morocco, on which he held courageous if unorthodox views, and on the interchange of Gibraltar and Ceuta. This last expression of opinion had caused his removal from the position of military governor of Cadiz which he then occupied. At the time of the *coup d'état* General Primo de Rivera was captain-general of Catalonia, his headquarters being in Barcelona.

In the early morning of Sept. 13, the Government published the news that the captain-general of Catalonia had risen in arms. The king was in San Sebastian. The military authorities of Bilbao and Saragossa had sided with the rebels and in Madrid, where the captain-general, General Muñoz Cobos maintained a cautious, though dubious attitude, a council of military commanders were acting for Primo de Rivera. A manifesto published the same day by Primo de Rivera declared that it was indispensable to liberate the country "from the professional politicians, the men who, for one reason or another, are responsible for the period of misfortune and corruption which began in 1898 and threatens to bring Spain to a tragic and dishonourable end." The general added that "the wide net of greedy politics has caught in its meshes and imprisoned the royal will itself." He announced the constitution of a military directorate in Madrid which was to find for the problem of Morocco a "quick, dignified and sensible" solution and was to bring home responsibility "promptly and justly" by the formation of "tribunals of recognized moral authority."

Immediately after the king's arrival (delayed 24 hours) the prime minister called on his majesty and proposed strong action against the military rebels, but the king asked for time for reflection and the Government resigned. Two hours later a deputation of generals was received at the palace and the king requested Primo de Rivera, still in Barcelona, to take office. Upon his arrival in Madrid on Sept. 15, Primo de Rivera proceeded to transform the provisional military directorate both in its personnel and in its constitution in order to grant representation in it to all the branches and all the garrisons of the army.

From a constitutional and administrative point of view, the directorate struck an original note. The only minister was Primo de Rivera himself and ministerial departments were left in charge of permanent officials. The directors studied specific questions. The Home Office was entrusted to General Martinez Anido, with the rank of under-secretary of State. Public opinion received the change in absolute silence, save for a protest from the Socialist Party.

The directorate declared the country in a state of war. The press was put under a strict censorship and all public demonstrations of a political character were forbidden. A few drastic measures enabled the new Government to gain control over the provincial and political machinery. In order to forestall possible trouble in the lower ranks of the army, a substantial rise in pay was granted to non-commissioned officers. A heavy budget, amounting to 54,000,000 pesetas, was set aside for Morocco.

On Nov. 13, two months after the *coup d'état,* Count Romanones and Don Melquiades Alvarez, the presidents respectively of the senate and of the congress of deputies, called on the king in order to remind him that the Crown was under a personal constitutional obligation to call the *cortes* together within three months of their dissolution. They were promptly dismissed by both king and prime minister. The king and his premier went on an official visit to the court of Italy in Nov. 1923. Both recorded their approval of and good wishes for the success and methods of Fascismo. Thus the king declared to General Italo Balbo: "I admire Fascismo. You are happy here in being so near the end of your labours. We are just beginning." In the Vatican, the king read a sensational speech which met with considerable criticism, not only in Vatican circles but also in Spain and South America. Spain was offered to His Holiness in the event of a new crusade being necessary. The answer of the pope was a discreet, broad-minded pronouncement.

Home Affairs.—The Government continued to repress all hostile expression of opinion. The agitation for an inquiry into the Moroccan campaign remained active and had for its centre the Ateneo de Madrid. The directorate closed the club—the first time since its creation in the second half of the 19th century. Don Miguel de Unamuno (*q.v.*), the famous author and professor of Salamanca university, whose strong stand against the directorate, expressed in indignant and sometimes offensive articles in the press of South America, had greatly incensed the directorate, was exiled to the Canary islands.

In March 1924, the council of national economy was created in order to co-ordinate the activities of numerous economic organizations working under several departments. It was divided into six sections: tariffs, valuation of goods for tariff purposes, statistics, commercial information, defence of production, treaties of commerce. The Treasury was heavily burdened with military and Moroccan expenditure. In April 1924, an internal loan was floated (700,000,000 pesetas of four-year-term bonds at 5% and 1% sinking-fund) in order to meet the Treasury bonds issued by them in Oct. 1923. This loan was covered nearly eight times over. In 1923 a national railway council was organized in order to co-ordinate the administration of the railway companies, the State and the companies sharing in the administration and the State participating in the financial liabilities and assets of the companies. The Government launched a railway loan (Oct. 1925) to the amount of 300,000,000 pesetas at 5% free from tax, with a lesser success due to unfavourable economic circumstances.

New Phase in Morocco.—The problem of Morocco soon monopolized the attention of the president. The expenses continued to increase. The budget of 1923–24 had to face a deficit of 576,000,000 pesetas, compared with a deficit of 920,000,000 in the budget of 1922–3, and of 1,101,000,000 for 1921–2. The decrease in the deficit in 1923–4 was not due to a reduction in expenses, but to a considerable increase in receipts due to the rise in the assessment of the tax on *utilidades* (a kind of tax on incomes) and to a better assessment of local and urban taxable property. As for the year 1924–25, while financial papers estimated the deficit at 1,000,000,000, the directorate declared that it did not go beyond 600,000,000. General Primo de Rivera tackled the problem of Morocco with characteristic courage. In the summer of 1924 he decided to carry out a considerable withdrawal and a reduction of military liabilities. Primo de Rivera steadfastly resolved to carry out his policy and he deserves credit for having succeeded, first in imposing his views on the Spanish army in the field at the risk, not only of his popularity, but even sometimes of his life, and also in conducting a difficult military retreat covering all the zone between Tetuan and Xauen. Later events, however, obliged him considerably to modify his policy. The sudden attack launched in 1925 by Abd-el-Krim against the French forces in the French protectorate, led to the combined action of the two countries. The French Government sent to Spain M. Malvy, who negotiated with General Primo de Rivera an agreement for military and political co-operation which led to the recovery of the French territory lost during the first onslaught of the Rifian troops, and to the occupation of Abd-el-Krim's headquarters, after a brilliant landing in Alhucemas Bay by the Spanish troops. (*See* further the special article on MOROCCO.)

Municipal Reform.—In 1925 the directorate undertook a reorganization of the provincial and municipal administration of the country in two decrees. The first establishes a system of municipal autonomy, delegating to municipalities the right to levy certain rates, thus enabling them to set up their municipal treasuries; and establishing female and proportional suffrage in municipal institutions. The second deals with provincial administration, incidentally abolishing the *mancomunidad*, a kind of Catalonian local parliament. In its Catalonian policy the directorate soon reversed the pro-home-rule orientation which had inspired the first utterances of Primo de Rivera evidently inspired in the desire to ensure support from the Conservative home-rule elements of Catalonia for his *pronunciamiento*. But Primo de Rivera found considerable opposition amongst the military forces which surrounded him to any measures of Catalan devolution, so that gradually the sympathies of the directorate towards the Catalonian autonomist movement made way for a régime described in Catalonia as one of systematic persecution.

On Dec. 2, Primo de Rivera parted from his military team and formed a ministry of which, apart from himself and the ministers of war and marine, a fourth soldier was a member in the person of Martinez Anido, who became home secretary and vice-president of the council. The other members of the cabinet were for the most part young and unknown men drawn from the extreme right of the old party system. Primo de Rivera however, in becoming president of the council, declared that he meant to retain full powers as dictator, and in particular, that the press was to remain under strict censorship. He was true to his word. In 1926 both the press and individuals were strictly censored, especially in Catalonia, where one eminent professor was exiled.

Foreign Affairs.—1926 was a year of diplomatic activity. In January a Spanish aviator flew from Spain to Buenos Aires and received an enthusiastic welcome from the Argentine republic. The event had considerable moral effect in all Spanish America. It was quickly followed by a flight to Manila (March) which thus gave to the flying activities of Spain a definite meaning towards maintaining the moral connection with the lands which once had belonged to the empire. Abd-el-Krim, hard pressed by the combined efforts of the French and the Spaniards, surrendered to the French army commander (May). Meanwhile Spain had claimed a permanent seat in the Council of the League of Nations in fulfilment of repeated promises made by the French and the English Governments. The position became confused, Brazil, Poland, China and Persia having also put forward similar claims, while Germany and the northern nations led by Sweden opposed all such increases in the number of permanent seats. The matter had to be adjourned till the June Council when Spain's usual representative, Señor Quiñones de Leon, was ominously absent. On Aug. 9 the treaty with Italy was signed stipulating mutual neutrality in case of unprovoked aggression. If not in its actual wording, which is innocuous, the treaty as an "act" does embody a new orientation in Spanish foreign policy and carried beyond the frontier the obvious conclusion to be drawn from the internal policy adopted, not by the country, but by the men in power. As if further to stress this independent mood Primo de Rivera in the same month announced his intention of asking for a drastic change in the Tangier Convention which amounted to the setting up of a Spanish protectorate in Tangier. Thus the questions of the League Council seat and of the Spanish position in Tangier became simultaneously acute. The Assembly and the Council of the League in Dec. 1926, decided to set up a special kind of Council seat of a semi-permanent character, making it quite clear that it was meant to meet the case of Spain. The Government, however, refused such a compromise and gave notice of withdrawal (September). Three months later (Feb. 1927) the foreign secretary resigned and the prime minister took over the Foreign Office.

Home Affairs.—The year had been no less active in home affairs. The president spent the first part of the year in propagandist efforts to set up an organization, the *Unión Patriótica*, which in his mind was to include all men of good will ready to accept his motto: "Country, Religion, Monarchy." His ministers undertook their several activities unfettered by any parliamentary or constitutional shackles. Good work was at once seen in the ministry of labour led by a young yet experienced Catalan, Señor Aunós, who tackled the organization of labour on a co-operative basis with effective vigour. The department of public works was ably conducted by an expert, the Marqués of Guadalhorce. A welcome sign of economic revival came spontaneously from the nation. The *Confederación del Ebro*, a free association of all the public bodies interested in the river from its source to the sea, was founded in order to adjust the several requirements of irrigation, power, water supply and navigation as between all the regions on the river and its tributaries. It proved a signal success and other bodies of a similar nature have been created since on other rivers. Ambitious schemes for the electrification of the railways and the repair and development of the roads (including the construction of special roads for fast motor traffic) have been set on foot. The main trouble comes from the censorship of the Press. In June 1926, a plot was discovered against the régime. It was led by Marshal Weyler, General Aguilera and several politicians. The Government settled the matter with commendable tact and even with mischievous shrewdness as shown in the decision to fine heavily the Liberal leader, Count Romanones. In September the president was faced with the gravest of the crises he had to meet. A decree (July 1926) having abolished the tradition jealously maintained by all the artillery officers never to accept promotion otherwise than by seniority the artillery officers protested, and after delicate negotiations an arrangement was arrived at by which the artillery officers agreed in principle to the new system while submitting it to guarantees against favouritism. The officers claimed that this arrangement was broken by Primo de Rivera. Whatever the merits of the case may be they were led to prepare a rebellion which the president nipped in the bud by abolishing the artillery corps by decree (September). Though an amnesty restored all but a handful of them to their posts the incident left behind much ill feeling within the country and between the artillery officers and the Government.

The fact is that the Government has not tackled the chief problem of the Spanish State—the reorganization of the army on an objective basis and its insertion within the framework of a civil society. The army is still mostly a nest of posts for the sons of the middle classes and an instrument of political bullying. In the 1925 reconstruction budget amounting to 3,747,000,000 pesetas no less than 1,508,000,000 were devoted to army and navy expenses (barracks 140,000,000, aviation 160,000,000, naval bases 187,000,000). Yet expenses in Morocco began to diminish after the surrender of Abd-el Krim and the Spanish zone was thoroughly pacified and disarmed by the new high commissioner, General Sanjurjo. A decree establishing an income tax was prepared in Dec. 1926, and is gradually working its way into the country's finances. A successful funding of a short-term debt (5,225,000,000 pesetas) led to a voluntary exchange of nearly all the outstanding Treasury bonds for long-term scrip, a trifling residue being refunded at par.

1927.—On Jan. 10, 1927, a sensational discovery was made in France when Señor Maciá, a Catalan separatist, an ex-major in the Spanish army, tried to invade Catalonia with a small band of armed men. The matter was more discussed in France than in Spain owing to its ramifications in Italy, some of Señor Maciá's accomplices being prominent Italian figures. The Government began to put into shape its plans for an assembly. For the rest of the year the country was able to follow—through the chinks in the censorship—the game of pull and push over the new-fangled pseudo-parliamentary creation of General Primo de Rivera. The strong man of the cabinet, General Anido, was understood to be against it; the king, threatened by the leader of the Conservatives, Señor Sánchez Guerra, with an open break if he consented to such a dispossession of the *cortes*, demurred. Finally the decree was signed and the king himself opened the assembly on Oct. 10, while Sánchez Guerra went into voluntary exile. The assembly is a purely advisory organization, all the members of which are appointed by the Government, and as such it has raised no interest. The president had solicited the collaboration of numerous intellectuals and of the Socialist Party but in the nature of things he was bound to meet with refusal in both these quarters and the assembly is as mediocre in its personnel as it is in its organization and work. True political events occur outside. The president had an interview with Sir Austen Chamberlain in Majorca (Oct. 1927). In this month also the king was able to visit Morocco, now entirely pacified. The Tangier negotiations with France, led finally, if not to the satisfaction of the Spanish claim, at least to a number of French concessions which put the position of Spanish safety in her zone on a slightly better basis than before (*see* TANGIER). These events paved the way for a change in Spain's attitude towards the League. Invited by the president of the League Council to reconsider her position (March 1928), Spain announced her willingness to remain within the fold of the League, handsomely trusting the League itself with the task of fixing her status on its Council. The situation thus reached a condition of stable equilibrium.

The president more than once announced his intention now to retire, now to remain in office for an indefinite number of years. The best successes of the Government have been reaped in the financial field where, owing to a period of peace, the admirable vitality of the country responded with added wealth and a budget was finally balanced, at least so far as could be ascertained under the existing system. In 1927 there was an increase of 80,000,000 pesetas over the previous year's receipts. The estimates for 1928 reasonably provided for a balanced budget; but in spite of such financial successes having for their background an economic situation on the whole prosperous, the political situation was far from steady. Though the censorship prevented not only the spreading of unfavourable news but particularly the possibility of any movement of opinion gathering momentum and reaching the field of political action, numerous incidents revealed the vitality of the opposition. Now and then an outspoken speech was heavily—though never cruelly—repressed, as in the case of Professor Asua of Madrid university, whose unjustified punishment led to a unanimous protest from the Faculty of Law of the University of Madrid and to a strike of students. The dictator, despite his evident good will and his successes in more than one field of government, has been the prisoner of his political inexperience. By gagging the nation he has deprived himself of adversaries, but by the same stroke he has deprived himself and the Crown of any alternatives. (S. DE M.)

The Queen Mother, Maria Christina, died on Feb. 6, 1929.

BIBLIOGRAPHY.—*Sources.* The minute and critical study of the sources of Spanish history (collections of documents and bibliography) has rendered most of the earlier collections almost valueless. Even from the point of view of the correctness of texts, some of these older collections have been in a large measure surpassed by more modern ones, among which the following may be recommended:

Bibliographical Guides.—B. Sánchez Alonso, *Fuentes de la historia española e hispano-americana* (1919, 2nd ed. 1927); R. Ballester, *Bibliografía de la historia de España* (Gerona 1921), *Las fuentes narrativas de la historia de España durante la Edad Media 417–1474* (Palma de Mallorca, 1908), and *Las fuentes narrativas de la historia de España durante la Edad Moderna*, Part 1 (Valladolid 1927); R. Foulché-Delbosc and L. Barrau-Dihigo, *Manuel de l'Hispanisant*, 2 vols. (New York 1920–25); Hispanic Society of America, *Bibliographie Hispanique*, 7 vols. (New York, 1905–17).

As regards modern historians and confining ourselves, as the nature of this note requires, to general works, the first was J. F. de Masdeu, *Historia critica de España y de la cultura española*, 20 vols. (1783–1805). After him came D. Modesto Lafuente y Zamalloa, whose work, the *Historia general de España*, 30 vols. (1850–67) was for half a century the most widely read and consulted, but has now been superseded by more modern works. An edition of his work in 25 vols. continued by J. Valera, A. Borrego and A. Pirala was published at Barcelona (1877–90).

At the beginning of the 20th century the *Historia de España y de la civilización española*, by R. Altamira y Crevea, 4 vols. (Barcelona, 1900–11, 4th ed., 1928) to a large extent superseded that of Lafuente because it embodies the results of recent research and also because it presents the most complete picture of Spanish civilization so far published and comprises the first selected bibliographical guide. The *Historia* stops at the year 1808, but its continuation will be found in the *Historia de la civilización española* by the same author (1928 edition in his *Obras completas*, Historical Series vol. iv.). Another work which treats the subject from a different point of view and is accompanied by a modern and selected bibliography is the *Epítome de la Historia de España*, also by Señor Altamira (1927). *See* also A. Ballesteros y Beretta, *Historia de España, su influencia en la Historia universal*, 4 vols. published (Barcelona, 1919, etc.), with an abundant bibliography; S. Aguado, *Manual de historia de España*, 2 vols. (Bilbao, 1927–28), which takes into account the most recent researches and contains a well arranged and critical bibliography. The *Historia general de España, escrita por individuos de la Real Academia de la Historia*, the publication of which was begun in 1892, has remained incomplete. Its various volumes, by a great variety of authors, are very unequal in quality and it is based on no general plan. Modern writers have also published fairly complete works on the separate history of the old divisions of Spain. The best hitherto published are those concerning Catalonia.

For the most recent period see *El Año Político* published yearly by Fernando Soldevilla; *El Anuario Financiero* published yearly by Emilio Riu; A. N. Young, *Spanish Finance and Trade* (1920); Count Romanones *El Ejército y la Política* (1921) and *Las Responsabilidades del Antiguo Régimen* (1924); F. de León y Castillo *Mis Tiempos* (1921); Francisco Cambó *En Torno del Fascismo Italiano* (1925); G. Maura Gamazo *Historia crítica del reinado de Don Alfonso XIII.* (1925).

Of works by non-Spanish authors the best are those of Martin A. S. Hume, *Spain, its Greatness and Decay, 1479–1788* (1898), *Modern Spain, 1788–1898* ("Story of the Nations" Series, 1899) and *The Spanish people* (1901); Butler Clarke *Modern Spain, 1815–1898* (1906).

R. Bigelow Merriman, *The Rise of the Spanish Empire in the Old World and in the New,* 2 vols. (New York 1918), and *Reflexiones acerca del imperio español* (in the Bulletin of the Academy of History 1923). Good summaries of Spanish history year by year are published in the *Annual Register.* On the political history of the 19th century *see* also the Spanish chapters in A. Stern, *Geschichte Europas seit 1815 bis 1871,* 10 vols. (Stuttgart, 1913–24).

SPAIN, BANK OF. The Banco de España, a successor to the Nuevo Banco Español de San Fernando, and the Banco de Isabel II., was raised to the category of the National Bank of Spain on March 19, 1874, by Don José Echegaray, then Minister of Finance. It was granted the exclusive privilege of issuing notes.

Its capital, at that time 57,000,000 pesetas, was 177,000,000 pesetas on Dec. 29, 1921. In Dec. 1928 the reserves stood at 65,000,000 pesetas.

The fiduciary issue is regulated by the law of Dec. 29, 1921, which stipulates that up to a total circulation of 4,000,000,000 pesetas, the metallic reserves shall be 45%, of which, at least, 40% must be in gold. Above 4,000,000,000 and up to a total maximum of 6,000,000,000 the metallic reserve shall be 60%, at least 50% being gold.

As a consideration for privilege of note-issue, the Bank has to perform, free of charge, many services to the Treasury, and in addition to the ordinary taxes payable by all banks, the Treasury obtains from the Bank of Spain a percentage of the profits, varying from 10% to 50% according to the dividend. The Bank has 64 branches, 4 foreign agencies and nearly 6,000 correspondents in Spain. (A. Va.)

SPAIN, CODES OF. (For mediaeval codes, *see* FUERO; GERMANIC LAWS.) The codes in force at the present time cover a considerable part of the legislation of Spain.

They are: (1) The *Código fundamental, i.e.,* the Constitution of the State of 1876, which was preceded by the Constitution of Cadiz of 1812, and that of 1869. (2) The *Código civil,* comprising the law on status, rights and duties of persons (primarily Spaniards) considered as active members of society from birth to death. It came into force on May 1, 1889, and in the same year was applied to Cuba, Puerto Rico and the Philippine islands. As in the Code Napoleon, the Roman concepts were followed. The code in fact carried out the directions of the *Ley de Bases* of May 11, 1888. (3) The *Código de comercio* of 1885 which came into force on Jan. 1, 1886, following the Code of 1829, was framed on the model of the French code of commerce with improvements taken from French jurisprudence and the previous local laws of Spain, such as the *Novísima Recopilacion* and the Ordinances of Bilbao. (4) The *Código de enjuiciamiento civil* (civil procedure) of Feb. 3, 1881. (5) The *Código de enjuiciamiento criminal* of Dec. 22, 1872. (6) The *Código penal* of 1870. (7) The *Ley Hipotecaria* (mortgage law) of 1870. These have all been modified by subsequent legislation.

SPALATIN, GEORGE, the name taken by George Burkhardt (1484–1545), an important figure in the history of the Reformation, who was born on Jan. 17, 1484, at Spalt (whence he assumed the name Spalatinus), near Nuremberg, where his father was a tanner. He went to school at Nuremberg, and afterwards to the university of Erfurt, where he took his bachelor's degree in 1499. There Nikolaus Marschalk, the most influential professor, made Spalatin his amanuensis and took him to the new university of Wittenberg in 1502. In 1505 Spalatin returned to Erfurt to study jurisprudence, and was welcomed by the little band of German humanists of whom Mutianus was chief. He became a teacher in the monastery at Georgenthal, and in 1508 he was ordained priest by Bishop Johann von Laasphe, who had ordained Luther. In 1509 Mutianus recommended him to Frederick III. the Wise, the elector of Saxony, who made him tutor to his nephew, the future elector, John Frederick. The elector sent him to Wittenberg in 1511 and procured for him a canon's stall in Altenburg. He managed all the elector's correspondence.

Spalatin's letters to Luther have been lost, but Luther's answers remain, and are extremely interesting. Spalatin read Luther's writings to the elector, and translated for his benefit those in Latin into German. He would have dissuaded Luther again and again from publishing books or engaging in overt acts against the papacy, but when the thing was done none was so ready to translate the book or to justify the act.

On the death of Frederick the Wise in 1525 Spalatin no longer lived at the Saxon court. But he attended the imperial diets, and was the constant and valued adviser of the electors, John and John Frederick. During the later portion of his life, from 1526 onwards, he was chiefly engaged in the visitation of churches and schools in electoral Saxony, reporting on the confiscation and application of ecclesiastical revenues and he was asked to undertake the same work for Albertine Saxony. He was also permanent visitor of Wittenberg University. He died on Jan. 26, 1545, at Altenburg.

His writings include: *Annales reformationis,* edited by E. S. Cyprian (Leipzig, 1718); and "Das Leben und die Zeitgeschichte Friedrichs des Weisen," published in *Georg Spalatins Historischer Nachlass und Briefe,* edited by C. G. Neudecker and L. Preller (Jena, 1851). A list of them may be found in A. Seelheim's *George Spalatin als sächs. Historiographer* (1876). There is no good life of Spalatin, nor can there be until his letters have been collected and edited, a work still to be done. There is an excellent article on Spalatin, by T. Kolde, in Herzog-Hauck, *Realencyklopädie,* Bd. xviii. (1906).

SPALATO or **SPALATRO:** *see* SPLIT or SPLJET.

SPALDING, ALBERT (1888–), American violinist, was born at Chicago (Ill.), on Aug. 15, 1888. At seven, he commenced his musical studies under Ulpiano Chiti in Florence, continuing them with Juan Buitrago in New York and Lefort in Paris. Spalding's début was made in 1905 in Paris, where in 1906 he appeared again with Patti. His first American appearance was with the New York Symphony Orchestra in 1908. In 1917 he joined the U.S. Aviation Corps, and served as liaison officer with the Italian command. He played at La Scala, Milan, in 1919. His compositions include many works for the violin, a string quartet in E minor and an orchestral work entitled *Alabama.*

SPALDING, a market town in Lincolnshire, England. Pop. of urban district (1921) 10,703. The parish church of St. Mary and St. Nicholas was built in 1284 and is of peculiar construction, having four aisles to the nave. It is mainly Decorated in style. The adjoining lady chapel was built in 1315.

Although there are no traces of settlement at Spalding (*Spaltnige*) before late Saxon times there was probably a village here before Thorold the sheriff founded his cell of Crowland Abbey in 1051. In Domesday Book the manor is said to belong to Ivo de Taillebois, who possessed a market there worth 40s.

SPALLANZANI, LAZARO (1729–1799), Italian man of science, was born at Scandiano in Modena on Jan. 10, 1729. At the age of fifteen he was sent to the Jesuit college at Reggio di Modena, but soon went to the university of Bologna, where his kinswoman, Laura Bassi, was professor of physics, and it is to her influence that his scientific impulse has been usually attributed. He was professor at Reggio, Modena and, under Maria Theresa, at Pavia, where he enriched the museum by the collections from journeys along the shores of the Mediterranean. In 1785 he was invited to Padua, but his sovereign doubled his salary and allowed him leave of absence for a visit to Turkey, where he made many observations. His integrity in the management of the museum was suspected, but an investigation cleared his honour. In 1788 he visited Vesuvius and Sicily, and embodied his researches in *Viaggi alle due Sicilie ed in alcune parti dell' Apennino* (1792).

His main discoveries were in the field of physiology: he wrote papers on respiration, on the senses of bats, etc., while he made experiments (1768) to disprove the occurrence of spontaneous generation, showing that animalcules did not develop in vegetable infusions which had been boiled and were kept in properly closed vessels. His great work is the *Dissertationi de fisica animale e vegetale* (2 vols., 1780). Here he first interpreted the process of digestion. He also carried out researches on fertilization in animals (1780). He died at Pavia on Feb. 12, 1799.

SPANDAU, a suburb of Berlin, Germany. Pop. (1925) 110,459. Spandau is one of the oldest places in the Altmark, and received civic rights in 1232. It afterwards became a favourite residence of the Hohenzollern electors of Brandenburg, and was fortified in 1577–83. In 1635 it surrendered to the Swedes, and in 1806 to the French. A short investment in 1813 restored it to Prussia. Spandau was one of the chief garrison towns of the old German

Empire and contained the Imperial war treasure.

SPANDRIL, Spandrel, in architecture, a space between any arch or arch-like form and the horizontal moulding or beam above it; also, in an arcade, the wall surface between two adjacent arches and any horizontal member above them.

SPANGENBERG, AUGUST GOTTLIEB (1704–1792), German Moravian bishop, Count Zinzendorf's successor, was born on July 15, 1704, at Klettenberg, on the south of the Harz Mountains, where his father, Georg Spangenberg, was court preacher and ecclesiastical inspector of the countship of Hohenstein. He was a student of law at Jena when he met Count Zinzendorf in 1728; in 1730 he visited the Moravian colony at Herrnhut. A "collegium pastorale practicum" for the care of the sick and poor was in consequence founded by him at Jena, which the authorities at once broke up as a "Zinzendorfian institution." His free lectures in Jena led to an invitation from Gotthilf Francke to the post of assistant professor of theology and superintendent of schools connected with his orphanage at Halle. He started work there in September 1732. But differences between the Pietists of Halle and himself soon became apparent. Spangenberg's participation in private observances of the Lord's Supper and his intimate connection with Count Zinzendorf brought matters to a crisis. He was offered by the senate of the theological faculty of Halle the alternative of doing penance before God, submitting to his superiors, and separating himself from Zinzendorf, or leaving the matter to the decision of the king, unless he preferred to "leave Halle quietly." The case came before the king, and, on April 8, 1733, Spangenberg was conducted by the military outside the gates of Halle. At first he went to Jena, but then to Herrnhut and found amongst the Moravians his life-work.

For the first thirty years (1733–62) his work was mainly devoted to the superintendence and organization of the extensive missionary enterprises of the body in Germany, England, Denmark, Holland, Surinam, Georgia and elsewhere. It was on an island off Savannah that Spangenberg startled John Wesley with his questions and profoundly influenced his future career. One special endeavour of Spangenberg in Pennsylvania was to bring over the scattered Schwenkfeldians to his faith. In 1741–42 he was in England collecting for his mission and obtaining the sanction of the archbishop of Canterbury. During the second half of this missionary period of his life he superintended as bishop the churches of Pennsylvania, defended the Moravian colonies against the Indians at the time of war between France and England, became the apologist of his body against the attacks of the Lutherans and the Pietists, and did much to moderate the mystical extravagances of Zinzendorf, with which his simple, practical and healthy nature was out of sympathy. The second thirty years of his work (1762–92) were devoted to the consolidation of the German Moravian Church. Zinzendorf's death (1760) had left room and need for his labours at home. At Herrnhut there were conflicting tendencies, doctrinal and practical extravagances, and the organization of the brethren was very defective. In 1777 Spangenberg was commissioned to draw up an *idea fidei fratrum,* or compendium of the Christian faith of the United Brethren, which became the accepted declaration of the Moravian belief. As compared with Zinzendorf's own writings, this book exhibits the finer balance and greater moderation of Spangenberg's nature. In his last years Spangenberg devoted special attention to education. He died at Berthelsdorf, on Sept. 18, 1792. In addition to the *Idea fidei fratrum,* Spangenberg wrote, besides other apologetic books, a *Declaration über die seither gegen uns ausgegangenen Beschuldigungen sonderlich die Person unseres Ordinarius* (*Zinzendorf*) *betreffend* (Leipzig, 1751), an *Apologetische Schlussschrift* (1752), *Leben des Grafen Zinzendorf* (1772–75); and his hymns are well known beyond the Moravian circle.

In addition to his autobiography (*Selbstbiographie*), *see* J. Risler, *Leben Spangenbergs* (Barby, 1794); K. F. Ledderhose, *Das Leben Spangenbergs* (Heidelberg, 1846); Otto Frick, *Beiträge zur Lebensgeschichte A. G. Spangenbergs* (Halle, 1884); Gerhard Reichel's article in Herzog-Hauck's *Realencyklopädie* (ed. 1906), *s.v.* "Spangenberg"; the article by Ledderhose, in the *Allgemeine deutsche Biographie;* also Moravian Brethren.

SPANISH-AMERICAN ARCHITECTURE. A brief study of architecture in Spanish-America must include a glance at the monumental and impressive architecture of the Mayas made up of receding terraced pyramids flanked with stairways and surmounted by temples of delicate proportions, of pure and refined design, with richly carved ornament decorating their surfaces. In Chichen Itzá the temples and buildings, 15 to 300 ft. high, square or rectangular in plan, were built of limestone, with walls, bases, cornices, doors and windows, typically Maya corbelled arches and rich ornament with sculptural carving. In the valley of Teotihuacan, about 20 m. from Mexico City, the Toltecs built two pyramids of imposing height and grandeur: one dedicated to the sun and the other to the moon. The former is larger than that of Mycherinus in Egypt. In Teotihuacan the structures are symmetrically laid along the main axis of the city called the Street of the Dead. The outstanding characteristics in the buildings and in the decoration are the use of straight lines, geometric figures, balance of masses, repetition of the same colours and the conventionalized design of plants and animals. The base of the "Ciudadela," the citadel, was 1,300 ft. on the side.

Spanish Colonization.—The outstanding and dominating feature of all architectural work in Spanish-America during the 16th, 17th and 18th centuries is the number, quality and character of the religious buildings that rose from the fertile land conquered by the Spaniards. At first the influence of the Italian Renaissance (*see* Renaissance Architecture) is evident. Then, gradually a fusion of the European arts, especially the Spanish and Italian Baroque, with the technique and the sentiment of the natives takes place. Finally, in the 18th century—and more so in Mexico than elsewhere—there springs the Ultra-Baroque of Spanish-America.

In Peru and Bolivia the native art, which had grown free from all exotic influence and which was unknown to Spain, was undoubtedly a fully developed art that, in spite of persecution and almost total destruction at the hands of the conquerors, had enough vitality left to rise again to influence the architecture and decorative arts of the Spaniards, and to leave in the architectural works of these centuries a trace of the lives and very souls of the natives.

This is also true of Mexico, whose architecture has very marked plastic and constructive characteristics which distinguish it from its Italian and Spanish inspirations, and which give it individuality in its arbitrary and flighty but effective ornamentation based on polychromic work. In Mexico, native architecture did not influence the colonial religious architecture; on the other hand, decorative sculpture and carving, among the most vigorous expressions of the aboriginal art shown in the native motives, did.

Monks of the Franciscan Order arrived in New Spain in 1523, of the Dominican Order in 1526, and the Augustines in 1533. The first type of construction used by the missionaries for their churches, in 1564, is that of the basilica (*q.v.*). The principal part of the convent is the church, and the church's exterior has the aspect of a fortress. This combination of temple and fortress in one building is a characteristic of 16th century religious architecture in Mexico. Religious buildings in Mexico may be divided into five types: (1) primitive churches as provisional temples; (2) the basilica type; (3) open chapels; (4) great fortified churches with single nave and no crossing, Romanic buttressing, Gothic vaulting and Renaissance or Baroque ornamentation in the portals; (5) cathedrals. The Augustines excelled the Franciscans in magnificence. The perfect type of Augustine churches of the middle of the 16th century is the church and convent of St. Augustine Acolman (1539), which had a single nave, no tower, fine frescoes, a beautiful cloister and a Plateresque (*q.v.*) portal that is the most notable example of this style in America. The Franciscans oriented their buildings from east to west. The convent of San Francisco in Mexico City was a monument of unusual grandeur and the most remarkable example of its type, covering originally an area of 33,000 square feet. The Dominicans were less sumptuous than the Augustines, but more so than the Franciscans in their buildings, and they tended to make their façades after the severe and sober Herrerian style of the Escorial.

Climax and Later Developments.—From the beginning of the 17th century the prosperity of Spanish-America became so great that a wave of religious building swept over it. The 18th century found a complete religious unity and the power and wealth of the church reached an unsurpassed splendour, propitious to a great manifestation of the arts. The climax of all Spanish-American Colonial religious architecture, as far as magnitude and excellence are concerned, is reached when the cathedrals of the 17th century were built. Mexico alone has 35 cathedrals. The first great cathedral of America was that of Santo Domingo, built in 1514. The first one in New Spain was that of Mérida in Yucatán. The cathedral of Puebla was completed in 1649. That of Mexico City represents the work of three centuries—the maximum personal effort of Spanish colonial art. Its first stone was laid in 1563; it was dedicated in 1667 and completed in June 1813. It is undoubtedly the most remarkable monument that Spanish-American architecture produced. In all small cities the church had its atrium (*q.v.*), which served not only for religious purposes, but as a centre of concentration and defence. The outside defensive wall of the atrium became later an ornamental motif. A great part of the social life of the community, including dances and processions, took place in these centres. The parish church and its atrium represent the most interesting factor of Mexican collective life for 300 years. In three centuries of Spanish domination nearly 15,000 religious buildings were built in Mexico alone, and of these 8,000 in the 18th century. There are more than 18,000 cupolas in Mexico.

The Ultra-Baroque of Spanish-America has rhythmic symmetry, exuberance of decoration, pictorial beauty and vigorous, plastic sentiment coupled with clever and artistic use of polychromic effects. Besides these elements, the co-operation between the monks and the native labourers, masons, carvers and painters, their intuition and skilful use of building materials, and their spirit of improvisation to satisfy the requirements of construction as they presented themselves, made them successful in their search for effects in chiaroscuro through carving, or pictorial through the use of mass, outline and colour.

In the 19th century Spanish-American architecture underwent a period of stagnation and decline because of political activities and unrest. It is characterized by the works of European architects, principally French and Italian, which unquestionably affect the architecture of the period. The early 20th century records an initial movement toward the utilization of Spanish colonial types and motifs, chiefly in the solution of housing problems, which may lead to something worth while, provided there is a closer understanding of the changes that have taken place in the development of labour, industry, transportation and city planning, and a closer co-operation between architects, sculptors, painters and workers. Finally, the universal influence of the Exposition of Decorative Arts in Paris in 1925 has reached Spanish-America and its architecture shows once more the ill effects of hybrid imported architecture lacking the expression of the lives and needs of its people.

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SPANISH-AMERICAN LITERATURE. For more than 300 years after its discovery Hispanic America was culturally as well as politically an Iberian colony. The *conquistadores* and the missionaries who accompanied them wrote the first Hispanic-American literature in the letters and reports which they sent back to Spain and Portugal telling of their victories with sword and cross. Longer accounts of the conquest like the *Sumario de la natural y general historia de las Indias* (1526) by Gonzalo Hernández de Oviedo y Valdés (1478–1557) and *La conquista de México y de la nueva España* (1552) by Francisco López de Gomara (1511–77?) soon followed. The oppressed Indians found a champion in Fray Bartolomé de las Casas (1474–1566), whose *Brevísima relación de la destrucción de las Indias* appeared in 1552, but no one of their own blood rose to tell their story until the Inca, Garcilaso de la Vega (1540–1616), published his *Comentarios reales* (Pt. I. 1609, Pt. II. 1616) and Fernando de Alva Ixtlilxochitl (1568–1648) his *Historia Chichimeca* more than a century after the invasion. The colonizing missionaries, notably Padre José de Anchieta (1530–97), in Brazil, also produced grammars and lexicons of the Indian languages, as well as sermons and hymns.

Before the end of the 16th century Mexico and Lima had become centres of intellectual activity. A printing press was set up in Mexico in 1539 and charters for a university were granted both cities in 1551. The extent to which letters were cultivated at the viceregal courts may be inferred from the fact that in a contest held at Mexico in 1585 more than 300 poets took part. In colonial poetry, as in that of Europe, Ariosto's influence was dominant throughout the latter half of the century, but the epic, *Arauco domado* (Lima, 1594) by the Chilean Pedro de Oña (b. *c.* 1560) and the long descriptive poem, *Grandeza mexicana* (Mexico, 1604) by Bernardo de Balbuena (1568–1627), first bishop of Porto Rico, was constructed on native American themes.

The cult of Góngora, which in the following century superseded that of the Italians, called forth the first important piece of literary criticism in America, the *Apologético en favor de D. Luis de Góngora* (Lima, 1694) by Juan de Espinosa Medrano, as well as the lyrics and prose selections of the anthology, *Ramillete de varias flores poéticas* (1675), collected by Jacinto de Evia (b. 1636), the *Música do parnaso* of Manoel Botelho de Oliveira (1636–1711) and the poems of Gregorio de Mattos Guerra (1637–92). While the Mexican-born Juan Ruíz de Alarcón (*c.* 1580–1639)—generally counted among the great dramatists of Spain—is comparatively free from the affectations of this school, the mystical poems of his compatriot, Sor Juana Inés de la Cruz (1651–95), plainly show its influence.

In the barren 18th century, except for the epic on national themes, represented in Mexico by the *Hernandia* (1755) of Francisco Ruíz de León and in Brazil by José Basilio da Gamma's *Uruguay* (1769) and José de Santa Rita Durão's *Caramuru* (1781), only the long Latin georgic, *Rusticatio mexicana*, by the Guatemalan Jesuit, Rafael Landívar (1731–93), the bucolic poems of the Mexican Manuel de Navarrete (1768–1809) and the writings of the group of scientists at Bogotá led by José Celestino Mutis (1732–1808) and Francisco José Caldas (1741–1816) deserve mention. From this group of Colombian scientists came some of the first martyrs of Spanish-American independence. In Colombia, too, were first printed translations of the prohibited political pamphlets of the French Revolution. These were disseminated throughout the colonies and together with the writings of men like José Joaquín de Lizardi (1774–1827), who criticized Spanish misrule in his journal, *El pensador mexicano*, and in *El periquillo sarniento*, the first real American novel, encouraged the colonists to throw off the Spanish yoke.

In all parts of Hispanic-America the revolutionary victories called forth patriotic verse. *La victoria de Junín. Canto a Bolívar* by José Joaquín Olmedo (1784–1847), of Ecuador, was the most successful of these occasional poems. Among the other distinguished poets who wrote in the cause of liberty were José María Heredia (1803–39) of Cuba, best known for his *Himno del desterrado* and his ode to Niagara, José Fernández Madrid (1784–1830) and Luis Vargas Tejado (1803–29) of Colombia, Juan Cruz Varela (1794–1839) of Argentina, José Bonifacio de Andrade e Silva (1763–1838) of Brazil, and Andrés Bello (1781–1865) of Venezuela. Bello, who was to become later one of Spanish America's greatest scholars, is, however, not remembered for his political verse but for his *Silva a la agricultura de la zona tórrida*.

At the close of the revolutionary period the poets, imbued with a hatred of all things Spanish, turned for their inspiration to aboriginal themes. In "La cautiva" (*Rimas*, 1837) the Argentine

Esteban Echeverría (1805–51) wrote the first significant poem of the pampas, and in *A conspiração dos Tamoyos* (1834) the Brazilian Domingos José Gonçalves de Magalhães (1811–82) extolled the rebel Indians. Through the works of these men, who had studied in Paris, French romanticism was introduced into America. It was carried from Argentina to Uruguay and Chile by political refugees who fled the tyranny of Rosas, among them Juan María Gutiérrez (1809–78), compiler of the anthology *América poética,* and José Mármol (1818–81), author of *El peregrino,* a South American *Childe Harold,* and of the famous political novel *Amalia* (1851). In its later phases the movement is represented in Argentina by Olegario Víctor Andrade (1838–83), author of *Atlántida* and the greatest poet of the republic. The type of romanticism which reached other sections of Latin America came directly from Spain. In Mexico, Ignacio Rodríguez Galván (1816–42) and Fernando Calderón y Beltrán (1809–45), like their models Espronceda and Zorrilla, were both lyric poets and dramatists. The poetry of José Joaquín de Pesado (1801–61), author of *Las Aztecas,* and of Manuel María Flores (1840–85) and some of the work of the Colombian, José Eusebio Caro (1817–53), is romantic in tone. Although the romantic period is richest in lyric poetry, it also produced three important novels: Mármol's *Amalia,* the *María* of Jorge Isaacs (1837–95) and the *Moreninha* of the Brazilian Joaquím Manoel de Macedo (1820–82).

Of especial significance in the development of Hispanic-American literature is the appearance in the latter half of the 19th century of an indigenous phenomenon peculiar to the Argentine, the so-called "Gaucho poetry." The gaucho's life as literary material had been used in the dialogues of *Chano y Contreras* by Bartolomé Hidalgo (1787–?) and in Domingo Faustino Sarmiento's *Facundo* (1845). Now it received epic treatment in the popular idiom in Estanislao del Campo's *Fausto* (1866) and José Hernández's *Martín Fierro* (1872).

Another original literary *genre,* which appeared at about the same time in Perú, is the creation of one man, Ricardo Palma (1833–1919), who in his famous *Tradiciones peruanas* (first series 1872) elevated the historical anecdote to the realm of art.

Two Modern Movements.—Within more recent times two forces have come to direct the course of Hispanic-American letters. The first of these, the "modernista" movement, has been concerned chiefly with problems of literary form. It calls for the enrichment of poetry by new rhythms and new words. Its spokesman was Rubén Darío (1867–1916), a native of Nicaragua, but a resident of most of the countries of South America at some time of his life. Among its adherents have been counted poets from almost all the Latin American republics. The most eminent of them are the Colombian, José Asunción Silva (1860–96), the Uruguayan, Julio Herrera y Reissig (1875–1910), the Mexicans, Manuel Gutiérrez Nájera (1859–95), whose poems even before the publication of Darío's epoch-making *Azul* (1888) had been modernistic in spirit, Salvador Díaz Mirón (1855–1928), and Amado Nervo (1870–1918), the Cuban, Julián del Casal (1863–93), and the Bolivian, Ricardo Jaimes Freyre. Most of the present generation of lyric poets are still under the influence of the "modernista" tradition.

The second movement, "Americanismo" or "Criollismo," is concerned with the subject matter of literature. In its broadest aspects it is a gospel of nationalism and racial solidarity. Its prophet was the Uruguayan, José Enrique Rodó (1872–1917), the "Latin Emerson," who wrote his message in the essay *Ariel* (1899). It was introduced into poetry by José Santos Chocano (1867–   ) and into the novel by Manuel Romero García (1865–   ) in his *Peonía* (1890). It has found expression in the dramas of Florencio Sánchez (1875–1910) and the lesser playwrights of the Argentine *teatro criollo* (creole theatre). The greater number of its followers are writers of prose fiction. Among the novelists Gonzalo Picón Febres (b. 1860), Carlos Reyles (b. 1870), Ricardo Güiraldes (1886–1927) and Enrique Larreta (b. 1875) write of ranch life; Martín Aldao (b. 1879) and Manuel Gálvaz (b. 1882) of urban society; Rufino Blanco Fombona (b. 1874), Manuel Diaz Rodríguez (1868–1927), Lorenzo Marroquín (d. 1918) and Roberto Payró (1867–1928), of national or local politics. The short-story writers, Luis Urbaneja Achelpohl, Manuel Ugarte (b. 1875), Javier de Viana (1872–1926), Horacio Quiroga (b. 1879) and Coelho Netto (b. 1864), show a preference for rural settings and local colour.

With the recent economic and industrial development of the Hispanic-American States the different nationalities have become more individualized and their cultural life more distinct. In the economically more advanced countries prose fiction is replacing poetry as the favourite vehicle of expression. The future literary history of Spanish America will be more and more a history of the literature of the individual countries.

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(E. H. H.)

SPANISH-AMERICAN WAR OF 1898. On Feb. 15, 1898, the U.S. battleship "Maine" was destroyed in Havana harbour by an explosion, with a loss of 266 lives. An American board of inquiry made an extensive examination of the wreck, and reported to the navy department on March 21 that the explosion was caused by an exterior mine, the principal reason for this decision being the upheaval of the ship's bottom. On April 20 President McKinley approved a resolution demanding the withdrawal of Spain from Cuba and setting noon of April 23 as the latest date for a reply. Before this could be delivered by the American minister in Madrid, the Spanish Government sent him his passports. On the 22nd the president declared a blockade of Cuban ports; on the 24th the Spanish Government declared war; and on the 25th the United States Congress declared that war had existed since the 21st.

The joint resolution of Congress of April 20 had declared that relinquishment by Spain of authority in Cuba was the object of American action; the struggle thus naturally centred about the island and all operations were thus at hand. The regular United States army, the only available force until war was declared and a volunteer force was authorized, had been assembled at Tampa, New Orleans and Chickamauga; but until the control of the sea was decided, the army could not prudently be moved across the Strait of Florida. The Spanish fleet under Cervera, which had left the Cape Verde islands for the West Indies, was the real objective of the navy, and had to be settled with before any military action could be undertaken. Accordingly Rear-Admiral Sampson left Key West early on April 22, and began the blockade of Havana and the north coast of Cuba. His North Atlantic squadron of 28 vessels of all kinds, of which the armoured cruiser "New York" (flag), the battleships "Iowa" and "Indiana," and the monitors "Puritan," "Terror" and "Amphitrite" were the most important, and which included six torpedo-boats, was increased to 124 vessels by July 1.

Battle of Manila Bay.—In the Pacific, the American squadron—the protected cruisers "Olympia" (flagship of Commodore George Dewey), "Baltimore," "Raleigh" and "Boston," the small unprotected cruiser "Concord," the gunboat "Petrel," the armed revenue cutter "Hugh M'Culloch," with a purchased collier "Nanshan" and a purchased supply ship "Zafiro"—left Hongkong at the request of the governor and went to Mirs bay, some miles east on the Chinese coast. Ordered (April 25) to begin operations, particularly against the Spanish fleet, which he was directed to capture or destroy, Dewey left Mirs bay on the 27th, and arrived off Luzon, in the Philippines, on April 30. The Spanish admiral Montojo anchored to the eastward of the spit on which are the village and arsenal of Cavite, in a general east and west line, keeping his broadside to the northward. His force consisted of the "Reina Cristina," the "Castilla" (an old wooden steamer which had to be towed), the "Isla de Cuba" and "Isla de Luzon" (protected cruisers of 1,050 tons), the "Don Juan de Austria" and the "Don Antonio de Ulloa" (gunboats of about 1,150 tons) and the "Marques del Duero" (of 500 tons).

Dewey passed into the Boca Grande, paying no attention to rumours of torpedoes, and at midnight passed El Fraile. When he sighted the Spanish squadron to the southward he stood down in column with the "Olympia," "Baltimore," "Raleigh," "Petrel," "Concord" and "Boston" at 400-yd. intervals. When within 5,000 yds. he ported his helm, and at 5.41 A.M. opened fire. He stood westwards along the Spanish line, using his port batteries, turned to starboard and stood back, gradually decreasing his distance to 2,000 yds. At 7.35 Dewey withdrew and gave his men breakfast. Before he re-engaged at 11.16 the "Cristina" and "Castilla" had broken into flames, so that the remainder of the action consisted in silencing the Cavite batteries and completing the destruction of the smaller Spanish ships. The victory was complete. All the Spanish ships were sunk or destroyed. The injury done the American ships was practically nil. The Spanish lost 167 killed and 214 wounded, out of a total of 1,875. The Americans had 7 slightly wounded out of 1,748 men in action. Dewey took possession of Cavite, and awaited the arrival of a land force to capture Manila.

Santiago.—Cervera had left the Cape Verde islands on April 29 with four armoured cruisers, the "Almirante Oquendo," "Infanta Maria Teresa" and "Vizcaya" (sister ships of 7,000 tons) and the "Cristobal Colon" (same size; differently equipped) and three torpedo-boat destroyers. On hearing (May 1) of Cervera's departure, Sampson went east to San Juan, Porto Rico, with the armoured cruiser "New York," the battleships "Iowa" and "Indiana," the cruisers "Montgomery" and "Detroit," and one torpedo-boat. He reached San Juan on the 12th. Cervera's was not present, and Sampson at once started back for Havana. Cervera reached Santiago de Cuba early on the 19th without being sighted *en route*. It was not until the end of the month that the American fleet was assembled before the harbour. An attempt was made to sink the collier "Merrimac" in the entrance channel, which was less than 200 ft. broad in parts available for ships. The preparations for a quick sinking were chiefly carried out by naval constructor Richmond P. Hobson, who went in, in the early morning of June 3, with a crew of seven men. The steering-gear was disabled by a shell, and the ship drifted too far and was sunk in a broad part of the channel where it did not block the egress of Cervera's squadron.

On June 6 the batteries at the entrance were bombarded and their weakness was ascertained. Sampson thereupon placed, every evening, a battleship close in, with a searchlight turned on the channel, making it impossible for the Spanish squadron to escape by night. The port of Guantánamo, 40 m. east of Santiago, was occupied and was used thereafter as a base and coaling station.

The Land Campaign.—When war was declared the total military forces of the United States consisted of 27,822 regulars and 114,602 militia. An act of April 22 had authorized the president to call upon the States and Territories for men in proportion to their population. A first call was made for 125,000 men, and a month later a second call for 75,000. On April 26 large additions to the regular army were sanctioned for the war. The quotas were filled with extraordinary rapidity, and in May 124,776 had volunteered. The troops were concentrated chiefly at Chickamauga, Ga., at Camp Alger, Va., and at Tampa, Fla., which was selected as the point for the embarcation of the expeditionary force for Cuba, and where Major-General W. R. Shafter was in command. After the arrival of Cervera at Santiago, the blockade of his squadron and the request (June 7) of Admiral Sampson to send a land force for co-operation, the troops embarked on June 7 and 8, but a start was not made until the 14th. On the 29th the fleet of 32 transports arrived off Santiago. The whole force consisted of about 17,000 officers and men, 16 light field guns, a train of heavier pieces, and some 200 vehicles. On the 22nd–25th the army was landed at Daiquiri, 18 m. east of Santiago, on a rough coast with scarcely any shelter from the sea; after the first day Siboney, 7 m. nearer Santiago, was used as well as Daiquiri. With the exception of three volunteer regiments (the 1st Volunteer Cavalry, known as the Rough Riders, of which Theodore Roosevelt was lieutenant-colonel; the 2nd Massachusetts and the 71st New York Volunteers), these troops were composed almost wholly of regulars, most of whom had served on the plains against the Indians. Soon afterwards more volunteers arrived.

No opposition was made to the landing. The American troops (commanded by Major-General Joseph Wheeler until the 29th, when General Shafter landed) pushed forward, but the advance was slow and a week elapsed before Shafter was ready to fight a battle in front of Santiago. Here the defenders, under General Arsenio Linares, held two positions, the hill of San Juan, barring the direct road to Santiago, and the village of El Caney, to the northward of the American position at El Pozo. The plan of attack on July 1 was Shafter's, but owing to illness the actual command was exercised by the subordinate generals, Joseph Wheeler, H. W. Lawton and J. F. Kent. General Lawton's division was to attack and capture El Caney, and thence move against the flank and rear of the defenders of San Juan, which would then be attacked in front by Kent and Wheeler from El Pozo. But Lawton for nine hours was checked by the garrison of El Caney, in spite of his great superiority in numbers (4,500 to 520); at 3 P.M. the final assault on El Caney was successfully delivered by General A. R. Chaffee's brigade. Only about 100 of the Spanish garrison escaped to Santiago; about 320 were killed or wounded, including General Vara del Rey, who was killed. In the meantime Wheeler and Kent had an equally stubborn contest opposite San Juan hill, where, in the absence of the assistance of Lawton, the battle soon became a purely frontal-fire fight, and the rifles of the firing line had to prepare the attack unaided. The strong position of the Spaniards, gallantly defended by about 700 men, held out until 12.30, when the whole line of the assailants suddenly advanced, without orders, and carried the crest of the Spanish position. On the American side over 1,500 men out of 15,000 engaged, including several of the senior officers, were killed or wounded. On the Spanish side, out of the small numbers engaged, over 50% were out of action. Linares himself was severely wounded.

Though victorious, the American army was in danger: after great fatigue under a tropical sun by day, the time spared at night from digging trenches was spent on a rain-soaked ground; the soldiers' blankets and heavy clothing had been cast aside; and there was insufficient food. Brisk firing was continued on July 2 and 3, with a considerable number of casualties to the Americans. On the morning of the 3rd a demand was sent to the Spanish commander to surrender, with the alternative of a bombardment of the city to begin on the 4th.

Naval Battle of Santiago.—On the morning of July 3 Sampson, in his flagship the "New York," left the fleet to confer with General Shafter at Siboney with regard to combined operations at the harbour entrance. At 9.31, when he had gone about 5 m., the "Maria Teresa" was seen coming out. The ships in front of the port were the yacht "Gloucester," the battleships "Indiana," "Oregon," "Iowa" and "Texas," the armoured cruiser "Brooklyn" and yacht "Vixen." The "Iowa" hoisted the signal "Enemy coming out." All at once stood in toward the Spanish ships, which were standing westwards along shore, and began a heavy fire. The "Maria Teresa" (flagship) was followed at 800-yd. intervals by the "Vizcaya," "Colon" and "Oquendo." They were firing vigorously, but most of their projectiles went far beyond the American ships. The "Brooklyn" (flag of Commodore Schley, the senior officer present) made a turn to starboard, which seems to have caused the "Texas" to stop and back, and to have given the "Colon" the opportunity of passing almost unscathed. The "Maria Teresa" and "Oquendo" had taken fire almost at once, and were run ashore about 6½ m. west of Santiago, burning fiercely. The "Vizcaya" and "Colon" were still standing westwards. The "New York," Sampson's flagship, had passed, and stood on signalling the "Iowa" and "Indiana" to go back and watch the port, lest an attack be made on the American transports. The "Vizcaya" hauled down her colours off Aserraderos, 15 nautical miles west of Santiago, and was there run ashore burning. The "Iowa" was ordered to stop and rescue her men, and the "Oregon," "Brooklyn" and "Texas" (and behind them the flagship) settled down to the chase of the "Colon," some 6 m. ahead. She was, however, slacking her speed, and at 12.40 the "Oregon" opened with her 13-in. guns at a range of 9,000 yds., as did also the "Brooklyn," with her 8-in. When the "Oregon" had fired five shells, the "Colon" hauled down her colours, and was beached at the mouth of the Rio Turquino. The whole Spanish fleet was destroyed; Admiral Cervera was taken prisoner. Over 500 Spaniards were killed or wounded, and the survivors (except a few who escaped to Santiago) were prisoners. On the American side only one man was killed and ten were wounded, and no ship received serious injury.

After the naval victory combined operations were arranged for attacking the batteries of the harbour, but little more fighting occurred, and eventually a preliminary agreement was signed on the 15th, and the besiegers entered Santiago on the 17th. The exposure of the campaign had begun to tell in the sickness of the Americans: yellow fever had broken out to some extent; and no less than 50% were attacked by the milder forms of malarial fever. The army, indeed, was so weakened by illness that the general officers united in urging its removal from Cuba.

Fall of Manila.—On May 7 a telegram had been received from Dewey at Manila: "I control bay completely, and can take city at any time, but I have not sufficient men to hold." Major-General Wesley Merritt, to whom was assigned the command of the troops for the Philippines, first requested a force of 14,000, and afterwards asked for 20,000 men. On May 25 the first troops, 2,491 in number, under Brigadier-General T. M. Anderson, sailed from San Francisco. On June 20 possession was taken of the island of Guam, and on June 30 the ships arrived in Manila bay. A second detachment of troops, 3,586 in number, under Brigadier-General F. V. Greene arrived on July 17; on July 25 General Merritt, who had been appointed governor-general, arrived; and on the 31st the five transports with which he had left San Francisco arrived with 4,847 men, making nearly 11,000 men at Manila, with 5,000 more on the way. General Merritt moved his forces from Cavite, and established an entrenched line within a thousand yards of the Spanish position at Manila. On Aug. 7, a joint note from Dewey and Merritt, announcing that bombardment might begin at any time after forty-eight hours, was sent to the Spanish captain-general, Fermin Jaudenes, who replied that he was surrounded by the insurgents, and that there was no place of refuge for the sick and for the women and children. A second joint note demanding surrender was declined by the Spanish commander. Preparations were made for an attack. There were 13,000 troops within the city fortifications, but with the strong fleet in front, and with the beleaguering force of Americans and insurgents ashore, resistance was hopeless. When the combined assault of army and navy was made on the 13th there was no great resistance, and a white flag was hoisted at 11 o'clock. The total loss of the Americans during the whole campaign was 20 killed, 105 wounded.

Porto Rico.—Immediately after the surrender of Santiago (July 17), preparations were made for the invasion of Porto Rico with 3,500 troops which had been sent as reinforcements to Santiago, but had not landed. They were largely reinforced and left Guantánamo, under General Miles, on July 21. The towns on the south side of the island were occupied, practically without resistance. The attitude of the population was exceedingly friendly, and opposition was not met until advance was begun northward. The troops were divided into four columns, advancing from Guanica around the western end of the island to Mayaguez; from Arroyo at the eastern end to meet the San Juan road at Cayey; from Ponce by the fine military road, 70 m., to San Juan; and the fourth column by way of Adjuntas and Utuado, midway of the island. The various movements involved several skirmishes. On Aug. 12 operations were begun by the "Newark" and other vessels against Manzanillo. But during the night news arrived of the signing of the peace protocol on the 12th, and of an armistice.

The total American loss was—in the navy, 1 officer, 17 men killed; in the army, 29 officers, 440 men. The health of the American fleet was kept remarkably. Its average strength during the 114 days of hostilities was 26,102; the deaths from disease during this time were 56, or at the rate of 7 per 1,000 per year. As nearly the whole of the service was in the tropics, and in the summer or wet season, this is a convincing proof of the efficiency in sanitary administration. The army did not fare so well, losing by disease during May, June, July and August, 67 officers and 1,872 men out of an average total of 227,494. Its larger proportion of illness must of course be ascribed, in part, to its greater hardships. The lack of proper preparation by the war department and the ignorance and thoughtlessness of the volunteers were the principal reasons for the high death-rate in the army.

For the terms of the peace and the results of the war *see* UNITED STATES; PHILIPPINE ISLANDS; CUBA; PORTO RICO.

The literature of the Spanish-American War is voluminous. *See* the *War Notes* of the Office of Naval Intelligence, Washington, the appendix to the report of the Bureau of Navigation and reports of other Government departments for 1898. F. E. Chadwick, *The Spanish-American War* (2 vol., 1911) is the standard work. Good histories are H. C. Lodge, *The War with Spain* (1899), and H. W. Wilson, *The Downfall of Spain* (1900). *See* also W. A. M. Goode, *With Sampson through the War* (1899); J. Wheeler, *Santiago Campaign* (1899); Theodore Roosevelt, *The Rough Riders* (1899); C. D. Sigsbee, *Personal Narratives of the Battleship Maine* (1899); R. A. Alger, *Spanish-American War* (1900); Gomez Nuñez, *La Guerra hispano-americana* (1900); John D. Long, *The New American Navy* (2 vols., 1903); and George Dewey, *Autobiography* (1913).

SPANISH BROOM, a handsome shrub with long switch-like green, few-leaved or leafless branches and large yellow sweet-scented papilionaceous flowers. It is a member of the pea family (Leguminosae), and known botanically as *Spartium junceum.* It is a native of the Mediterranean region and the Canary Islands, and is often cultivated, especially in California where it blooms almost throughout the year. The whole plant, but especially the flower shoots and seeds, has a bitter taste and tonic and diuretic properties, and was formerly used medicinally. The fibres of the young stems were used in making nets, carpets, mats, baskets, etc.; the flowers yield a yellow dye.

SPANISH LANGUAGE AND LITERATURE. The Iberian Peninsula was, up to the fifteenth century, linguistically more diversified than at present. The chief languages and dialects were Castilian, Asturian-Leonese, Navarro-Aragonese, Mirandese, Catalan and Galician-Portuguese (Northern and Southern Dialects). The Mirandese dialect acquired at an early date Galician-Portuguese characteristics; Catalan is a Provençal dialect; Castilian absorbed the Asturian-Leonese and Navarro-Aragonese languages and in later years gave rise to a literature which was quantitatively and qualitatively the most important amongst Peninsular literatures. Its authority gradually extended beyond the geographical limits of Old and New Castile, even Catalan and Portuguese authors writing in *Castellano.* The Spanish-speaking world has between 80 and 90 million inhabitants (about twice as many as those speaking French and nearly three times as many as those speaking Italian). The Castilian language has become identified with Spanish (*Español*).

Spanish and Latin.—Romance languages in their morphology and syntax derive from *spoken* Latin, older than the *written* Latin of the classical writers and probably differing from it in its syntax, as the syntax of the Romance languages, which is more closely akin to that of High German or of modern Greek than to that of written Latin, tends to show. A definite Latin influence is the Spanish use of the Subjunctive. Generally speaking Spanish syntax is very elastic; thus the position of the subject is more variable than in French or even in English. The Peninsula began to be latinised at the end of the third century B.C., long before Gaul and Northern Italy. But our knowledge of spoken Latin is necessarily slight, and early latinisation alone does not account for the characteristics of Spanish, as compared to the other Romance languages.

The influence of pre-Roman Iberian languages is doubtful There remain, besides place-names, **vega** (open plain, mead), **nava** (plain surrounded by mountains) and the word **páramo** (deserted plain, moor) which appears on a votive altar, dedicated to Diana and discovered in Leon, in an inscription according to which Tullius offers Diana the antlers which he has hunted *in parami aequore*—on the desert plain.

The Phonetics of Modern Spanish.—The Spanish vowels are very close to the standard vowels of the phonetic scheme. The following points should be noticed:

1. The "a" is distinctly velar before back vowels like *o* and *u*, before *l*, and any velar consonant such as *k*, *x*, *g*, etc. This is particularly noticeable in **caja**=κáχɐ.

2. The difference between open and close *e* (ϵ, e) is generally much less marked than in French for example, the most extreme cases of difference being seen in **cielo** and **tierra**. The closed *e* is more open than the French **é** in *été*.

3. The same remarks apply to the open and closed *o* (ɔ, o), the closed *o* being also more open than the French *ô* in *tôt*.

4. The closed vowels occur as a rule in open syllables and the open vowels in closed syllables or in contact with a double *r*, but the closed *e* also occurs in a syllable closed by *s* or a nasal, as in **cesta** and **atento**.

5. The semi-vowels in such words as **ley, soy** are preceded by an open vowel.

6. The semi-vowel *u* velarises the preceding *a* in such words as **causa**.

There is a general tendency in Spanish to combine groups of vowels into one syllable, so that we find tripthongs in which the first vowel (*u* or *i*) has become a semi-consonant and the last (*u* or *i*) semi-vowel: **averigüéis, cambiáis.** This blending of vowels to form one syllable occurs also when the vowels are not contained in one word, thus **Italiaha intervenidoen la guerra-europea.** This, as spoken by a Spaniard at a normal pace, would contain twelve syllables, the last two vowels of "**europea**" forming two separate syllables.

The general smooth fluency of Spanish speech is seen in the historical development of consonants which have come down by oral tradition, and in the treatment of words derived from foreign sources or learned words of Latin origin which often contain difficult consonant groups: Lat. *nata*>**nada** (ð) Lat. participle ending in *-atu*>**-ado.**

The tendency towards assimilation is very noticeable: **Ascensión** in which *c* often yields to influence of *s*, **apto** in which *p* becomes a mere implosive under influence of *t*. In the case of learned words in modern speech, the pronunciation is a compromise between smoothness and an effort at correctness: **acción** (agθjɔn).

Accent of intensity. This accent or stress is particularly important in Spanish and requires greater muscular tension in its production than is usual in English words, because the unstressed vowels are pronounced in Spanish with great care, as, though slightly weakened, they never lose their identity. In general the syllable which bore the accent in Latin retains it in Spanish.

The Articles.—In spoken Latin the noun was preceded by the demonstrative pronoun *ille* (*illum, illu*) and the indefinite pronoun *unus* (*una*). From them derive the definite articles **el, la, lo,** plural **los, las,** and the indefinite articles **uno, una.**

Nouns.—The inflexions so characteristic of *written* Latin were never used to the same extent in the *spoken* langauge. In Spanish, there are strictly speaking no declensions though traces survive in a few cases such as that of the personal pronoun **yo, me, mi; el, le; nosotros, nos.** In spoken Latin the prepositions indicated cases, *e.g.*, Plautus says *hunc ad carnificem dabo.* In modern Spanish the preposition **de** corresponds to the genitive, **para** and **a** to the dative, **a** or the absence of preposition to the accusative, **o** to the vocative and **con, en, por, sin, sobre, trás** to the ablative. But the remains of the classical declensions are seen in the grouping of the noun, the form of which in the great majority of cases is traceable to that of the accusative case in singular or plural forms.

The nouns belonging to the Latin third declension appear in Spanish as words ending in *e* or in a consonant, the plural ending in *es*:

S. *patre-*>**padre**	Pl. *patres*>**padres**
S. *leone-*>**león**	Pl. *leones*>**leones**

This group also absorbed words from other declensions, especially the fifth as the accusative endings were similar. The gender of nouns derived from the third declension is generally the same as in Latin, the neuter nouns being distributed between the two groups according to no settled rule, thus for instance the Latin *sal* which appears in French as masculine (**le sel**) is feminine in Spanish (**la sal**).

Adjectives and Adverbs.—Adjectives follow the principles described in the development of the noun. The neuter has disappeared (except in the abstract use of the adjective as a noun: **lo usual es**—it is the custom), and therefore the Latin three and two endings are reduced to two and one respectively: **inglés** (**-a**), **triste.** There is however a tendency to supply a feminine form as in **Superiora** (Mother Superior), noticeable also in adjectives ending in **on, ol**; *e.g.*, the Spanish-speaking Jews of the Balkan peninsula still say **la lengua español** instead of the modern feminine **española**; on the other hand the same Jews have added feminine endings to **ilustre ilustra** and **joven, jóvena** (a young girl) while Peninsular Spanish preserves the old usage in one ending. *Comparison:* The classical comparative and superlative are rare in Spanish (**bueno, mejor, óptimo**) and are expressed by the use of the adverb *magis*>**más** in the case of the comparative and by the comparative preceded by the article to render the superlative: **tonto, más tonto, el (la, lo) más tonto.** The superlative in *-issimus*>**-isimo** is a latinism which was felt to be un-Spanish by the old writers like King Alfonso X (d. 1284), and, although accepted to-day, it has a pedantic and rhetorical flavour.

Regular adverbial usage differs from the Latin: (a) The adverb is normally formed by the substantive *mente* appended to the feminine form of the adjective: **tonto, tonta, tontamente.** (b) A great number of Latin adverbs were, however, preserved: *adhuc*>**aun**, *quando*>**cuando**, *magis*>**más**, *sic*>**si**; also combinations of prepositions and adverbs: *de-intro*>**dentro**, *intuncce*>**entonces**, *de-ex-post*>**después**, *ad-illic*>**allí**, **etc.**

Pronouns.—The Pronouns include Personal Pronouns (Nominative: **yo, tu, el, ella**; Plur. **nosotros, vosotros, ellos**; Dative: **le, lo, les, los**; Accusative: **me, te, se, nos, os**; Emphatic forms used after prepositions: **él, mí, tí**; Note **conmigo, contigo, consigo**) with the closely connected Possessive or Adjective Pronouns (**mi, tu, su; mio, tuyo, suyo**); the Demonstrative Pronouns (**este, ese, aquel**) amongst which, historically speaking, should be classed the third person of the Personal Pronouns and the article, and finally the almost identical relatives and interrogatives (**que, quien, el cual; ¿qué? ¿quien? ¿cuál?**).

Numerals.—The cardinal numerals are: **uno (-a), dos, trés, cuatro, cinco, seis, siete, ocho, nueve, diéz; veinte** (20), **treinta** (30), **cuarenta** (40), **cincuenta** (50), **sesenta** (60), **setenta** (70), **ochenta** (80), **noventa** (90), **cien, ciento,** (100), **doscientos** (200), **quinientos** (500) **setecientos** (700), **novecientos** (900), **mil** (1,000). The ordinals are **primero (a), segundo (a), tercero (a), cuarto (a), quinto (a), sexto (a), séptimo (a), octavo (a), noveno (a), décimo (a).** The ordinals are learned in form and are not used in ordinary conversation beyond ten.

Verbs.—In Spanish the four Latin conjugations are reduced to three, the infinitive endings being **ar, er, ir,** that is to say that the second and third conjugations in ĕre, ēre have been amalgamated. The only traces of original differences are seen in the strong preterites and past participles of irregular verbs. The Present Indicative and Subjunctive of regular verbs are very close to the Latin originals:

Pres. Ind. **canto, cantas, canta, cantamos, cantáis, cantan**
Subj. **cante, cantes, cante, cantemos, cantéis, canten**
Pres. Ind. **temo, temes, teme, tememos, teméis, temen**
Subj. **tema, temas, tema, temamos, temáis, teman**
Pres. Ind. **parto, partes, parte, partimos, partís, parten**
Subj. **parta, partas, parta, partamos, partáis, partan**

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SPANISH LITERATURE

Spanish literature falls into three divisions: Castilian, Catalan, Galician. Galician is included under Portuguese. It should not be forgotten, however, that Spain, in the two Senecas, Lucan, Martial and Quintilian—as also in Prudentius—made a considerable contribution to Latin literature; while the writings of Spanish Muslims and Jews, both in prose and verse, form an important branch of the literature of Arabic.

1. CASTILIAN LITERATURE

By the time of the Muslim invasion (711) the Latin spoken in the peninsula was already in process of transformation into a Romance *patois* which, from the few words that have come down to us (some of them preserved in jest by the Arabic-speaking conquerors), seems to have resembled the modern dialect of Galicia rather than that of Castile. The earliest documents date from the 10th century; while the revival of the study of Latin in northern Spain in the 11th century led to the neglect of the vulgar tongue by the learned, and the complete separation between the spoken and the written language. Castilian, *romance castellano,* became the official language for public documents under Ferdinand III. (1217–52) and Alfonso X. (1252–84).

Heroic Poetry, 1050–1250.—Castilian literature begins with the poem of the Cid (*Cantar de mio Cid*), an historical character named Rodrigo Díaz de Bivar (d. 1099) and usually known by his Arabic title, *Sid* (lord). The poem, as the brilliant researches of Menéndez Pidal have abundantly proved (*see* bibliography), dates from 1140; the only existing ms. is an imperfect copy made in 1307. It was first printed in 1779. The *Cantar de mio Cid* is a work of noble inspiration. Apart from all questions of originality—whether it owes more to French or to Germanic models, the poem is intensely Castilian in its directness of expression and unflinching realism. The assonant metre seems to be on the same principle as that of the other early Spanish epics which have partly survived—*Los siete infantes de Lara,* reconstructed by Menéndez Pidal from a prose chronicle in which it had been incorporated, and the *Roncesvalles* fragment, recently discovered in the cathedral at Pamplona. It is *versificación irregular;* that is, it depends not on the number of syllables (11–20) in the line, but on a system of "pointing," a regular number of accents or beats such as would naturally be made by a minstrel in the process of chanting. The frequent allusions in the chronicles to the narratives of the minstrels, or *juglares,* suggest that Castilian heroic poetry was far richer than the scarcity of mss. would lead us to believe. These poems were composed not only by minstrels, but also in monasteries in which a hero happened to be buried—a distinction which was considered worthy of advertisement. Thus the *Poema de Fernán González* (the first independent Count of Castile) is the work of a learned Benedictine in the monastery of San Pedro de Arlanza.

Berceo.—The same form was used for the religious and didactic poetry of the 13th century, the chief representative of which is Gonzalvo de Berceo (d. after 1246), the earliest Spanish poet whose name is known. Born at Berceo near Logroño at the end of the 12th century, he entered a Benedictine monastery in the neighbourhood of Calahorra, where he put into poetical form the lives of Spanish saints, the miracles of the Virgin Mary, and other devotional subjects; and his verse gives the impression of a child-like wonder which Spanish poetry was never able to recapture. Berceo called his poems *prosa, decir* or *dictado,* indicating that he intended them to be read or recited, and not sung like the *cantares;* yet he maintains the fiction that he is really a minstrel, singing in the language in which a man speaks to his neighbour and adds that his *prosa* should be worth a cup of good wine. The single-rhyme quatrain was also the form in which two other 13th century poems were written: *El Libro de Alixandre* (the mediaeval legend of Alexander) and *El Libro de Apolonio* (Apollonius of Tyre), both of considerable length and derived from French and Latin sources. To the 13th century also are assigned a life of *Santa Maria Egipciaca,* derived ultimately from a poem attributed to Robert Grosseteste, Bishop of Lincoln (d. 1253); an Adoration of the Magi (*Libro de los tres reyes de oriente*) of Provençal origin, and a fragment of a Debate between the Soul and the Body (*Disputa del alma y cuerpo*), closely related to an Anglo-Norman version of one of the mediaeval Latin poems, entitled *Rixa animi et corporis.*

In the earlier epic period the influences from abroad were predominantly French. The second period is one in which the chief foreign influence was Arabic. The gates of Oriental learning and story were opened to Spain and to the whole of Europe by the capture of Toledo (1085), which became a school of translation from oriental languages. As early as 1120 Petrus Alfonsi, a Spanish Jew who had become a convert to Christianity, introduced Indian fable into Spain with the famous collection of stories written in Latin and known as *Disciplina clericalis.* The Spanish translation of the "beast-fable" *Kalila and Dimna,* made directly from an Arabic text, dates from 1251; it is the first attempt at story-telling in the Spanish language. The romance of the Seven Sages (or *Sendebar*), under the title of *Libro de los engannos é asayamientos de las mujeres* (book of the wiles and deceptions of women), was translated in 1253, and other collections of Eastern stories followed.

Alfonso the Sage.—Alfonso X., *el Sabio* (the Sage), king of Castile and León (1252–84), may justly be called the father of Castilian prose. Under his patronage, and indeed under his editorship, a number of vast works were undertaken, including the great legal code, *Las Siete partidas* (a mine of curious information on Spanish life and customs of the time); together with valuable compilations from Arabic sources, such as the *Libro de saber de astronomía*, the "Alfonsine Tables," the *Lapidario* and the *Libro de los juegos*—an illustrated book of games, including dice, draughts and several varieties of chess played on boards of different sizes. Alfonso X. was also the founder of Spanish historiography in the vulgar tongue. The *Crónica general*, begun under his direction, gave rise to a whole series of chronicles in the vernacular. Alfonso X. was also responsible for one of the greatest collections of mediaeval poetry and music; the illuminated mss. of the *Cántigas de Santa María*, but as the language employed in them is Galician Portuguese, they have been considered under the literature of Portugal.

The period of translation and compilation from oriental and other sources represented by the school of Alfonso X. was succeeded by a brilliant period of original work, in the prose of the Infante Don Juan Manuel (1282–1349?) and the poetry of the archpriest of Hita (d. before 1351). Both had learnt from Eastern story not only how to employ fables for teaching moral lessons, but also how to set them in a suitable frame. In Don Juan Manuel's *Conde Lucanor* the count asks the advice of his councillor, Patronio, on certain questions of life and government, and Patronio replies in each case by telling a story to illustrate the point. Many of the 50 stories are admirably told, and are the first works of Spanish fiction which give evidence of an individual style. The moral tone is uniformly high, and the author is clearly conscious that he has a public duty to perform by writing.

The Archpriest of Hita.—Juan Ruiz, archpriest of Hita, is a man of the people, with no sense of personal obligation to society and still less with any apparent religious vocation. Yet he is a true poet, and an artist to the tips of his fingers. His book of verse, generally known as *Libro de buen amor* ("the book of true love"—*buen amor*, as contrasted with earthly love, *loco amor*), is, in form, a satirical autobiography in which he tells with disarming candour the story of his love-affairs. There is no possible chance of an allegorical interpretation. The love that leads the archpriest is earthly love, though he protests in lyrics of passionate sincerity his devotion to the Virgin Mary. Not all his desires end in fulfilment; but some of the ladies, *e.g.*, Doña Endrina, are vividly and enchantingly portrayed, and the go-between, Trotaconventos (an ancestor of La Celestina), is the first great character in Spanish literature. Though the form of the work is to a certain extent oriental (a frame-work on which numerous apologues and fables are hung), the archpriest has also availed himself of forms and subjects from France. He employs every metre known to him in a masterly fashion.

Contemporary with the *Libro de buen amor*, or perhaps, earlier, is the *Poema de Yuçuf*, a version of the legend of Joseph written in Aragonese dialect in single-rhymed quatrains. Its peculiarity is that though the words are Spanish, they are written in Arabic; and the entire poem is derived from the Koran and other Islamic sources. It shows how the Spanish Muslims clung to their handwriting, even after they had lost their language and their religion.

Arthurian Romance.—14th century Spain had already begun to be acquainted with the romances of chivalry; and the oldest known Spanish example, *El Caballero Cifar*, was probably composed near the beginning of the 14th century. The "matter of Britain," also, was known to Spain even in the time of Don Juan Manuel (who, in a book on the chase, mentions the fact that hawks in his possession were called Lancelot and Gawaine), although the narratives now in existence belong almost exclusively to the 15th and 16th centuries. In spite of the numerous versions and continuations of *Amadis* which followed printing, the romances of chivalry were always importations from abroad; and nothing is further from the unromantic, realistic Spanish spirit than the two distinguishing features of the Round Table: sentimental devotion and supernatural adventure. The chivalry which Cervantes satirized was not Spanish at all.

The 15th century shows the first effects in Spain of literary influence from Italy; it is the period of transition from the middle ages to the Renaissance. There was a growing sense of privacy, a craving for refinement on the part of a society still savage and blood-thirsty at heart and always on the verge of civil war. The artificiality and exaggerated good manners of the poetry of this epoch renders it dull and unattractive to modern readers; but it should never be forgotten that it was an attempt, on the part of the finer spirits among the great lords and the poets in their service, to soften the asperities and barbarities of daily life, and to provide collections of verse which could be recited or sung on festal occasions. Examples of such collections are the *Cancionero de Baena* made for Juan II. of Castile *ca.* 1445, and the *Cancionero de Stúñiga* compiled for use at the Neapolitan court of Alfonso V. of Aragon (1416–58), while, after the invention of printing, the tradition was continued in the *Cancionero general* (1511) and the shameless *Cancionero de obras de burlas* (1519).

Marqués de Santillana.—Early in the 15th century, however, longer didactic poems began to be written under the influence of Dante. The *Divina Commedia* was introduced into Spain by Francisco Imperial, the son of a Genoese who had settled at Seville; the works of Petrarch and Boccaccio began to be read, and the Greek and Latin classics to be translated. Juan de Mena was the author of a fantastic allegorical poem *El Laberinto de Fortuna* (1444?); but the great name in the literary history of the century is that of Don Iñigo López de Mendoza, first Marqués de Santillana (1398–1458). Santillana, like Don Juan Manuel, was not only a soldier and a statesman, but also a scholar and a gentleman, with a keen sense of public duty and of the responsibilities placed upon him by his position in the world, both as a man and as a writer. The most illuminating of his works is the letter addressed to the Constable of Portugal, on the nature of poetry—the earliest piece of literary criticism in Spanish—in which the writer draws upon his reading in Italian, French, Provençal, Catalan, Galician and Portuguese, and upon such Greek and Latin classics as he had been able to obtain in translation. He was a great collector of manuscripts (many of which are still to be found in the Biblioteca Nacional at Madrid), and his Florentine bookseller bore witness to his intimate knowledge of the Italian tongue. He was the first to introduce the Italian sonnet into Spain, and the first to paraphrase Horace. But he is best remembered for his shorter *canciones* and *decires*, and above all for his delightfully musical *serranillas*, which give the impression of having come into his mind in the first instance during the long rides to which his active life as a great feudal lord led him. He also was the first to notice how rich in proverbial sayings the speech of the Spanish country-people can be, and he made a collection of "The wise saws (*refranes*) of old women who sit by the fire."

In the confusion and decadence of the following reign, that of Enrique IV. (1454–74), literature found expression in biting satire or in resignation and the contemplation of death. This was the attitude which produced one of the most justly famous of all Spanish poems, the *Coplas* of Jorge Manrique (d. 1478) on the death of his father.

In prose, the 15th century saw the first appearance of Spanish books of travel, as represented by the journey to Samarkand (1403–06) of an ambassador of Enrique III., Ruy González de Clavijo; and the travels in Europe (1435–39) of Pero Tafur. In biography, Fernán Pérez de Guzmán with his *Generaciones y Semblanzas* (part of a larger work entitled, *Mar de historias*) and Hernando del Pulgar with his *Claros varones de Castilla*, left admirable portraits of eminent Castilians of their time.

The Spanish Humanists.—The Renaissance may be said to begin in Spain with the accession of Ferdinand and Isabella in 1474, the year in which the first Spanish printing press was set up at Valencia. The revival of learning led in two opposite directions; it brought a taste for the antiquities of classical tradition and also for the antiquities of Spanish tradition, as preserved in the *romances* (ballads), *refranes* (proverbs), as well as in the chronicles and earlier prose works. New Spanish prose in a classical mould was printed side by side with the stories of Don Juan Manuel (1575) and the travels of González de Clavijo (1582); while in the poetry of the period, the new forms introduced from Italy by Boscán (d. 1542) and Garcilaso de la Vega (d. 1536) became acclimatized at the same time that the traditional Spanish forms of *romance* and *villancico* began to attract the attention of men of letters. The first Spanish humanists were also the first grammarians and lexicographers of the Spanish language; the *Universal vocabulario en latin y romance* of Alonso de Palencia (1490) and Nebrija's *Arte de la lengua castellana* (1492) are the first of their kind. Other Spanish humanists of distinction, who were also disciples of Erasmus, were Luis Vives, and Juan de Valdés (author of the admirable *Diálogo de la lengua*) both belonging to the reign of Charles V. (1517–56); while Juan del Mal Lara, Arias Montano, Francisco Sánchez "el Brocense" and Luis de León lived under the increasing persecution of thought in the reign of Philip II. (Recent attempts to belittle or justify the repressive zeal of the Inquisition should be received with caution.) Many of the best brains and noblest minds in Spain at the time were followers of Erasmus, who, by his personal example and the example of his writings (printed in Spanish from 1520 until their suppression after his death in 1536), was the guiding light of the Spanish renaissance.

The Romancero.—*Romances* are defined by Menéndez Pidal as short epic-lyric poems sung to an instrument, either in choral dances, at festal gatherings or during work in common. They were first printed in *pliegos sueltos* (not as "broadsides," but as pamphlets), and then, about 1550, collected into the *Cancionero de Romances,* published at Antwerp. The older *romances* date from the century before, and one or two may go back even farther than that. Many of them are fragments of epic poems, remembered and sung by the people themselves after the decay of minstrelsy in the second half of the 14th century, and the metre (16-syllable verses with uniform assonance) suggests an instinctive attempt to systematize the irregular versification of the epics. Another group of *romances,* novelesque rather than heroic, employed a stanza-form more appropriate to lyric poems. The poetical value of many *romances* is heightened by their fragmentary condition. This is well shown by the famous *romance* of Count Arnaldos. The complete ballad has been collected from exiled Spanish Jews in Tangier, yet the curtailed version has transformed a ballad into an other-worldly poem of haunting beauty. This cutting-down of long *romances* by generations of singers has endowed them with a singular perfection of style; and those versions, worked out by some of the most cultured men of the time, are the versions in which the *romances* are now generally known.

The Stage.—Nowhere is the popularity of the *romances* better shown than in their capture of the public stage. The origin of drama in Spain is presumed to have been not very different from that in France and England. Direct evidence is lacking, between the *Auto de los reyes magos,* a 13th century fragment of a play on the three kings and the *Representación del nacimiento de nuestro Señor,* a 15th century nativity play by Gómez Manrique. There is, however, a constant tradition of religious performances in the vulgar tongue, supported by references in legal and other documents, and by the *Mystery of Elche,* still performed on Aug. 14 and 15. (*See* CATALAN LITERATURE.) The existence of a secular drama in the 13th century is proved by a passage in the *Siete partidas* of Alfonso X. By the end of the 15th century the difference was not so much between sacred and secular plays, as between plays in verse and plays in prose, and between the private stage and the public stage.

Among the earliest examples in verse are the *Representaciones* and *Eglogas* of Juan del Enzina, many of which were written for performance before the duke of Alba and end with lyrical *villancicos* set to music by the author himself. The *Cancionero* containing most of his works was printed in 1496. Among his Nativity, Passion and Resurrection plays, the *Auto del Repelón* stands in curious contrast, its subject being the relation between "town" and "gown" in the University of Salamanca. His shepherds and peasants have become comic characters, speaking a definite rustic dialect (*sayagués*) which afterwards became a dramatic convention. In imagination, plot, characterization, and a sense of the stage, he was surpassed by his Portuguese contemporary, Gil Vicente, 11 of whose 43 plays are written entirely in Spanish. His lyrics are the gems of Spanish poetry of the period; his vivid, plastic representation of allegory looks forward to Calderón. The *Barca da gloria* (a ship in which all the passengers are dead) suggests an English play of the 20th century, while the *Auto da sibilla Cassandra* has a psychological interest unsurpassed by any play of its period: the heroine refused to marry, believing herself destined to become the mother of God. Bartolomé de Torres Naharro, who settled at Naples, had a greater sense of the stage than Enzina, and more technique in the management of dialogue. He also had a sense of humour. While his *Comedia soldadesca* (1517) satirizes an army of occupation, his *Tinellaria* is the comedy of the servants' hall in the palace of a Roman cardinal, where the mixture of languages must have sounded irresistibly comic when brought on to the stage, however tiresome it may be to a modern reader. His *Aquilana* and *Calamita* (1520) look forward to the romantic, novelesque plays of Lope de Vega; *Seraphina* and *Imenea* foreshadowed the comedy of cloak and sword. Torres Naharro wrote for a private Italian stage and an audience of cardinals.

The public stage in Spain is first known from the works of Lope de Rueda (d. 1565; not to be confused with Lope de Vega), a famous travelling showman who had been inspired by the vivid acting of a company of Italian players, touring Spain with *Commedia dell' arte.* His longer plays (six in prose, three in verse) are mainly founded on Italian originals. His comic prose *pasos* (interludes performed during the pauses of other plays), though admirable as examples of the actual spoken Spanish of the period, lose the reason for their existence without the traditional and often obscene comic business and "gag" with which they must inevitably have been presented. Lope de Rueda was, in his turn, an inspiration to Cervantes, who afterwards described his simple staging and properties, and whose own Interludes (*entremeses*) whether in verse or prose, are masterpieces in the style. The prose theatre in Spain developed no further until the 18th century. The first dramatist to realize what might be made of the *Romancero* in the theatre (although he never used the actual metre of the *romances*) was Juan de la Cueva, whose plays were printed in 1583. With Lope de Vega and his followers, however, the *Romancero* was brought bodily on to the public stage, and in *Las Mocedades del Cid* (1618) of Guillén de Castro, ballad-characters from the cycle of the Cid's youth come on to the stage and recite the *romances* in which they occur. The plays of Cervantes belong to an earlier and, as he believed, a better tradition; had they been written in prose they might have received more of the attention which they deserve.

Fiction.—The masterpiece of the reign of Ferdinand and Isabella is a novel in dialogue form, the *Tragicomedia de Calisto y Melibea* generally known as the *Celestina.* The authorship is uncertain. First printed, it seems, in 1499, the *Celestina* ran through numerous editions in Spain and has been translated into most European languages (English, by James Mabbe 1631) while it has given rise to innumerable sequels and imitations. In conception, it is a tragedy worthy of Shakespeare, in execution admirable dialogue is one more example of the blending of the popular with the erudite. Like Shakespeare, the author of the *Celestina* has fully developed the personalities of even the minor characters; while the stark realism of the whole story, particularly in the surroundings of La Celestina herself, has had an influence on European literature which can hardly be exaggerated. Another work of fiction had a long line of successors and an English translation; the *Historia del Abencerrage y la hermosa Xarifa,* a tale of Moors and Christians by an unknown writer of the time of Ferdinand and Isabella, which eventually found its way into the *Diana* of Montemayor (d. 1561), the first Spanish example of the pastoral novel introduced from Italy. (J. B. T.)

Classic Age, 16th and 17th Centuries.—The golden age of Spanish literature belongs to the 16th and 17th centuries, extending approximately from 1550 to 1650. Previous to the reign of the Catholic sovereigns there exists, strictly speaking, only a Castilian literature, largely influenced by imitation first of France and then of Italy; the union of the two crowns of Aragon and Castile, and afterwards the advent of the house of Austria and the king of Spain's election as emperor, achieved the political unity of Spain and the unity of Spanish literature. After the death of Philip IV. (1665) the light went out; the nation, exhausted by wars and bad administration, produced nothing; it fell again under the influence of France.

Poetry.—Lyric poetry, especially that of the more ambitious order, was generally inspired by the Italian masters. Juan Boscán, Garcilaso de la Vega and Diego Hurtado de Mendoza wrote *al itálico modo.* The defects of Boscán and Mendoza (such as certain faults of rhythmic accentuation) were corrected by their disciples Gutierre de Cetina, Gregorio Silvestre, Hernando de Acuña, by the poets of the so-called school of Seville, headed by Fernando de Herrera and also by those of the rival school of Salamanca, rendered famous mainly by the inspired poetry of Luis de León. Against these innovators the poets, faithful to the old Castilian manner, the rhymers of *redondillas* and *romances,* held their own; under the direction of Cristóbal de Castillejo, they carried on a fierce war against the "Petrarchists." But by the last third of the 16th century the Italian school had triumphed.

Almost all the poets of the 16th and 17th centuries tried their powers in both kinds of versification. Thus Lope de Vega, first of all, who wrote *La Dragontea* (1598), *La Hermosura de Angélica* (1602), *La Jerusalem conquistada* (1609), in Italian verses and in octaves, composed his long narrative poem on Isidore, the patron of Madrid (1599), in *quintillas* of octosyllabic verse, not to mention a great number of *romances.* The 17th century is characterized by a superabundance of lyric poetry. Góngora introduced into Castilian poetry the baroque style, characterized by sonorous diction, artificial arrangements of phrase and a system of inversions based on Latin syntax; but Góngora, a poet of really great powers, had begun with *romances* in which he found true poetic accents, ingenious ideas and felicitous expressions. Quevedo, much greater in prose than in verse, displays real power only in satire, epigram and parody. There is in some of his serious pieces the stuff of a Juvenal, and his satiric and burlesque *romances,* of which several are written in slang (*germania*), are in their way little masterpieces. Tasso's epic was inspired by *Gerusalemme;* when the author happens to have taken part in the events he narrates, it has a genuine historical interest. Alonso de Ercilla's *Araucana* was written less with a pen than with a pike. *La Gatomaquia* of Lope de Vega, and *La Moschea* of Villaviciosa (d. 1658) show witty invention.

Fiction.—The departments of imaginative literature in which the genius of the new Spanish nation revealed itself with most vigour and originality are the *novela* and the drama. By *novela* must be understood the novel of manners, called *picaresca* (from *pícaro,* a rogue or "picaroon") because of the social status of the heroes of those fictions; and this type of novel is a Spanish invention. The pastoral romance, on the other hand—the best-known examples of which are the *Diana* of Jorge de Montemayor, continued by Alonso Pérez and Gaspar Gil Polo, the *Galatea* of Cervantes, and the *Arcadia* of Lope de Vega—as well as the novel of adventure begun by Cervantes in his *Novelas exemplares,* and cultivated after him by a host of writers, is directly derived from Italy. The *Arcadia* of Sannazaro is the source of the *Diana* and of all its imitations, just as the Italian *novellieri* are the masters of most Spanish *novelistas* of the 17th century. The picaresque novel starts in the middle of the 16th century with the *Vida de Lazarillo de Tormes, sus fortunas y adversidades;* the impetus was given, and the success of *Lazarillo* was so great that imitators soon appeared. In 1599 Mateo Alemán published the first part of the adventures of another picaroon, Guzmán de Alfarache; before he could issue the sequel (1604) he was anticipated (1602) by an unscrupulous rival, whose continuation was on a lower plane. Quite unlike that of the *Lazarillo,* the style of Mateo Alemán is eloquent, full, with long and learned periods, sometimes diffuse. (*See* PICARESQUE NOVEL.)

By degrees the picaresque romance was combined with the novel of Italian origin and gave rise to a new type—half novel of manners, half romance of adventure—of which the characteristic example appears to be the *Marcos de Obregón* (1618) of Vicente Martínez Espinel, one of the best written works of the 17th century. To the same class belong almost all the novels of Alonso Jerónimo de Salas Barbadillo, Luiz Vélez de Guevara and Francisco Santos's popular pictures of life in Madrid, *Día y noche de Madrid* (1663), *Periquillo, el de las gallineras,* etc. On the other hand, the novels of Tirso de Molina (*Los Cigarrales de Toledo,* 1624), Perez de Montalbán (*Para todos,* 1632), María de Zayas (*Novelas,* 1635–1647), are more in the manner of the *Novelas exemplares* of Cervantes, and consequently of the Italian type. Among the so-called historical romances may be mentioned the *Guerras civiles de Granada* (1595–1604) by Ginés Pérez de Hita, which describes the last years of the kingdom of Granada.

Don Quixote (1605–15), the masterpiece of Cervantes (*q.v.*), is too great a work to be treated with others. It is the social romance of 16th and 17th century Spain. The purpose was not to ridicule the books of chivalry, which were already out of fashion by his time, but to show by an example pushed to absurdity the danger of those prejudices of pure blood and nobler race with which three-fourths of the nation were imbued, and which, by the scorn of all useful labour which they involved, were destined to bring Spain to ruin. The lesson is all the more effective, as Cervantes's *hidalgo,* although ridiculous, wins our sympathy.

Drama of the 17th Century.—The stage in the 17th century in some measure took the place of the *romances* of the previous age; it is, as it were, the medium of all the memories, all the passions, and all the aspirations of the Spanish people. Its style, being that of the popular poetry, made it accessible to the most illiterate classes, and gave it an immense range of subject. The Bible, the lives of the martyrs, national traditions, the chronicles of Castile and Aragon, foreign histories and novels, even the daily incidents of contemporary Spanish life, the escapades and nightly brawls of students, the gallantries of the Calle Mayor and the Prado of Madrid, balcony escalades, sword-thrusts and dagger-stabs, duels and murders, fathers befooled, jealous ladies, pilfering and cowardly valets, inquisitive and sprightly waiting-maids, sly and tricky peasants, fresh country girls—all are turned to dramatic account.

The enormous mass of plays with which the literature of this period is inundated may be divided into two great classes—secular and religious; the latter may be subdivided into (1) the liturgical play, *i.e.,* the *auto* either *sacramental* or *al nacimiento,* and (2) the *comedia divina* or the *comedia de santos,* which has no liturgical element, and differs from a secular play only in the fact that the subject is religious and frequently, as one of the names indicates, derived from the biography of a saint. In the secular drama, classification might be carried almost to any extent if the nature of the subject be taken as the criterion. It will be sufficient to distinguish the *comedia* (*i.e.,* any tragic or comic piece in three acts) according to the social types brought on the stage, the equipment of the actors, the artifices resorted to in the representation or the place of performance—public theatre or private stage. We have (1) the *comedia de capa y espada,* which represents everyday incident, the actors belonging to the middle class, simple *caballeros,* and consequently wearing the garb of ordinary town life, of which the chief items were the cloak and the sword; and (2) the *comedia de teatro* or *de ruido,* or again, *de tramoya* or *de aparencias* (*i.e.,* the theatrical, spectacular or scenic play), which has kings and princes for its dramatis personae and makes a great display of mechanical devices, decorations and music. Besides the *comedia,* the classic stage has also a series of little pieces subsidiary to the play proper: the *loa,* or prologue; the *entremés,* a kind of interlude which afterwards developed into the *sainete;* the *baile,* or ballet accompanied with singing; and the *zarzuela,* a sort of operetta thus named after the royal residence of La Zarzuela, where the kings of Spain had a theatre.

As to the dramatic poets of the golden age, it is hard to group them. All are more or less pupils or imitators of the great chief of the new school, Lope Felix de Vega Carpio, described as "monster of Nature." Among Lope's contemporaries only a few poets of Valencia—including Guillén de Castro, the author of the

Mocedades del Cid (from which Corneille derived his inspiration)—formed a small school, which could only win the applause of the public by copying as exactly as possible the manner of the great initiator. Lope's most incontestable merit is to have given the Spanish stage a range and scope of which it had not been previously thought capable, and of having taught his contemporaries to invent dramatic situations and to carry on a plot. It is true he produced little that is perfect: his prodigious fecundity and facility allowed him no time to mature his work; he wrote negligently what he considered to be good for the *vulgo*.

Lope's first pupils exaggerated some of his defects, but at the same time, each, according to his own taste, widened the scope of the *comedia*. Antonio Mira de Amescua and Luis Vélez de Guevara were successful, especially in tragic histories and *comedias divinas*. Gabriel Téllez, better known under the pseudonym of Tirso de Molina displayed no less talent in the comedy of contemporary manners than in historical drama. *El Burlador de Sevilla* (*Don Juan*) is reckoned his masterpiece; but he showed himself a much better dramatist in *El Vergonzoso en palacio*, *Don Gil de las Calzas Verdes* and *Marta la Piadosa*. Finally Juan Ruiz de Alarcón the most serious and most observant of Spanish dramatic poets, successfully achieved the comedy of character in *La Verdad sospechosa*, closely followed by Corneille in his *Menteur*. The second epoch of the classical drama is represented mainly by Pedro Calderón de la Barca, the Spanish dramatist who has obtained most celebrity abroad. Calderón more than any other writer made honour, or more correctly the point of honour, an essential motive in the conduct of his personages (e.g., *El Médico de su honra*); it is he also who made the *comedia de capa y espada* uniform even to monotony, and gave the comic "part" of the *gracioso* (confidential valet of the *caballero*) a rigidity which it never previously possessed. There is depth and poetry in Calderón, and a great sense of the stage. Two contemporaries were Francisco de Rojas Zorilla, author of the fine historic play *Del Rey abajo ninguno*, and Agustín Moreto, author of some pleasant comedies. Luis Quiñones de Benavente was a skilful writer of *entremeses*.

History.—A new manner of writing appears with the revival of learning; the purely objective style of the old chroniclers, accumulating one fact after another, without showing the logical connection or expressing any opinion on men or things, began to be thought puerile. An attempt was made to treat the history of Spain in the manner of Livy, Sallust and Tacitus, whose methods of narration were directly adopted. The 16th century, however, still presents certain chroniclers of the mediaeval type, with more erudition, precision and the promise of a critical faculty. *La Crónica general de España*, by Ambrosio de Morales; the *Compendio historial* of Estéban de Garibay; and the *Historia general de las Indias occidentales*, by Antonio de Herrera, are, so far as style is concerned, continuations of the last chronicles of Castile. Jerónimo de Zurita is emphatically a scholar; no one in the 16th century knew as he did how to turn to account documents and records for the purpose of completing and correcting the narratives of the ancient chronicles; his *Anales de la corona de Aragón* is a book of great value, written in a laboured style.

With Juan de Mariana history becomes a work of art. The *Historia de España* by the celebrated Jesuit, first written in Latin (1592) in the interest especially of foreigners, was afterwards rendered by its author into excellent Castilian; as a general survey of its history, well planned, well written and well thought out, Spain possesses nothing that can be compared with it. Among works of less extent, there are the *Guerra de Granada*, by Diego Hurtado de Mendoza (a history of the revolt of the Moors of the Alpujarras under Philip II.), written about 1572, immediately after the events, but not published till 1627; the narrative of the expedition of the Catalans in the Morea in the 14th century, by Francisco de Moncada (d. 1635); that of the revolt of the same Catalans during the reign of Philip IV., by Francisco Manuel de Mello, a Portuguese by birth; and that of the conquest of Mexico by Antonio de Solís.

The historians of the wars of Flanders, such as Carlos Coloma, Bernardino de Mendoza, Alonso Vázquez and Francisco Verdugo, are less refined, and more vivid. The accounts of transatlantic conquests are either by eyewitnesses, *e.g.*, Bernal Díaz del Castillo (1492–1581), one of the companions of Cortés, and Bartolomé de las Casas, the apostle of the Indians; or by official historiographers, such as Francisco López de Gómara, who wrote in Spain second hand.

Philosophy.—The Spanish thinkers of this epoch, whatever the school to which they belonged—scholastic, Platonic, Aristotelian or independent—wrote in Latin. Ascetic and mystical authors alone made use of the vulgar tongue for the readier diffusion of their doctrine among the illiterate, from whose ranks many of their disciples were recruited. Luís de Granada (1504–1588), Luis de León (1528–1598), Santa Teresa (1515–1582), Pedro Malón de Chaide and St. John of the Cross are the brighter lights of this class of writers. Some of their books, like the *Guía de pecadores* of Luis de Granada, the autobiography of St. Teresa, and Malón de Chaide's *Conversion of the Magdalen* (1588), have much influenced the development of mysticism in France. The Spanish mystics are not so remarkable for the depth or subtlety of their thoughts as for the intensity of the divine love with which they are inspired; many of them are masters of style, and some, like St. John of the Cross, have composed fluent devotional verse inspired by the *Song of Songs*. They profess practical ideas in the matter of morality. Nothing is more sensible, nothing less ecstatic, than the manual of domestic economy by Luis de León—*La Perfecta casada*.

Lay moralists are numerous in the 16th and 17th centuries. Some write long and heavy treatises on the art of governing, the education of princes, the duties of subjects, etc. But there is a kind of morality in which the Spaniard excels, namely, in social satire, which, under all its forms—dialogue and dream in the style of Lucian, epistle after the manner of Juvenal, or pamphlet—has produced several masterpieces and a host of ingenious, caustic and amusing compositions. Juan de Valdés (d. 1541), the most celebrated of the Spanish Protestants, led the way with his *Diálogo de Mercurio y Carón*—admirable in vigour.

The most eminent author in the department of social satire, as in those of literary and political satire, is Quevedo. Nothing escapes his scrutinizing spirit and pitiless irony. All the vices of contemporary society are remorselessly pilloried and cruelly dissected in his *Sueños* and other short works. This great satirist is a disciple of Seneca. His phrases are charged with a double meaning (*Conceptism*). This new school had its Boileau in Baltasar Gracián, who published his *Agudeza y arte de ingenio* (1642), in which all the subtleties of conceptism are reduced to an exact code.

Spanish thought as well as public spirit and all other forms of national activity began to decline towards the close of the 17th century. The advent of the house of Bourbon, and the increasing invasion of French influence in the domain of politics as well as in literature and science, frustrated the efforts of a few writers who had remained faithful to the pure Spanish tradition. The first symptoms, not of a revival, but of a certain resumption of intellectual production, appear in the department of linguistic study. In 1714 there was created, on the model of the French academies, La Real Academia Española, intended to maintain the purity of the language and to correct its abuses. This academy set itself at once to work, and in 1726 began the publication of its dictionary in six folio volumes, the best title of this association to the gratitude of men of letters. The *Gramática de la lengua castellana*, drawn up by the academy, did not appear till 1771.

Ignacio de Luzán, well read in the literatures of Italy and France, a disciple of Boileau and the French rhetoricians, yet not without some originality of his own, undertook in his *Poética* (1737) to expound to his fellow countrymen the rules of the new school, and, above all, the principle of the famous "unities" accepted by the French stage from Corneille's day onward. What Luzán had done for letters, Benito Feijóo, a Benedictine of good sense and great learning, did for the sciences. His *Teatro crítico* and *Cartas erúditas y curiosas*, collections of dissertations in almost every department of human knowledge, introduced the Spaniards to the leading scientific discoveries of foreign countries, and helped to deliver them from many superstitions and absurd prejudices. The study of the ancient classics and the department of learned research in the domain of national histories and literatures had an eminent representative in Gregorio Mayáns y Siscar (1699–1781), who worthily carried on the great traditions of the Renaissance; besides publishing good editions of old Spanish authors. Something of the old picaresque novel came to life again in the *Fray Gerundio* of the Jesuit Isla, a biographical romance which is also and above all a satire on the follies of the preachers of the day. One or two poets can be named. At the head of the new school is Meléndez Valdés, and with him are associated Diego González (1733–1794), José Iglesias de la Casa (1748–1791), known by his *letrillas*, Cienfuegos, and some others.

Among the verse writers of the 18th century who produced odes and didactic poetry it is only necessary to mention Leandro Fernández de Moratín and Quintana. The poverty in lyric poetry is even exceeded by that of the stage. The only dramatist who was really successful in composing on the French pattern some pleasant comedies, is Leandro Fernández de Moratín. There was one writer of talent, Ramón de la Cruz; nothing helps us better to an acquaintance with the curious Spanish society of the reign of Charles IV. than the interludes of this genial and light-hearted author.

19th Century Literature.—The struggle of the War of Independence (1808–14), exerted no immediate influence on the literature of Spain. One might have expected as a consequence of the rising of the whole nation against Napoleon that Spanish writers would no longer seek their inspiration from France, and would resume the national traditions which had been broken at the end of the 17th century. But nothing of the sort occurred. Not only the *afrancesados* (as those were called who had accepted the new régime), but also the most ardent partisans of the patriotic cause, continued in literature to be the submissive disciples of France. It is true both of Quintana and of Martínez de la Rosa, who, though less impressive, had a greater independence of spirit and a more classical taste.

The first decidedly romantic poet of the generation which flourished about 1830 was the duke of Rivas whose drama of *Don Alvaro ó la fuerza del sino* inspired Verdi's opera *La Forza del Destino*. Espronceda is a cosmopolitan romantic of the school of Byron. An exclusively lyric poet, he did not live long, but what he has left is often exquisite. Zorrilla has a more unequal talent; nevertheless, among hasty performances, his *Don Juan Tenorio*, a fantastic version of the legend treated by Tirso de Molina, Calderón, Molière, Zamora, Shadwell and Byron, is a curious specimen of Spanish romanticism. The play by García Gutiérrez, entitled *El Trovador*, inspired Verdi's well-known opera.

Bretón de los Herreros is the last of the dramatists who preserved the feeling of the ancient *comedia*. Mariano José de Larra, a prose writer of the highest talent, must be placed beside Espronceda, with whom he has several features in common. Caustic in temper, he was specially successful in the political pamphlet, the *article d'actualité*, in which he ridicules the oddities of his contemporaries. Also, we have Mesonero Romanos, whose *Escenas matritenses* (1842), give pleasure by the curious details they furnish with regard to the contemporary society of Madrid. Estébanez Calderón in his *Escenas andaluzas* (1847) sought to revive the manner of the picaresque writers. Agustín Durán published highly esteemed collections of old Castilian literature.

Drama.—Foreign influence is most clearly marked in the work of Ventura de la Vega (1807–1865), whose relationship to the younger Moratín, and therefore to Molière, is unmistakable in *El Hombre de mundo* (1845), a piece written after a long apprenticeship spent in translating French plays. A fusion of early and later methods is discernible in the plays of Tamayo y Baus. Campoamor wrote dramas which, though curious as expressions of a subtle intelligence cast in the form of dialogue, do not lend themselves to presentation, and were probably not intended for the stage. The successor of Tamayo y Baus in popular esteem was José Echegaray, whose earlier plays—such as *La Esposa del vengador* and *En el puño de la espada*—are in the romantic style; in his later works he attempts the solution of social problems or the symbolic drama. Such pieces as *El Gran Galeoto*, *El Hijo de Don Juan* and *El Loco dios* indicate a careful study of the younger Dumas and Ibsen. José Felíu y Codina (1843–1897), a Catalan wrote two vigorous plays entitled *La Dolores* and *María del Carmen;* Joaquín Dicenta (b. 1860), showed daring talent in *Juan José*, while Jacinto Benavente (b. 1866), is a dramatist whose mordant vigour and knowledge of stage-effect was first manifested in *La Comida de las fieras* and *Rosas de otoño*.

Poetry.—Rivas, Espronceda and Zorrilla owed more to foreign models than either Campoamor or Núñez de Arce. Campoamor has been described as a disciple of Heine, but he in fact continued in his own semi-philosophic fashion a national tradition of immemorial antiquity—the tradition of expressing lyrical emotion in four or eight lines which finds its most homely manifestation in the five volumes of *Cantos populares españoles* edited by Francisco Rodríguez Marín. No less national a poet was Núñez de Arce, whose best performance is *Gritos del combate* (1875). Absorbed by commerce, Vicente Wenceslao Querol (d. 1889) is represented by a single volume of poems as remarkable for their self-restraint as for a deep tenderness which finds expression in the *Cartas á María*. A more powerful and interesting personality was Joaquín María Bartrina (1850–1880), who endeavoured to transplant the pessimistic spirit of Leconte de Lisle to Spanish soil. Salvador Rueda (b. 1857), in his *Aires españoles*, represents the vivid colouring and resonant emphasis of Andalucía; Vicente Medina (b. 1866) in *Aires murcianos* and *La Canción de la huerta* reproduces with vivid intensity the atmosphere of the Murcian orchard-country. José María Gabriel y Galán (d. 1905), was extremely unequal, and his range of subjects was limited, but in *El Ama* he produced a poem which is unsurpassed in the Spanish poetry of its time. But more truly a poet than any of these was Rosalía de Castro, whose one volume of poems not in the Galician dialect, *En las orillas del Sar*, was published in 1884.

Fiction.—Since 1850 there has been a notable renaissance of the Spanish novel. Fernán Caballero is entitled to an honourable place in literary history as perhaps the first to revive the native realism which was temporarily checked by the romantic movement. In all that concerns truth and art she is superior to the once popular Manuel Fernández y González (d. 1888), of whom it has been said that Spain should erect a statue to him and should burn his novels at the foot of it. Antonio de Trueba followed Fernán Caballero in observing local customs. He had no gift of delineating character, and his plots are feeble; but he was not wanting in literary charm, and went his road of incorrigible optimism amid the applause of the crowd. His contemporary, Pedro Antonio de Alarcón, is remembered chiefly as the author of *El Sombrero de tres picos* (the Three-Cornered Hat), a delightful and peculiarly Spanish tale of picaresque malice, more than once translated into English. José María de Pereda is the founder of the modern school of realistic fiction in Spain, and the boldness of his experiment startled a generation of readers accustomed to Fernán Caballero's feminine reticence and Trueba's deliberate conventionality.

His rival, Juan Valera, is not, in the restricted sense of the word, realistic, but he is no less real in his own wider province; he has neither Pereda's energy nor austerity of purpose, but has a more infallible tact, a larger experience of men and women, and his sceptical raillery is as effective a moral commentary as Pereda's Christian pessimism. In Valera's *Pepita Jiménez* and *Doña Luz*, and in Pereda's *Sotileza*, we have a trio of Spanish heroines who deserve their fame. Benito Pérez Galdós gave a new life to the historical novel in his huge series entitled *Episodios nacionales*. The colouring is so brilliant, the incident is so varied and so full of interest, the spirit so stirring and patriotic, that the born Spaniard easily forgives their frequent prolixity. Their appeal is irresistible; there is also a considerable public for the politico-religious novels such as *Doña Perfecta*, *Gloria* and *León Roch*, which have been published in English versions. The quick response of Pérez Galdós to any external stimulus, his sensitiveness to every change in the literary atmosphere, made it inevitable that he should come under the influence of French naturalism as he does in *Lo Prohibido* and in *Realidad;* but his conversion was temporary, and two profound novels dealing with contemporary life—*Fortunata y Jacinta* and *Angel Guerra*—mark the third and culminating stage in the development of one of the greatest of Spanish novelists. The talent of Armando Palacio Valdés was first displayed in *El Señorito Octavio.* Two subsequent works—*Marta y María* and the delightful *La Hermana San Sulpicio*—raised hopes that Spain had, in Palacio Valdés, a novelist of the first order to succeed Valera; but in *La Espuma* and *La Fe,* two social studies which contained caricatures of well-known personages, the author ceased to be national and did not become cosmopolitan.

Another novelist who for a time divided honours with Palacio Valdés was Emilia Pardo Bazán. The powerful, repellent pictures of peasant life and the ethical daring of *Los Pazos de Ulloa* and *La Madre Naturaleza* are set off by graphic passages of description; and the local patriotism which inspires *Insolación* and *De mi tierra* is expressed in a style which secures Emilia Pardo Bazán a high place among her contemporaries. Leopoldo Alas (1851–1901), who used the pseudonym of "Clarín," was better known as a ruthless critic than as a novelist; the interest of his shorter stories has evaporated, but his ambitious novel, *La Regenta,* lives as an original study of the relation between mysticism and passion. Jacinto Octavio Picón (b. 1852), who deserted novel writing for criticism, displayed much insight in Lázaro, the story of a priest who finds himself forced to lay down his orders; this work was naturally denounced by the clerical party, and orthodoxy declared equally against *El Enemigo* and *Dulce y sabrosa;* more impartial critics agree in admiring Picón's power of awakening sympathy and interest, his gift of minute psychological analysis and his exquisite diction. Angel Ganivet (d. 1898) produced in *Los Trabajos del infatigable creador Pio Cid* a singular philosophical romance, rich in ideas and felicitous in expression, though lacking in narrative interest. Ramón del Valle Inclán (b. 1869) tends to preciosity in *Corte de Amor* and *Flor de Santidad;* but in his four *Sonatas, Primavera, Estío, Otoño* and *Invierno* (which have been translated into English), he has produced a masterpiece, and in the protagonist, the Marqués de Bradomín, a great character. (J. F.-K.; J. B. T.)

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CONTEMPORARY LITERATURE (1910–1928)

The dominant feature of contemporary Spanish literature may be found in a more conscious realization of the creative element of the race by its critical element and in a tendency towards the fusion of both these elements into a complete whole. With the death of Galdós, the sceptre of Spanish literature passes to Miguel de Unamuno, who represents the modern version of the Spanish mystic writer. His main concern is the relation of man to creation. It is the subject of his masterpiece *Del Sentimiento Trágico de la Vida* (1913), a book of passionate meditation (of which an excellent translation exists in English, *The Tragic Sense of Life,* 1921), and as an attitude of mind it dominates his criticism: *En torno al Casticismo* (1902), *Ensayos* (1916), *La Agonía del Cristianismo* (1926); his novels: *Niebla* (1914), *Abel Sánchez* (1917), *Tres Novelas Ejemplares y un Prólogo* (1920) and his play: *Fedra.* In these works Unamuno appears as the apostle of an ideal of life more closely connected with spiritual Easternism than with the intellectual and social tenets of the West. He thus fulfils in Spain much the same function as Dostoievsky did in Russia, for Spain like Russia is a transition between East and West. He aims at intensity rather than extension. His style is not unlike the style of Carlyle in that it is written with the whole being of the man, body and soul.

If, in order to complete the parallel with Russia, a Spanish western type of mind had to be opposed to Unamuno, as Turgenev could be opposed to Dostoievsky, a younger man, José Ortega y Gasset, might be selected for this purpose. Ortega y Gasset is a refined humanist, strongly influenced by German contemporary Neo-Kantian schools of thought. His main work is in the field of criticism and psychology—*Meditaciones del Quijote* (1911), *El Espectador* (1917). In more recent books he has endeavoured to draw philosophical and psychological conclusions from current events; for instance, in the field of politics with his *España invertebrada* (1922) and in that of philosophy and science with *El tema de nuestro tiempo* (1923), a masterly commentary on the new vistas opened out to thought by the discoveries of Einstein. In this same school may be included José Martínez Ruiz (b. 1876), better known under his literary name of "Azorín," whose art has all the finish and exquisiteness, and all the smallness as well, of miniature painting. He has the rarer merit of applying these gifts to the interpretation of national scenes and places, as in his *Castilla* (1920); *Los Pueblos* (1905); *La Ruta de Don Quijote* (1905), and has thus contributed in no small measure to the movement for national self-knowledge which is noticeable in contemporary Spain.

Fiction.—In fiction, though belonging to an older generation, Vicente Blasco Ibáñez must be mentioned. His war novel *Los*

Cuatro Jinetes del Apocalipsis (1916, Eng. trans. 1918) made him famous with the English-speaking public. Older novels (and better ones) have been translated, such as *La Barraca* (1899), *Sangre y Arena* (1908), *The Matador* (1918) and *The Cabin* (1919). Blasco Ibáñez represented an art which is Spanish only in its subject but not in its spirit, manner or style.

Of a younger generation, Pío Baroja (b. 1872) is perhaps the most widely read. A Basque, with all the acuteness of mind of his race and not a little of its rustic independence and antagonism to civilization, Baroja writes abundantly and carelessly with more spirit than art. His best work is perhaps *Idilios Vascos*, in which he has rendered the quaint charm of his own country. Many of his works have been published in English by American publishers. To this generation belongs also Ricardo León, who writes in a more consciously traditional vein and pays considerable attention to matters of style. His main work is *Casta de Hidalgos* (1908). Concha Espina, a brilliant woman novelist, has distinguished herself by novels of psychological insight and easy style, such as *El Metal de los Muertos* (1920).

Ramón Pérez de Ayala (b. 1881) is perhaps the best novelist of the younger generation. A critic of great talent and a poet, he has written several novels, the best of which are *Novelas Poemáticas de la Vida Española* (1916, translated into English under the title of *Prometheus*) and *Belarmino y Apolonio* (1921). He is a typical exponent of the fusion of the traditional Spanish spirit with the conscious knowledge of its resources referred to above, as characteristic of contemporary literature in Spain. The same may be said of Gabriel Miró, whose delicate sensibility and deep knowledge of the language make him one of the most richly endowed authors of contemporary Spain. Among his works are *El Humo Dormido* (1920); *El Libro de Sigüenza* (1921); *Figuras de la Pasión del Señor* (1916, this last translated into English 1924). Of recent years several authors have cultivated the utopian and satirical variety of novel-writing. To this kind belong *El Archipiélago Maravilloso* (1923) by Luis Araquistain, and *La Girafa Sagrada* by S. de Madariaga (originally written in English and published 1925). Among newcomers in novel-writing Claudio de la Torre and Felix Urabayen, *El Barrio Maldito* (1925) must be singled out.

Drama.—Jacinto Benavente still dominated the Spanish theatre during this period. His most famous play, *Los Intereses Creados* (1907), is not representative, for it illustrates but one phase of the talent of this many-sided author. A more powerful tragedy, *La Noche del Sábado* (1903), is of the same period. In more recent times he has given an intense drama of life in *La Malquerida* (1913). There is, however, a type of play in which Benavente must yield the prize to the brothers Álvarez Quintero (Serafín, b. 1871; Joaquín, b. 1873). As authors of Comedias de Costumbres these two writers, who always work together, are unsurpassed. The list of their comedies is long, and includes *Las de Caín* and *Puebla de las Mujeres* (1912). Other playwrights of note are Linares Rivas (b. 1866), remarkable for his skill in the handling of dialogue; Martínez Sierra, a name which stands for the collaboration of Don Gregorio Martínez Sierra (b. 1881) and his wife, resulting in a happy blend of dramatic skill and delicate psychology; and Pinillos (Parmeno) (1875–1923), a vigorous painter of social conflicts. The poetical theatre still lives in Spain, maintained by Valle-Inclán (b. 1870), Marquina, Cata and Ardavín. In recent years a writer of unusual power, Jacinto Grau, has conquered the foreign stage, particularly with his *El Conde Alarcos* (1917), *El Hijo Pródigo* (1918). But drama and comedy are only one, and that not the most important, aspect of the Spanish theatre. Still more typical of the nation is what is modestly known in Spain as *Género chico* (small genre), a type of theatrical production consisting of plays generally short and accompanied by music and ranging from variety pieces akin to operettas to little masterpieces of musical drama. Its best-known exponents are the brothers Quintero and Carlos Arniches (b. Alicante, 1866).

Poetry.—The two main influences acting on Spanish poetry towards the close of the 19th century, *i.e.*, national tradition and the example of foreign poetry, particularly that of the symbolist school of France, which reaches Spain through South-American poets, such as Rubén Darío, are still at work. Though the first is the more vigorous and conscious, the second widens so as to include all influences: D'Annunzio, Maeterlinck, Tagore. More typically national are Unamuno, *Rosario de Sonetos Líricos* (1911), *El Cristo de Velázquez* (1920); Antonio Machado (b. 1875), whose pessimistic serenity is in keeping with the landscape of central Spain (*Soledades, Campos de Castilla*) and Salvador de Madariaga (b. 1886), whose *Romances de Ciego* (1922) re-state in a new form the old Spanish theme of Jorge Manrique. Other poets produce under more complex influences. Thus Manuel Machado (b. 1874), whose main inspiration is popular and southern has, nevertheless, written excellent verse in which the influence of French elegant sensibility is discernible; Juan Ramón Jiménez (b. 1881), remarkable rather for exquisite sensitiveness than for power is led by his melancholy moods towards fluid rhythms which, though more settled, are reminiscent of Maeterlinck and, through him, of Rossetti. Ramón del Valle-Inclán (1870), perhaps the most skilful musician among modern Spanish poets, has given in *La Marquesa Rosalinda* (1913) an admirable example of the adaptability of the Spanish language to the most exquisite and complicated rhythms. Ramón Pérez de Ayala in his three volumes, *La Paz del Sendero* (1916); *El Sendero Innumerable* (1916); and *El Sendero Andante* (1921), effects a happy union of thought with harmonious poetry in a work not wholly uninfluenced by Francis Jammes, D'Annunzio and Walt Whitman. Among the rising generation may be mentioned Pedro Salinas, Jorge Guillén, García Lorca and Rafael Alberti.

Miscellaneous.—In the field of erudition and literary history the task of Menéndez y Pelayo is continued by Don Ramón Menéndez Pidal, whose works on the "Cantar de Mio Cid" (1911, 1913, etc.) and on the Spanish Chronicles have thrown much light on the origin of Spanish epic poetry. Francisco Rodríguez Marín (b. 1855), editor of *Don Quijote*, a specialist of Spanish folk lore, has succeeded the Master as head of the National Library. Father Asín has won world-wide fame by his illuminating work on the Arabic origins of Dante. Of the younger generation Federico de Onís (b. 1885) has edited *Fray Luis de León* (1914) and Américo Castro (b. 1885) has worked on *Lope de Vega* (1919).

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(S. DE M.)

CATALAN LITERATURE

Poetry in the Middle Ages.—Although the Catalan language is a branch of the southern Gallo-Roman, the literature, in its origin might be considered as supplementary to that of Provence. Until about the second half of the 13th century the poets of north-eastern Spain used no other language than that of the troubadours. Guillem de Bergadan, Uc de Mataplana, Ramón Vidal de Besalú, Guillem de Cervera, Serveri de Gerona, were all genuine Provençal poets, in the same sense as are those of Limousin, Quercy or Auvergne, since they wrote in the *langue d'oc* and made use of all the forms of poetry cultivated by the troubadours north of the Pyrenees. Ramón Vidal (end of the 12th century and beginning of 13th) was a grammarian as well as a poet; his *Dreita manera de trobar* became the code for the Catalan poetry written in Provençal, which he called *Lemosi*. From the combination of spoken Catalan with the literary language of the troubadours there arose a composite idiom. Among the oldest examples of this Provençalized Catalan verse are the poetical works of Raymond Lully or Ramón Lull (1235–1315), and one has only to read the fine piece entitled *Lo Desconort* ("Despair"), or some of his stanzas on religious subjects, to apprehend at once the eminently composite nature of that language. Muntaner (1265–1336), whose prose is exactly that spoken by his contemporaries, becomes a troubadour when he writes in verse; his *Sermó* on the conquest of Sardinia and Corsica (1323), introduced into his *Chronicle* of the kings of Aragon, exhibits linguistically the same mixed character as is found in Lully. Catalan verse writers of the 14th century are not very numerous, nor are their works of any great merit. The majority of their compositions consist of what were called *noves rimades*, that is, stories in octosyllabic verse in rhymed couplets. There exist poems of this class by Pere March, by Torrella, by Bernat Metge (an author more celebrated for his prose), and by others whose names we do not know; among the works belonging to this last category special mention ought to be made of a version of the romance of the *Seven Sages*, a translation of a book on good breeding entitled *Facetus*, and certain tales where, by the choice of subjects, by various borrowings, and even occasionally by the wholesale introduction of pieces of French poetry, it is clearly evident that the writers of Catalonia understood and read the *langue d'oui*. Closely allied to the *noves rimades* is another analogous form of versification—that of the *codolada*, consisting of a series of verses of eight and four syllables, rhyming in pairs, still made use of in one portion of the Catalan domain (Majorca).

15th Century.—The 15th century is the golden age of Catalan poetry. At the instigation and under the auspices of John I. (1387–1395), Martin I. (1395–1410), and Ferdinand I. (1410–1416), kings of Aragon, there was founded at Barcelona a consistory of the "Gay Saber," on the model of that of Toulouse, and this official protection accorded to poetry was the beginning of a new style much more emancipated from Provençal influence.

The language begins to rid itself more and more of Provençalisms, and tends to become the same as that of prose and of ordinary conversation. With Pere and Jaume March, Jordi de Sant Jordi, Johan de Masdovelles, Francesch Ferrer, Pere Torrella, Pau de Bellviure, Antoni Vallmanya, and, above all, the Valencian Auzías March, there developed a new school, which flourished till the end of the 15th century, and which, as regards the form of its versification, is distinguished by its almost exclusive employment of eight-verse *cobles* of ten syllables, each with "crossed" or "chained" rhymes ending with a *tornada* of four verses. Auzías March (1379–1459), the most inspired, the most profound, but also the most obscure of the whole group, was printed in the 16th century; his *Cants d'amor and Cants de mort* contain the finest verses ever written in Catalan. He was admired by Santillane and translated into Castilian by Montemayor (1560). Of a wholly different class, and in quite another spirit, is the *Spill des dones* of Jaume Roig (d. 1478), a Valencian also, like March; this long poem is in quadrisyllabic instead of octosyllabic verse. A bitter and caustic satire upon women, it purports to be a true history—the history of the poet himself and of his three unhappy marriages in particular. Notwithstanding its author's allegations, however, the *Spill des dones* is mostly fiction; but it derives a very piquant interest from its really authentic element, its vivid picture of the Valencia of the 15th century and the details of contemporary manners. Amongst other poets, Joan Roiç de Corella (1430–1500), was the author of the *Tragedia de Caldesa* and an *Oració* to the Virgin Mary. After this bright period of efflorescence, Catalan poetry rapidly faded, a decline due more to the force of circumstances than to any fault of the poets. The union of Aragon with Castile, and the resulting predominance of Castilian throughout Spain, inflicted a death-blow on Catalan literature, especially on its poetry. The fact that a Catalan, Juan Boscan, inaugurated in the Castilian language a new kind of poetry, and that the Castilians themselves regard him as the head of a school, is important and characteristic; the date of the publication of the works of Boscan (1543) marks the end of mediaeval Catalan poetry.

Prose of 13th–15th Centuries.—The earliest prose works in Catalan are later than the poems of the oldest Catalan troubadours of the Provençal school. Though the oldest Catalan document dates from between 1095 and 1110 (the text of an oath imposed on certain barons by a bishop of Urgell), and the *Homilies d'Organyá* are believed to date from the 11th century, literary prose dates no further back than the close of the 13th century. It has the advantage of being entirely original. The language is the very language of the soil which we see appearing in charters from about the time of the accession of James I. (1213). Its chronicles are the best ornament of mediaeval Catalan prose. Two of them—that of James I., apparently reduced to writing a little after his death (1276) with the help of memoirs dictated by himself during his lifetime; and that of Ramon Muntaner (1265–1336), relating at length the expedition of the Catalan company to the Morea and the conquest of Sardinia by James II., are distinguished alike by the artistic skill of their narration and by the quality of their language; it would not be too much to liken these Catalan chroniclers, and Muntaner especially, to Villehardouin, Joinville and Froissart. The Doctor Illuminatus, Raymond Lully, who, though he knew Arabic, had a poor acquaintance with Latin—his philosophical works were done into that language by his disciples—wrote in a somewhat Provençalized Catalan various moral and propagandist works—the romance *Blanquerna*, the *Libre de les maravelles*, into which is introduced a "bestiary" taken by the author from *Kalilah and Dimnah*, and the *Libre del orde de cavalleria*, a manual of the perfect knight, besides a variety of other treatises and opuscula of minor importance. The majority of the writings of Lully exist in two versions—one in the vernacular, which is his own, the other in Latin, originating with his disciples, who desired to give currency throughout Christendom to their master's teachings. Recent research has proved that Lully's peculiar method of exposition and many of his ideas were taken from Muslim Spanish mystics and *sūfīs*. Lully—who was very popular in the lay world, although the clergy had a low opinion of him, and in the 15th century even set themselves to obtain a condemnation of his works by the Inquisition—had a rival in the person of Francesch Eximeniç (1340–1409). His *Crestia* (printed in 1483) is a vast encyclopaedia of theology, morals and politics for the use of the laity. The *Libre de les dones*, which is at once a book of devotion and a manual of domestic economy, contains a number of curious details as to a Catalan woman's manner of life and the luxury of the period.

In the 15th century, Bernat Metge, himself well versed in Italian literature, presents some of its great masters to his countrymen by translating Boccaccio's story of Griselde from the Latin version made by Petrarch, and also by composing *Lo Sompni* ("*The Dream*"), in which the influence of the Italy of the 13th and 14th centuries is very perceptible. The chivalrous romance, *Tirant lo blanch* (finished in 1460 and printed in 1490), one of the few books saved from the library of Don Quixote, was mainly the work of Johanot Martorell of Valencia. *Curial y Guelfa* is an anonymous romance of the end of the 15th or beginning of the 16th century. The beginnings of the drama in Catalan are represented by *The Mystery of Elche*, a 15th century Assumption play based on an earlier *Representació*. It is still performed every year at Elche, on Aug. 14 and 15, and is sung throughout to traditional music.

16th–18th Centuries.—With the loss of political was bound to coincide that of literary independence in the Catalonian countries. Catalan fell to the rank of a patois. The 16th century, in fact, furnishes literary history with hardly more than a single poet at all worthy of the name—Pere Serafi, some of whose pieces, in the style of Auzías March, but less obscure, are graceful enough and deserve to live; his poems were printed at Barcelona in 1565. Prose is somewhat better represented, but scholars alone persisted in writing in Catalan—antiquaries and historians like Miquel Carbonell (d. 1517), compiler of the *Chroniques de Espanya* (printed in 1547), Francesch Tarafa, author of the *Cronica de cavallers catalans*, Anton Beuter and some others not so well known. In the 17th and 18th centuries the decadence became still more marked. Catalan had become the medium of familiar conversation, the language of folk-songs and ballads, printed in the *Romancerillo catalán* of Milá y Fontanals; but in these it lived on until the re-awakening at the beginning of the 19th century.

Revival of Catalan Language and Literature.—In 1814 appeared the *Gramática y apologia de la llengua cathalana* of Joseph Pau Ballot y Torres. The pioneers of reform, however, soon realized that ancient Catalan had fallen out of touch with their spiritual needs. They were living in an atmosphere of romantic mediaevalism, yet they found that a mediaeval literary language was inadequate for their purpose. Again, the popularity of the satirical poems and farces of José Robreño (1780–1838) was a serious obstacle, owing to the corruption of the language in which they were written, while Federico Soler (1839–95) openly advocated *Catalá qu'ara es parla* ("Catalan as she is spoke") in opposition to the literary language. The development of modern Catalan, however, has been steadily in the direction of a refined means of expression for contemporary thought. Aribau's patriotic *Ode* (1833), the poems of Victor Balaguer (1823–1901) led to the imagination and mysticism of Jacinte Verdaguer (1845–1902), whose epic woven round the figure of Columbus (*L'Atlántida*) is a noble conception and a great poem. The Majorcan poems of Tomá Aguiló, with their vague, fantastic charm, were followed by those of Miguel Costai Llabera; while a strong formal sençe was brought in by Juan Alcover (d. 1926) and Gabriel Alomar. Catalonia found its first modern poet of real greatness in Joan Maragall (1860–1911). Contemporary poets have still further refined the language, so that it has become an exquisite instrument for the expression of poetry. The chief names are Josep Carner (b. 1884), J. M. López-Picò (b. 1886), and J. M. de Sagarra.

The foundations of modern Catalan prose were laid by Joaquín Rubio y Ors (1818–99), by José Torres i Bagés, archbishop of Vich and author of *La tradició catalana* (1892). Francisco Pi i Margall, president of the Spanish republic of 1873, showed complete mastery over both Catalan and Castilian. Fiction was inaugurated by Narciso Oller with *Papallona* (1880). One of the best prose-writers of the Catalan movement was Eugeni d'Ors ("Xenius"), part of whose *Glosári* (1906–17), was translated into Castilian before the author abandoned Barcelona for Madrid and began himself to write in Castilian. His exquisite philosophical tale, *La Ben Plantada,* is one of the most notable achievements of the Catalan mind and the Catalan language.

In the theatre, too, Catalan dramatists have produced work of considerable originality. Angel Guimerá achieved European reputation with *Terra baixa* (1896), which was made into the opera *Tiefland* by Eugen d'Albert and has been translated into English as *Martha of the Lowlands.* Beginning with historical tragedy (*Gala Placidia,* 1879; *Judith de Welp,* 1883), he turned to rural drama in *La Boja* (1890), comedy in *La Baldirona* and *La Sala d'espera,* and modern tragedy in *Martha Rosa* (1894), and *La festa del blat* (1896). His last work, *Jesus que torna,* was brought out during the World War of 1914–18. Interesting dramatic work was also produced by Ignacio Iglesias (d. 1928), whose long series of social dramas—inspired originally by the early works of Gerhardt Hauptmann—produced something of a masterpiece in *Els Vells.* For a time he fell under the influence of Maeterlinck (e.g., *Focfollet, Cendres d'amor*) and eventually turned to pure comedy, in *Girassol.* Adrián Gual is the author of several works of fancy and originality, but his best work has been done as director of *Teatre Intim,* an "art-theatre" in Barcelona, founded in 1898, which produced works of pioneer tendencies. Santiago Rusiñol, a distinguished painter, achieved an unqualified success in a play with incidental music by Enric Morera, *L'Alegría que passa,* since when he has written a number of plays, including *L'Heróe, El Mistic, El Indiano,* etc.

The Catalan language is now used for valuable works in all branches of science and art, history and music. Linguistic studies have received invaluable support from the *Institut d'Estudis Catalans,* with its fine library and numerous publications.

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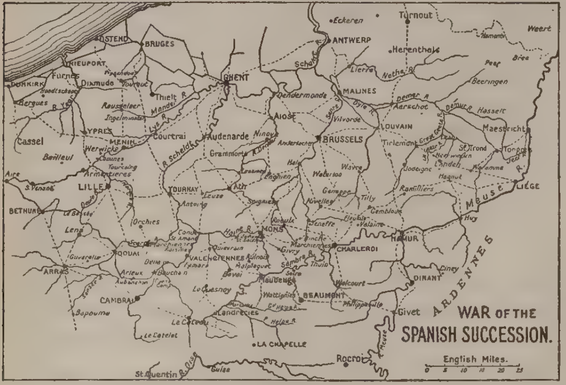
(J. F.-K.; A. M.-FA; J. B. T.)

SPANISH MOSS (*Tillandsia usneoides*), the name given to a plant of the family Bromeliaceae which hangs in long festoons from the branches of trees in tropical and sub-tropical American forests, being especially conspicuous on the live oak in the southern United States. The whole plant is covered with scaly hairs for the absorption of water, giving it a grey colour. It is used like horse-hair. From its appearance, which resembles a lichen, it is sometimes called old man's beard.

SPANISH SUCCESSION, WAR OF THE, the name given to the general European war which began in 1701 and ended with the Treaties of Utrecht and Rastatt in 1713–14. Its monotonous round of marches and sieges is often quickened by the genius of three great soldiers, Marlborough, Eugene and Villars, while Peterborough and Galway, Catinat and Vendôme, though less highly gifted, were men of unusual and conspicuous ability. As usual in these wars, manoeuvres, threats and feints played the principal part in field warfare. The tangible assets, at the conclusion of peace, the effective seizure of fortresses and provinces was in most cases the principal object with which kings and princes made war. Nevertheless, the object of this war, at least in the case of England and Holland, was less to add a few cities and districts to their own domains than to cripple the power of Louis XIV. The ambition of the *Grand Monarque* by placing on the throne of Spain his grandson Philip, had brought into politics the fear not merely of a disturbance but of an entire overthrow of the "Balance of Power." Thus the instrument of his ambition, his magnificent army, was (above all for England) an object in itself and not merely an obstacle to the attainment of other objects. Many of the allies, however, had good reason to fear for their own possessions, and others entered the alliance with at least the hope of acquiring a few material gains at small expense. On the side of the allies therefore, throughout the war, there was a perpetual struggle between offensive activity and defensive passivity.

The action of Louis XIV. in the matter of the Spanish succession had been foreseen, and William III. of England devoted his last years to providing against the emergency by the formation of a coalition to deal with it, and the production of a claimant for the Spanish throne, the archduke Charles. The coalition naturally grew out of the Grand Alliance (*see* GRAND ALLIANCE, WAR OF THE), and consisted of Austria, some of the German states, Great Britain, Holland, Denmark and Portugal. On the other side Louis XIV. was supported by Spain—where Philip, recognized as heir by the dying Charles II., had been promptly installed—Bavaria and Cologne. A doubtful ally was the duke of Savoy, whose policy was to secure and aggrandise himself by adhering at each moment to the stronger party.

Italy Chiari 1701.—The war began, to all intents and purposes, with the handing over of the fortresses in the Spanish Netherlands to the French in March 1701. England and Holland at once began their preparations, but neither state was able to put an army in the field in the year—England because her peace-time army was absolutely insignificant, and Holland because she dared not act alone. In Italy, however, the emperor took the initiative, and an Austrian army under Prince Eugene, intended to overrun the Spanish possessions in the Peninsula, assembled in Tirol in the early summer. The French army under Catinat blocked the defile of Rivoli, but secretly reconnoitred passages over the mountains between Roveredo and the Vicenza district in neutral Venetian territory. On May 27, taking infinite precautions as to secrecy, and requesting the Venetian authorities to offer no opposition so long as his troops behaved well, Eugene began his march by paths that no army had used since Charles V.'s time, and on the 28th his army was on the plains. Catinat was surprised, for he had counted upon Venetian neutrality, and when, in the search for a passage over the lower Adige, Eugene's army spread to Legnago and beyond, he made the mistake of supposing that the Austrians intended to invade the Spanish possessions south of the Po. He thinned out his line to cover all the front as far as that river. But Eugene found an unguarded spot. With the usual precautions of secrecy (deceiving even his own army), he crossed the lower Adige in the night of July 8–9. Catinat at once concentrated his scattered army backwards on the Mincio, while Eugene turned northward and regained touch with his old line of supply, Roveredo-Rivoli. For some time Eugene was in great difficulties for supplies, as the Venetians would not allow his barges to descend the Adige. At last, however, he made his preparations to cross the Mincio close to Peschiera and well beyond Catinat's left. This was executed on July 28. It seems that the marshal was well content to find that his opponent had no intention of attacking the Spanish possessions in the Peninsula, at any rate he fell back quietly to the Oglio. But his army resented his retreat before the much smaller force of the Austrians and, early in August, his rival Tessé reported this to Paris, whereupon Marshal Villeroy, a favourite of Louis, was sent to take command. The new commander was the least competent of all the French senior officers. Ere long he attacked Eugene in a well entrenched position at Chiari (Sept. 1), and was thoroughly defeated, with a loss, it is said, of 3,000 to the Austrians' 150.


WAR OF THE SPANISH SUCCESSION.
English Miles.
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OSTEND
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ALOST
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Weert
Hamont
Bree
Peer
Beeringen
MALINES
Demer R.
Aerschot
Hasselt
Senne R.
Vilvorde
Dyle R.
LOUVAIN
Maestricht
BRUSSELS
Anderlecht
Tirlemont
Great Geete R.
St Trond
Tongres
Jeer R.
Neerwinden
Landen
Jodoigne
Waremme
Hannut
Wavre
Waterloo
Hal
Enghien
Ninove
Grammont
Audenarde
Courtrai
Lys R.
YPRES
MENIN
Wervicke
Comines
Tourcoing
Cassel
Bailleul
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S. Venant
LILLE
BETHUNE
La Bassée
Lens
Orchies
TOURNAY
Leuse
Antoing
Ath
Steenkerke
Soignies
R. Scheldt
Genappe
Tilly
Ramillies
Nivelles
Gembloux
Fleurus
Velaine
Seneffe
Roeulx
MONS
Haine R.
Binche
Marchiennes
Givry
CHARLEROI
NAMUR
Huy
LIEGE
MEUSE R.
Condé
St Amand
Marchiennes
Quievrain
VALENCIENNES
Aulnois
Malplaquet
DOUAI
Guvarelle
Denain
Famars
Bavai
Sambre R.
Thuin
Solre
Maubeuge
ARRAS
Arleux
Bouchain
Aubanchon
Sensée R.
CAMBRAI
Bapaume
Le Quesnoy
Wattignies
BEAUMONT
Walcourt
Philippeville
Landrecies
Gd Helpe R.
P. Helpe R.
Le Cateau
Le Catelet
LA CHAPELLE
St Quentin
R. Oise
Guise
Rocroi
Meuse
Givet
DINANT
Ciney
ARDENNES

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As yet there was no declaration of war by either party. Preparations were made by both sides during the year, most vigorously of all by Louis, who set on foot no less than 450,000 regulars and embodied militia, and had always prided himself on being first in the field. But the début was disheartening, and in the winter a fresh mishap befell the French. Eugene surprised Cremona on the night of Feb. 1, 1702, and, after a confused fight, drew off, taking with him Villeroy as a prisoner. The rest of the French army thereupon retreated, while Eugene quietly resumed his winter quarters and his blockade of Mantua.

Marlborough's First Campaign.—With the year 1702 the real struggle began. Villars and one or two others of Louis's counsellors urged the king to concentrate his attention on the Rhine and the Danube, where, they pointed out, was the centre of gravity of the coalition. This advice was disregarded, and with political aims, the largest French army was employed on the side of the Meuse, while the Rhine front was entrusted to smaller forces acting on the defensive. In Italy the balance of power remained unchanged, except that one of Louis's best generals, Vendôme, was sent to replace the captured Villeroy. In the Low Countries, Ginckell, earl of Athlone, the interim commander of the allies (English, Dutch and minor German states), was at the outset outmanoeuvred by the French (Boufflers), and the momentary threat of a French invasion had a lasting effect on the Dutch authorities, whose timidity thereafter repeatedly ruined the best-laid schemes of Marlborough, who was obliged to submit to their obstruction and their veto. This handicap, moreover, was not the only one under which Marlborough suffered. Unless it is realized and borne in mind that the great captain was struggling against factiousness and intrigue in England and against jealousies, faint-heartedness and disagreements amongst the states who lent their contingents to his miscellaneous army, the measure of his achievements in ten years seems small. But in fact it was marvellous. Under 18th-century conditions of warfare, and with an army so composed that probably no other man in Europe could have held it together at all, obstructed and thwarted at every turn, he yet brought Louis XIV. and France to the very edge of ruin.

In this theatre of war the French, in concert with the garrisons of the Spanish Netherlands, had fortified a line of defence more than 70 m. long from Antwerp to Huy, as well as another line, longer but of only potential importance, from Antwerp along the Scheldt-Lys to Aire in France. Besides the "lines of Brabant" Boufflers held all the Meuse fortresses below Huy except Maestricht. Marlborough concentrated 60,000 men (of whom 12,000 only were British) about Nijmwegen in June, and early in July, having made his preparations, he advanced directly by Hamont on Diest. Boufflers hastily fell back, in order to regain the Brabant lines. Marlborough, with the positive object of bringing his opponent to battle at a disadvantage, won the race and awaited the arrival of Boufflers' tired army to strike it a paralysing blow. But at the critical moment the Dutch deputies forbade the battle, content to see the army that had threatened Holland with invasion driven off to a safe distance without bloodshed (July 22). After this experience Marlborough thought it prudent to pacify the Dutch by besieging the Meuse fortresses, several of which fell in rapid succession (September–October). Boufflers fell back within the defended area of the lines of Brabant, and the campaign closed with the capture of Liége by the allies (Oct. 12). Marlborough was created a duke on his return to England in November. He had checked the main enterprise of the French, and every man in the army knew that but for the Dutch deputies the enemy would have been destroyed.

Friedlingen.—On the Rhine the campaign was, except for two disconnected episodes, quite uneventful. The Imperialists under a methodical general, the margrave Louis of Baden, gathered in the Neckar country and crossed the Rhine above Spire. Catinat, now old and worn out, was sent to Strasbourg to oppose the threatened invasion of Alsace, and, like MacMahon in 1870, he dared not assemble his whole force either on the Lauter or on the Ill. The margrave invested Landau (July 29) and with a covering army occupied the lines of the Lauter about Weissenburg, which Catinat did not attack. Hence Landau, valiantly defended by Melac, had to be surrendered on Sept. 12. But at the same time the elector of Bavaria took the side of France, surprised Ulm, and declared a local war on the house of Austria and the "circles" of Swabia and Franconia. The margrave then, in order to defend his own country, hurried to Kehl with the greater part of his army, leaving a garrison in Landau and a corps of observation on the Lauter. To co-operate with the elector, Catinat had made up a corps out of every available battalion and squadron and placed it under Lieut.-General Villars. This corps drew away into Upper Alsace and the margrave followed suit until the two armies faced one another on opposite sides of the Rhine near Huningen. Villars crossed the Rhine and won the first victory of his brilliant career at Friedlingen (opposite Huningen). Soon afterwards he placed his army in winter quarters in Alsace, and Louis of Baden disposed his troops in two entrenched camps opposite Breisach and Strasbourg respectively. In Italy Vendôme, superior in numbers but handicapped by instructions from Versailles and by the necessity of looking to the Italian interests of King Philip, gained a few minor successes over Eugene. A very hard-fought and indecisive battle took place at Luzzara on the Po on Aug. 15.

In the next two years Bavaria was the centre of gravity of the French operations, and only campaigns of the methodical and non-committal kind were planned for Italy and the Low Countries. In this year began the Camisard insurrection, in the Cevennes, which necessitated the detachment of a considerable body of troops from Vendôme's army in Italy.

In the Netherlands the French field army was behind the lines of Brabant, the Spanish troops in the lines of Flanders (Antwerp-Ghent-Aire). Together the two considerably outnumbered Marlborough (90,000 against 50,000), but the duke managed to be first in the field. After capturing Bonn in May, Marlborough's plan was to break the immensely long line of defence of the French and Spaniards by the capture of Antwerp. One Dutch corps under Coehoorn was to assemble in the Sluys-Hulst region, and another under Opdam at Bergen-op-Zoom while Marlborough, after manoeuvring Villeroy's field army out of the way, was to join them before the fortress. Marlborough executed his own share of the movement with his usual skill, but the Dutch generals enabled the French to emerge from the manoeuvre with a handsome victory. Great projects were now entertained by the French, nothing less than the capture of Vienna by a Franco-Bavarian-Hungarian army being the intention. The elector of Bavaria insisted that Villars should cross the Black Forest and join him, which Villars was unwilling to do thus early in the year, as two-thirds of his officers were as usual on leave or detached on recruiting duties. Courtier though he was, the marshal would not stir even in spite of the king's orders until he was ready. At the end of April, leaving Tallard alone to defend Alsace against the margrave of Baden, Villars plunged into the defiles of the Black Forest and on May 8 joined the elector at Ebingen. All seemed favourable for the advance on Vienna, but at the last moment the elector half repented of his alliance with the enemies of Germany and proposed instead a junction with Vendôme in Italy by way of Tirol. This proposal came to nothing, the Tirolese were soon roused to revolt by the misconduct of the ill-disciplined Bavarians, and Vendôme, who, like Luxembourg, was a giant in battle and a sluggard in camp, would not stir.

Hochstett, 1703.—Villars had posted a protective force at Ulm to contain the Margrave's army should it turn back upon him, and this, after an engagement at Munderkingen (July 31) induced the cautious Louis to return to the Rhine. Five weeks later, however, the Margrave returned in full force, and moving by the right bank of the Danube reached Augsburg on Sept. 6. The elector, returning from his futile Tirol expedition, had already rejoined Villars at Dillingen, and the marshal persuaded him to attack the Austrian army that covered Vienna before the two imperial generals could join forces. The result was the battle of Hochstett (Sept. 20) in which the elector and Villars won a great victory, at a loss of only 1,000 men to the enemy's 11,000. Rarely indeed had an 18th-century general so great an opportunity of finishing a war at one blow. But even Villars saw no better use for the victory than the unimpeded junction of his own army and Tallard's and winter quarters in Württemberg. But Tallard remained on the Rhine, and Villars in disgust applied to be recalled. The Margrave, entrenched as usual, kept the field for another month and then retired to the Lake of Constance, where, in a still unexhausted district, he spent the winter. Tallard meanwhile invested Landau which surrendered on Nov. 12. Old Breisach, besieged by Vauban, capitulated on Sept. 6. Thus in Germany, though the grand advance on Vienna had come to nothing, the French had won important successes and established an army in Bavaria. In Italy, on the other hand, Vendôme, although no longer opposed by Eugene, achieved nothing.

Rhine and Danube Campaign, 1704.—The campaign of 1704, though in the Low Countries and in Italy practically nothing was done, is memorable for what was perhaps the greatest strategical operation in the 18th century, Marlborough's march to the Danube. At the outset the elector and Marsin (Villars' successor) were on the Iller, between Ulm and Memmingen, Tallard between Strasbourg and Landau, Villeroy as usual between the Brabant lines and the Meuse. On the other side the Margrave Louis was in the Stockach-Engen region. Responsible for guarding the whole of the Middle Rhine as well as for opposing the elector he was weak everywhere, and his defence of the Rhine was practically limited to holding the "lines of Stollhofen," a defensive position near Bühl in Baden. With Breisach and Kehl in their own hands, the French were more or less closely in touch with their comrades in Bavaria, and Tallard convoyed a large body of recruits for Marsin's army through the Black Forest defiles. But in doing so he lost most of them by desertion, the Margrave's army dogged his march, and in fact no regular line of communication was established. Marlborough's purpose at any rate was quite definite—to transfer a large corps from the Low Countries to Bavaria and there in concert with the allies in that quarter to crush the elector decisively, but rather than be burdened with Dutch counsellors he chose to forgo the assistance of the Dutch troops. These were left under Overkirk to defend the Meuse, and English and English-paid troops alone took part in the venture.

Marlborough's March to the Danube.—Marlborough calculated that as he progressed up the Rhine the French would collect to prevent his crossing, instead of themselves passing over to join the elector and Marsin. Thus the expedition would reach the Neckar mouth, without its true purpose being suspected, and once there Marlborough would vanish from the ken of the defenders of the Rhine, to reappear on the Danube where he was least expected. On May 12 the army crossed the Meuse at Ruremond, on the 23rd it reached Bonn, on the 29th Mainz. On June 1 the puzzled French noted preparations for bridging the Rhine at Philipsburg. But two days later the English had turned to their left into the valley of the Neckar. On June 10 Prince Eugene and on the 13th the Margrave appeared at the duke's headquarters to concert operations. It was arranged that the margrave was to join Marlborough and that Eugene should command the Stollhofen and other forces on the Rhine, for Tallard, it seemed, was about to be joined by Villeroy[1] and Marlborough knew that these marshals must be kept west of the Rhine for the six weeks he allowed himself for the Bavarian enterprise. The Margrave's army duly joined Marlborough's on June 22 at Ursprung, 12 m. north of Ulm, where the elector and Marsin were encamped. The endurance of Marlborough's corps, as displayed in the long march from Ruremond, was not the least extraordinary feature of the operation. For 18th-century troops such performances were generally provocative of desertion, and involved the ruin of the army that attempted it. But Prince Eugene, we are told, was astonished at the fine condition of the army. On the French side meantime all was perplexity, and it was not until a week after the Margrave and Marlborough had joined, that Villeroy's main body from the Meuse started for Alsace to watch Eugene's corps, or rather the Stollhofen-Buhl position. This meant conceding both the initiative and the superiority in numbers to Marlborough.

Campaign on the Danube, 1704.—The duke had now manoeuvred himself with brilliant success from one theatre of war to another, and had secured every advantage to himself. From before Ulm he sidled gradually along the north side of the Danube in the hope of finding an unguarded passage. He and the Margrave exercised the general command on alternate days, and when on his own day he arrived opposite Donauwörth, knowing Louis's caution, he thought that direct attack was better than another two days' extension to the east. Moreover he needed a walled town to serve as a magazine. In the late afternoon of July 2 the army was flung, regardless of losses, against the entrenched hill of the Schellenberg at Donauwörth, where the elector had posted a strong detachment. The attack cost 6,000 men, but it was successful, and of the 12,000 Bavarians on the hill only 3,000 returned to their main body, which had now moved from Ulm to Lauingen. Passing the river, the allies besieged and took the small fortress of Rain, and thence moved to the neighbourhood of Augsburg, thoroughly and deliberately devastating the countryside so as to force the elector to make terms. The best that can be said of this barbarous device, is that Louis XVI. had several times practised it. Its most effective condemnation is that military devastations, in these purely political contests, were entirely unprofitable. Louis had already found them so, and had given up the practice. In the present case Marlborough's own supplies ran short, and his convoys were harassed. The movements of the two armies were but trifling. Marlborough, though superior, was not decisively superior, and his opponents, well entrenched near Augsburg, waited for Tallard and (in vain) for Villeroy. Marlborough marked time until Eugene should join him.

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[1] Even Villeroy it appears rose to the situation thus far, but the king only allowed him to send 25,000 men to Tallard.

There were now five armies in the field, two allied and three French. The centre of gravity was therefore in Villeroy's camp. If that marshal followed Tallard, even Eugene's junction with Marlborough would not give the latter enough force. If Tallard alone joined the elector and Eugene Marlborough, the game was in the hands of the allies. But none of the possible combinations of two armies against one were attempted by either side. Eugene when informed that Tallard was on the move slipped away from Villeroy to join Marlborough. Tallard and the elector, aware of Eugene's march, were content to join forces peaceably at Augsburg. Villeroy, in whose hands was the key of the situation, hesitated and finally tried in vain to detain Eugene (who was already far away) in the Stollhofen lines. The last stage of the campaign was brief. Marlborough and Eugene had in mind a battle, Tallard and Marsin a war of manoeuvre to occupy the few weeks now to be spun out before winter quarters were due. The two allied armies met in the Danube valley on Aug. 6. If the enemy remained on the south side Eugene was to cross, if they recrossed to the north bank Marlborough was to follow suit. The margrave Louis of Baden had been sent off to besiege Ingolstadt as soon as Eugene had come within a safe distance. When therefore the French and Bavarians were reported opposite Eugene on the north side, Marlborough crossed at once, and without waiting for the margrave the two great soldiers went forward. On Aug. 2 (*see* BLENHEIM) they attacked and practically destroyed the armies of Tallard, Marsin and the elector.

Campaign of 1705.—The campaign of 1705 was uneventful and of little profit to either side. Marlborough's army had returned to the Low Countries. Villeroy had also returned to Brabant and retaken Huy. With him was the now exiled elector of Bavaria. On July 18, after a series of skilful manoeuvres, Marlborough forced the lines of Brabant at Elissem near Tirlemont, but not even the glory of Blenheim could induce the Dutch deputies to give him a free hand, or the Dutch generals to fall in with his schemes. King Louis was thus able to reinforce Villeroy betimes from Villars's Lorraine army, and the campaign closed with no better work than the razing of the captured French entrenchments. On the Rhine Villars, with a force reduced to impotence, carried on a spiritless campaign against the Margrave Louis. In Italy there was serious fighting. Here Vendôme's army engaged in the attempt to subdue Victor Amadeus of Savoy and was so far successful that the duke implored the emperor for aid. Eugene was sent with new reinforcements, opposed to which was a force under Vendôme's brother Philippe, called the Grand Prior. This man, a lazy dilettante, let himself be surprised by Eugene's fierce attack on the line of the Adda. The day was restored however, and the Austrians beaten off, thanks to Vendôme's opportune arrival and dauntless courage (battle of Cassano, August 16). Nevertheless, the subjugation of Piedmont was put off until the next year.

Ramillies, 1706.—1706 was a bad year for the French. At the very outset of the campaign in the Netherlands, Villeroy, hearing that some of the allied contingents that composed Marlborough's army had refused to join, ventured out from his new defensive lines along the Dyle and moved towards Namur. Marlborough hurried forward to intercept him before he could reach the shelter of the Meuse fortresses and was able (May 12) not only to win but also to profit by the glorious victory of Ramillies (*q.v.*) on the 12th of May.

In Italy the campaign had, as before, two branches, the contest for Piedmont and the contest between the French forces in Lombardy and the Austrian second army that sought to join Victor Amadeus and Starhemberg. The latter, repulsed by Vendôme at Cassano, had retired to Brescia and Lake Garda, Vendôme followed, and in April 1706, profiting by Eugene's temporary absence, attacked the Imperialists' camps. His onset broke up the defence completely (battle of Calcinato, April 19), and he hustled the fragments of the Imperialist army back into the mountains, where Eugene had the greatest difficulty in rallying them. Until the middle of June Vendôme completely baffled all attempts of Eugene to slip past him into Piedmont. He was then, however, recalled to supersede Villeroy in Belgium, and his feeble successor entirely failed to rise to the occasion. Philip of Orleans, with Marsin, was besieging Turin. As soon as he knew of Vendôme's departure Prince Eugene emerged afresh from the mountains, and, out-manoeuvring the French in Lombardy, hurried towards Turin. Victor Amadeus, leaving the defence to the Austrian and Piedmontese infantry, escaped through the besiegers' lines and joined his cousin with a large force of cavalry. On Sept. 7 they attacked the French lines round Turin. Owing to the disagreements of their generals, the various corps of the defenders, though superior in total numbers, were beaten in detail. Marsin was killed and Orleans retreated ignominiously to Pinerolo. The battle of Turin practically ended the war in Italy.

Both in the north and in the south the tide had now receded to the frontiers of France itself. But it is from this very point that the French operations cease (though only gradually it is true) to be the ill-defined and badly-joined patchwork of forays and cordons that they had hitherto been. In the place of Tallards, Marsins and Villeroys Louis made up his mind to put his Villars, Vendômes and Berwicks, and above all the approach of the allied armies roused in the French nation itself a spirit of national defence which bears at least a faint resemblance to the great uprisings of 1792. For the gathering of this unexpected moral force 1707 afforded a year of respite. Marshal Tessé formed a strong army for the defence of the Alpine frontier. In Germany Villars not only pricked the bubble reputation of the lines of Stollhofen, but raided into Bavaria, penetrating as far as Blenheim battlefield before he gave up the attempt to rouse the Bavarians again. The Imperialists and Piedmontese in the south succeeded in turning the Alpine barrier, but they were brought to a complete standstill by Tessé's gallant defence of Toulon (August) and finally retired over the mountains. In Belgium the elector of Bavaria, who was viceroy there for King Philip, and was seconded by Vendôme, remained quiescent about Mons and Gembloux, while Marlborough, paralysed more completely than ever before by the Dutch, spent the summer inactive in camp on the Gheete.

Campaign of 1708.—In 1708 Eugene foresaw this shift of the centre of gravity and arranged with Marlborough to transfer his army which was ostensibly destined for the Rhine campaign to Brabant, since the French was markedly superior in numbers to Marlborough's and hardly inferior to Marlborough's and Eugene's combined. King Louis had put his young grandson and heir, the duke of Burgundy, at the head of the great army which assembled at Valenciennes, and gave him Vendôme as mentor. But the prince was pious, mild-mannered, unambitious of military glory and also obstinate, and to unite him with the fiery, loose-living and daring Vendôme, was, as Saint-Simon says, "mixing fire and water." At the end of May Vendôme advanced to engage Marlborough before Eugene should join him. As the French came on towards Brussels, Marlborough, who had concentrated at Hal, fell back by a forced march to Louvain. Vendôme having thus won the first move, there was a pause and then the French suddenly swung round to the west, and began to overrun Flanders, where their agents had already won over many of the officials who had been installed by the allies since 1706. Ghent and Bruges surrendered at once, and to regain for King Philip all the country west of the Scheldt it only remained to take Oudenarde. On the day of the surrender of Ghent Marlborough was moving to interpose himself between the French and their frontier, and one long forced march brought his army almost within striking distance of the enemy. But though Eugene himself had joined him, Eugene's army was still far behind. Vendôme soon moved on Oudenarde. But scarcely had he begun this investment when Marlborough was upon him.

Oudenarde.—The duke discussed the situation with Eugene.

Marlborough was half inclined to wait for Eugene's troops, for he knew that Vendôme was no ordinary opponent, but Eugene counselled immediate action lest the French should escape, and relying on his own skill and on the well-known disunion in the French headquarters, Marlborough went forward. As he approached, the enemy gave up the siege of Oudenarde and took up a position at Gavre, 7 m. lower down the Scheldt. Here the dissensions in the French headquarters became flagrant. Vendôme began to place part of the army in position along the river while the duke of Burgundy was posting the rest much farther back as another line of defence. The allied main body, marching with all speed, crossed the Scheldt at all hazards. In the encounter-battle which followed (*see* OUDENARDE) Marlborough separated, cut off and destroyed the French right wing. The French retreated in disorder on Ghent (July 11) with a loss of 15,000 men. Marlborough was prevented from carrying out his desire for a prompt move on Paris after Oudenarde. For the moment Berwick, recalled from Alsace, manoeuvred about Douay, while Vendôme remained near Ghent, and between them Marlborough's and Eugene's armies devoted themselves to the siege of Lille. In this town, one of Vauban's masterpieces of fortification, the old Marshal Boufflers had undertaken the defence, and it offered a long and unusually gallant resistance to Eugene's army. Marlborough covered the siege. The French generals limited their efforts first to attempting to intercept a huge convoy of artillery and stores that the allies brought up from Brussels for the siege, and secondly to destroy another convoy that was brought up from Ostend by the General Webb known to readers of *Esmond.* The futile attack upon the second convoy is known as the action of Wynendael (Sept. 28).

On Dec. 8 the brave old marshal surrendered, Eugene complimenting him by allowing him to dictate the terms of capitulation. Ghent and Bruges were retaken by the allies without difficulty, and, to add to the disasters of Oudenarde and Lille, a terrible winter almost completed the ruin of France. In despair Louis negotiated for peace, but the coalition offered such hard terms that not only the king, but his people also, resolved to fight to the end.

1709, Malplaquet.—When spring came round Marlborough proposed to make a daring thrust toward Paris, masking the fortresses, but this scheme was too bold even for Eugene, who preferred to reduce the strong places before going on. Lille having been successfully besieged, Tournai was the next objective, and the allies suddenly and secretly left their camps before Lille as if for an attack on the Douai lines (June 26–27). But before noon on the 27th they had invested Tournai. A few days afterwards their siege guns came up from Menin by water (down the Lys and up the Scheldt) and the siege was pressed with intense vigour. But it was Sept. 3 before the citadel capitulated. Then Marlborough, free to move again, transferred his army secretly and by degrees to the river Haine, and burst through the French lines almost unopposed. Mons was weakly held, and Marlborough hoped by the rapidity of his operations to take it before Villars could interrupt him. But Villars also moved quickly, and his eager army was roused to enthusiasm by the arrival of Boufflers, who, senior as he was to Villars, had come forward again at the moment of danger to serve as his second in command. Thinking that the allies were somewhat farther to the east than they were in fact, the French marshal marched secretly, screened by the broken and wooded ground, to the south of the fortress, and occupied the gap of Aulnois-Malplaquet (Sept. 9) to work feverishly to entrench himself. Marlborough at once giving up the siege of Mons brought his army forward to attack as rapidly as his brigades came on the scene. At this crisis the duke submitted the question of battle—unwillingly, as one may imagine—to a council of war, and Eugene himself was opposed to fighting an improvised battle when so much was at stake, and it was not until the 11th that the duke delivered his attack on the now thoroughly entrenched position of the French. The battle of Malplaquet (*q.v.*) was by far the most desperately contested of the war. In the end Boufflers, who took command when Villars was wounded, acknowledged defeat and drew off in good order. Eugene was wounded, and Marlborough, after the most terrible experience in any soldier's lifetime, had only enough energy remaining to take Mons before he retired into winter quarters. The loss of the French is given variously as 7,000 and 12,000. The allies sacrificed no less, probably more, than 20,000 men.

Campaign of 1710.—In 1710 Villars lay entrenched behind a new series of lines, which he called *Ne plus ultra* and which extended from Valenciennes to the sea. Marlborough made no attempt to invade France from the side of Mons, for Villars at the head of the army which had been through the ordeal of Malplaquet was too terrible an opponent to pass by with impunity. In England, too, the anti-Marlborough party was gaining the upper hand in the queen's council. So Marlborough took no risks, and returning to the Lille side, captured Douai (June 26) and Béthune (Aug. 26). No attack was attempted upon the lines. In Dauphiné, Berwick repulsed the Austrians and Piedmontese.

The year 1711 was Marlborough's last campaign, and it was remarkable for the capture of the *Ne plus ultra* lines by manoeuvres that must be recorded as being the *ne plus ultra* of the 18th century way of making war by stratagem. In May the sudden death of the emperor completely altered the political outlook, for his successor Charles was the coalition's claimant to the throne of Spain, and those who were fighting for the "Balance of Power" could no more tolerate a new Charles V. than they could see Louis XIV. become a Charlemagne.

In accordance with a strategic policy of passive endurance the marshal Villars remained on the defensive behind his lines, and Marlborough determined to dislodge him. What force could not achieve, the duke trusted to obtain by ruse. The lines extended from the sea along the Canche, thence to Arras, and along the Sensée to Bouchain on the Scheldt. As the western part of the lines, besides being strong, were worthless from the invaders' point of view because their capture could not lead to anything, Marlborough determined to pass the barrier between Arras and Bouchain. On July 6 Marlborough marched away to the west, as if to attack the lines between Arras and the headwaters of the Canche. Villars followed suit. The plot of the comedy now thickened. Marlborough lost his usual serenity, and behaved in so eccentric a manner that his own army thought him mad. He sent off one part of his forces to Béthune, another back to Douai, and ordered the small remainder to attack the lines between the Canche and Arras, where, as every one knew, Villars's whole army was massed. In the night of Aug. 4–5 the main army slipped off westward, at the highest possible speed. The Scarpe was crossed and then the pace was increased, though thousands of the infantry fell out and scores died from exhaustion. Five hours ahead of the French army the allies crossed the great lines unresisted. The troops concentrated at Cambrai when Marlborough, declining Villars's offer of a battle, manoeuvred still farther to the east and invested Bouchain. The siege, covered by a strong "line of circumvallation" which Villars did not attempt to attack, ended with the surrender of the place on Sept. 13, and so terminated a series of manoeuvres so extraordinary as to be almost incredible. In December Marlborough was dismissed the service in disgrace.

But Holland and Austria determined to make one last effort to impose their own terms on Louis. Eugene's army, which had been used in 1711 to influence the imperial election instead of to beat Villars, was brought back to the Low Countries. Reading the meaning of Marlborough's fall, he quietly made preparations to take over the various allied contingents into Imperial or Dutch pay. So when England seceded, Ormonde only marched away with 12,000 sullen men, while 100,000 remained with the prince.

Misfortunes at Versailles helped Eugene in his first operations, for two successive heirs apparent to the crown died within a month and all was in confusion, not to speak of the terrible misery that prevailed in the country. But the old king's courage rose with the danger and he told Villars that if the army were beaten he would himself join it and share in its fate. Villars, though suffering still from his Malplaquet wound, took command on April 20, and spun out time on the defensive until the end of May, when Ormonde's contingent withdrew. Eugene, as the defection of England had made further operations near the sea unprofitable, took Le Quesnoy (July 4) and moved thence on to Landrecies, which was closely invested. Then followed the last serious fight of the war, the battle of Denain, which saved the French monarchy and completed the disintegration of the coalition.

Denain.—In order to protect his camps around Landrecies, Prince Eugene constructed the usual lines of circumvallation with such speed that Villars, on coming up, found that they were too formidable to attack. Villars anxiously looked out for an opportunity of breaking through. At Denain, the besiegers' route crossed the Scheldt and he resolved to attack them there. The enterprise, like Marlborough's forcing of the *Ne plus ultra* lines, involved an extraordinary combination of force and fraud—for the point of attack was far away and the opposing army almost within cannon-shot. Some days were spent by Villars in deceiving Eugene and his own army as well, as to his real intentions. Then on the night of July 23 the French army moved off silently, and by 9 A.M. on the 24th had completely deployed on the north bank of the Scheldt. Eugene galloped away to bring up his army from Landrecies. But, long before it arrived, Villars's troops stormed the lines. A mass of Dutch troops—spiritless since Malplaquet—were huddled into the narrow avenue between the two entrenchments and forced back against a broken bridge. Their generals were taken. The broken mob of fugitives tamely surrendered. Eugene arrived on the other bank with some brigades of the imperial infantry, but failed to reopen the passage. Villars followed up his victory at once, capturing Marchiennes and St. Amand, and in these places all Eugene's reserve stores, pontoons and guns. On Aug. 2 Eugene broke up the siege of Landrecies and retreated by a roundabout route to Mons, while Villars's lieutenants retook Douai and Bouchain (September–October). Before the next campaign opened the treaty of Utrecht had been signed, and although the emperor continued the struggle alone for another year, the enfeebled combatants were content to accept Villars's captures of Landau (July 22, 1713) and Freiburg (Nov. 21) as decisive. The treaty of Rastatt, between Austria and France, was signed on March 7, 1714, Eugene and Villars being the negotiators.

See J. W. Fortescue, *Hist. British Army*, vol. i. (London, 1899); lives of Marlborough (especially Frank Taylor's); the Austrian official *Feldzüge des Prinzen Eugen* (Vienna, 1871–1892); Roder v. Diersburg's *Markgraf Ludwig von Baden* (Karlsruhe, 1850); Arneth's *Prinz Eugen; Mémoires militaires relatifs à la succession d'Espagne* (1835; ed. De Vault); detailed histories of the French army, and monographs in the French general staff's *Revue d'histoire*. (X.)

NAVAL OPERATIONS AND MILITARY OPERATIONS IN SPAIN

The great campaigns fought in the Rhine delta and in North Italy, often tend to obscure the fact that the principal objective of both sides during the war was Spain. The French could reach the theatre of operations quite easily by land, but the Austrian Imperialists had to rely entirely on Anglo-Dutch fleets to make their efforts effective. On the formation of the Grand Alliance, considerable difference of opinion arose as to how the English fleet should be used, William III. and Marlborough being in favour of a concentration in the Mediterranean, while many of the sailors advocated oceanic operations on the Atlantic coast of Spain and Portugal, and on the east coast of America.

Allied Victory at Cadiz.—Admiral Sir George Rooke was put in command of the combined fleet, consisting of 30 English ships of the line, and 20 Dutch under Admiral van Almonde, and carrying 13,000 English and Dutch troops under the Duke of Ormonde. Rooke was instructed to seize Cadiz as a base for future operations in the Mediterranean. Inevitable complications, however, arose. It was judged inexpedient to compel the Spaniards to acknowledge the Archduke Charles as their rightful king, by means of a bombardment, and they, being not unnaturally somewhat backward in receiving the candidature of an Austrian Prince, lent no support to the Anglo-Dutch arms. Consequently the attempt on Cadiz could not be pushed too vigorously and may be said to have failed. Rooke was already steering north again when he learnt that the Spanish treasure fleet had entered Vigo Bay, protected by Admiral Châteaurenault with a French squadron. The Allies at once determined to prevent the French obtaining the treasure by capturing it themselves, and, entering the bay, Ormonde's troops were landed to attack the forts, while Rooke pushed forward a special advance squadron and forced the boom which the French had laid across the entrance to the inner harbour (Oct. 12, 1702). In the furious engagement which followed, Rooke sank and captured the 24 French warships and the 17 Spanish galleons, and recovered bullion worth two million pounds.

Portugal Joins Allies.—In 1703 Portugal joined the Allies so that Lisbon could be used as a naval base, but Admiral Clowdisley Shovell was sent to the Mediterranean too late to achieve any object, and many of his ships on their return were destroyed in the Channel during the great storm of Nov. 27. Great efforts were made in 1704 to bring about something decisive. Rooke sailed in February and landed the Archduke Charles at Lisbon, together with 2,000 English and Dutch troops to co-operate with the Portuguese in an invasion of Spain.

Rooke carried his fleet through the Straits, hoping to be able to make an attack on Toulon in concert with the duke of Savoy, who had recently joined the alliance. This, in conjunction with Marlborough's march across Germany to Blenheim, would have been a fine counterstroke to the French thrust at Vienna, but as often happened afterwards, Savoy failed to co-operate. An attempt was made to win over Barcelona to the archduke's cause, but the governor refused to admit the allied forces. Meanwhile, the Comte de Toulouse succeeded in bringing the French Brest fleet into the Mediterranean and though Rooke sighted him, his ships were too foul to catch the French, who entered Toulon unopposed, and so united their principal Atlantic and Mediterranean forces. Rooke therefore passed the Straits and met Shovell and the Dutch between Cape St. Vincent and Cadiz, and then reentered the Mediterranean to watch for the French.

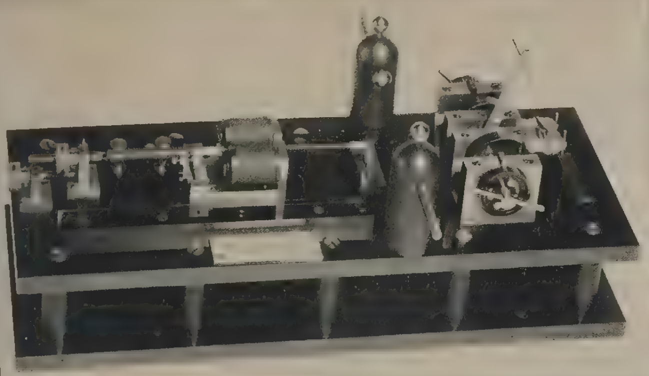
Gibraltar Taken by Allies.—At this juncture the allied leaders took the memorable decision to capture Gibraltar and so advance their sphere of activity 300 miles beyond Lisbon. After lengthy preparations the attack was begun by Admiral George Byng, who bombarded the fortress with a special squadron on July 23 (1704), while Prince George of Hesse-Darmstadt, the Imperial representative, landed 1,800 English marines and cut off the fortress on the land side. Gibraltar being only weakly held, an attacking force was soon landed from the ships, and the place surrendered next day.

Hardly was this great success achieved than Toulouse was reported sailing south-west to recapture the fortress. Rooke left Prince George and 900 marines in Gibraltar and went in search of Toulouse, having had to spend some time watering his fleet at Tetuan. On Aug. 9 the fleets were in sight of each other, but the French retreated and then attempted to double back again close inshore. Rooke, however, sighted them slipping past and brought them to action off Malaga on Aug. 13, each side having about 50 ships of the line. The French were decisively beaten.

The allies returned to Lisbon to refit, leaving Prince George with all the marines and some ships, guns and stores to defend Gibraltar. He was soon attacked by land and sea in overwhelming force, but was relieved by Admiral Leake, who arrived from Lisbon where he had been left in command by Rooke, who had gone home. Entering the bay on Oct. 25, the day on which the final attack was to take place, he destroyed the French flotilla, enfiladed the Franco-Spanish entrenchments on shore, and revictualled and reinforced the garrison. The French now sent Marshal Tessé with a siege train to command the attack by land, and Prince George was again hard pressed, but Leake again reinforced and revictualled him in December. At last, on March 10, 1705, Leake destroyed de Pointis' force at Marbella, and Tessé raised the siege.

Allies Invade Spain.—The Allies now took the offensive, Shovell and Lord Peterborough coming out from England as joint commanders. Picking up Leake at Lisbon and Prince George at Gibraltar, they sailed to Barcelona and besieged it. It was finally captured and occupied on Oct. 3, 1705, but Prince George was killed during the assault. Philip, the Bourbon candidate, hurried to Catalonia with Marshal Tessé to recapture it, and a squadron put out from Toulon. Leake, however, was able to foil all the French efforts and forced them to raise the siege on April 30, 1706.

SPARK PHOTOGRAPHY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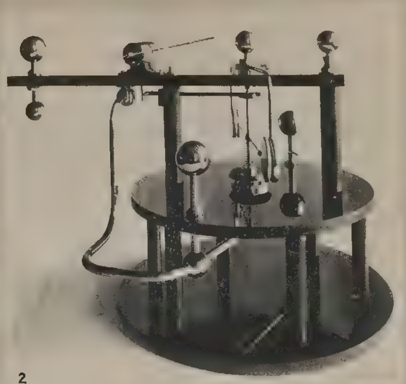
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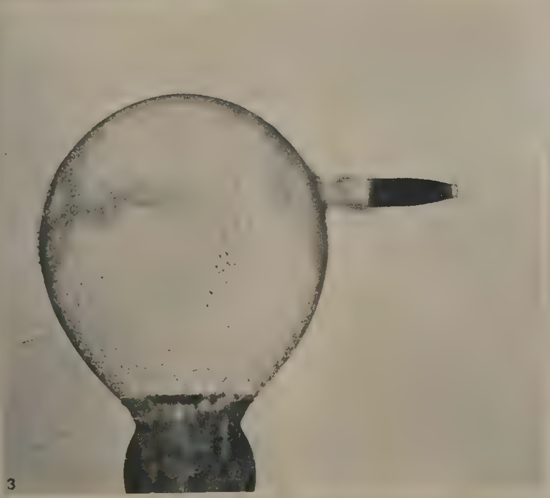
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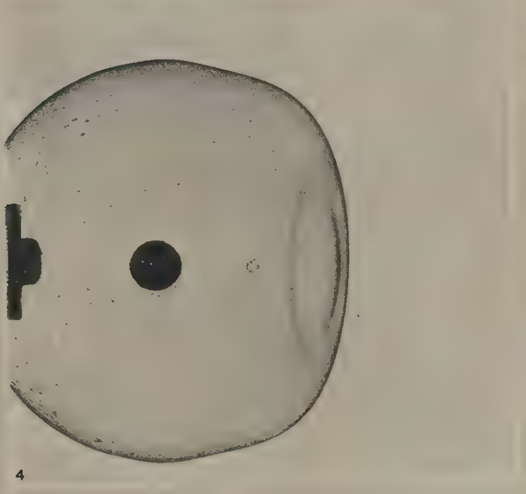
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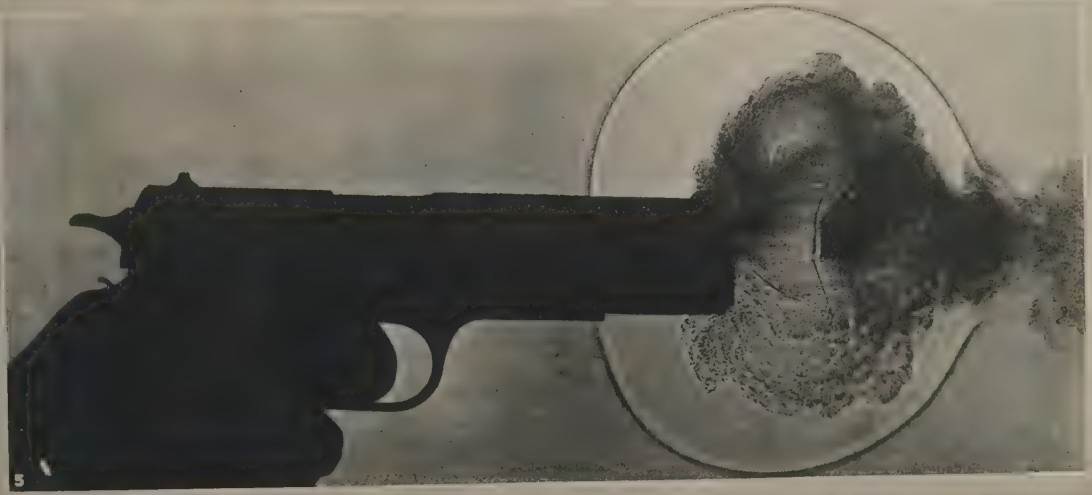
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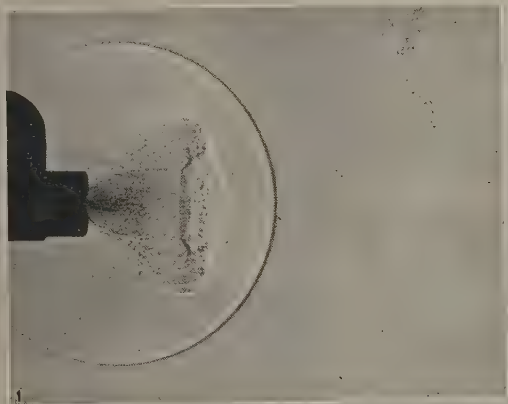
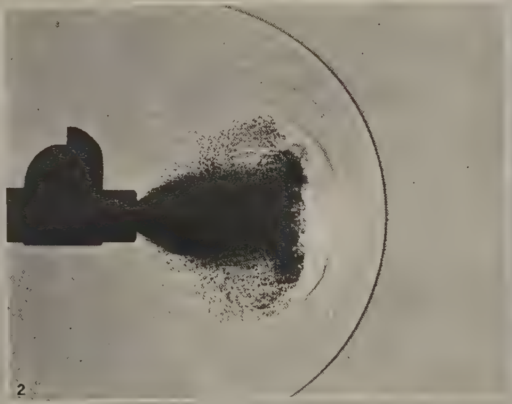
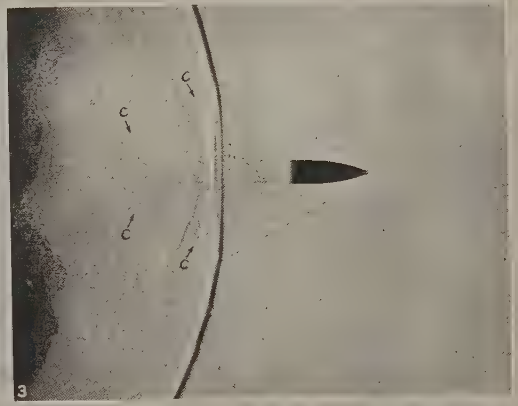
BY COURTESY OF PHILIP P. QUAYLE

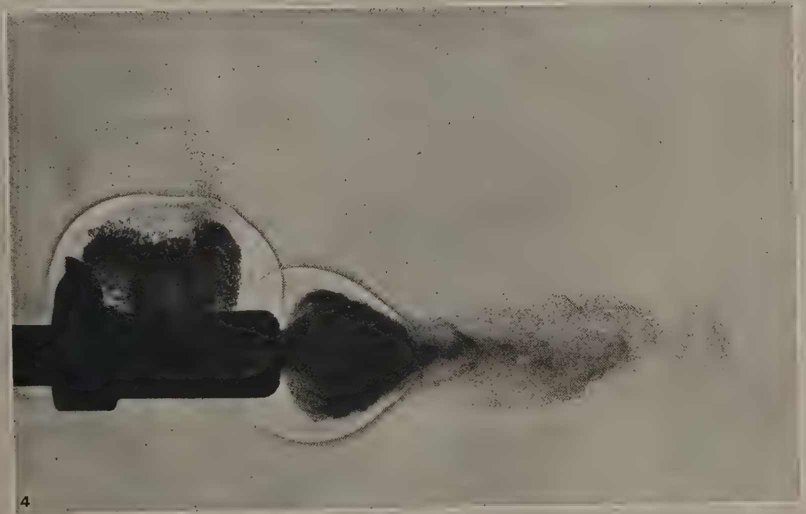
APPARATUS AND EXAMPLES OF SPARK PHOTOGRAPHY

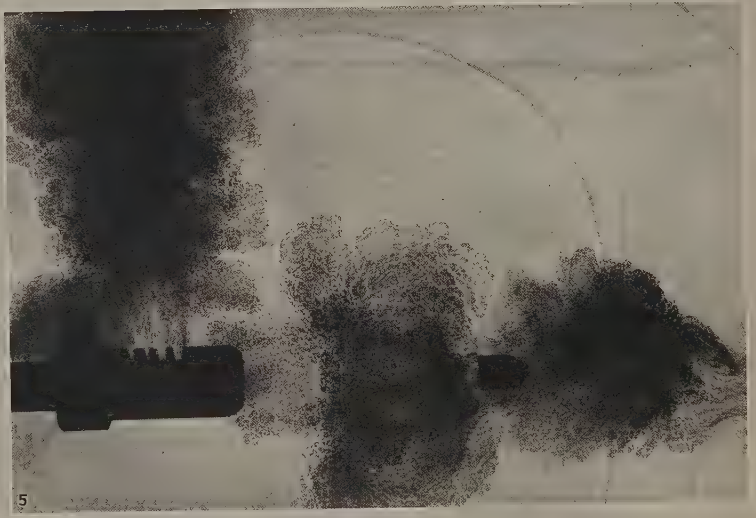
1. Quayle Spark Switch for spark photography. Electric spark provides illumination of such short duration that rapidly moving objects appear stationary. 2. Delicate apparatus in Quayle Spark Switch: 80 consecutive shot shells have been photographed in one lot. 3. Modified .30 calibre bullet after passing through a soap bubble filled with a mixture of hydrogen and air which produces distortion. 4. Steel ball after falling into soap bubble which closed after it. 5. Automatic pistol with gases and bullet issuing from muzzle











BY COURTESY OF PHILIP P. QUAYLE

PICTURES TAKEN BY SPARK PHOTOGRAPHY

1. Spark photograph of gun muzzle before bullet has emerged
2. Photo of same gun muzzle. Bullet cannot be seen on account of propelling charge
3. Showing the bullet, a .30 calibre Springfield, only 11 in. from the muzzle of the gun, yet it has already outdistanced the outermost effect of the propelling charge
4. Muzzle of a Thompson sub-machine gun fitted with Cutts compensator; bullet and propelling charge emerging from barrel
5. Another view of machine gun. Bullet shown in fig. 4, seen at right between puffs of emerging smoke, some of which escapes through slots in top of compensator attached to muzzle of gun (left)

Leake, who was again left in command of the fleet, made good use of his time by capturing Cartagena (June 1, 1706) and Alicante (Aug. 24, 1706), and then sailing to the Balearic Islands and capturing Mallorca (Majorca) and Iviza in September.

Meanwhile, the allied troops advanced from Portugal and captured Madrid (June 26, 1706) and proclaimed the archduke Charles. The Castilians, however, did not relish invasion by the Portuguese, and being rallied by Berwick, compelled the allies to retreat south-east to Valencia, on the coast.

Closing Operations.—In July and August combined operations were again attempted against Toulon, but again Savoy defaulted, and Shovell, returning with 12 of the line, was wrecked on the Scilly Isles on Oct. 22, 1707, together with several other ships which were lost with all hands. Leake now exercised the permanent command-in-chief and operated in the Mediterranean with great success, reducing Sardinia for the Imperialists in August 1708. In September General Stanhope captured Minorca.

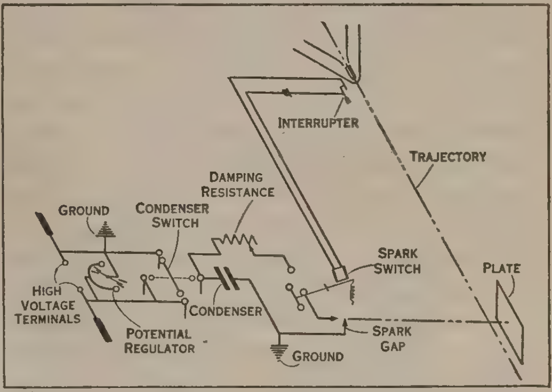
The war in Spain languished owing to the increasing exhaustion of both sides and the apathy of the Spaniards. Stanhope, however, in 1710 persuaded the Imperialist troops to join him in another invasion, and they actually succeeded in bringing the archduke Charles to Madrid. Previous conditions, however, reasserted themselves, and the allies were again driven east to the coast by the duc de Vendôme, the new general of the Franco-Spanish forces. Stanhope was defeated and captured on Dec. 9, 1710 at Brihuego, and the Imperialists were only just able to make good their retreat to Barcelona, which they held till the Peace of Utrecht, though the Catalans themselves heroically defended it against Berwick till Sept. 12, 1714. At sea, Admiral Wager captured a Spanish treasure fleet off Cartagena in May 1708, and Duguay Trouin captured an English convoy off the Lizard on Oct. 20. In 1710 Commodore Martin's squadron, assisted by American Colonists, captured Nova Scotia.

Bibliography.—O. Troude, *Batailles Navales de la France* (1867); J. S. Corbett, *England in the Mediterranean*, 2 vols. (1917); Geoffrey Callender, *Life of Sir John Leake*, 2 vols. Navy Record Society (1920) contains a bibliography. (G. A. R. C.; W. C. B. T.)

SPANNER is a tool for turning nuts, setscrews, coachscrews, spindles, including those of hydrants and valves. The principal forms are the *straight* spanners, single-ended or double-ended, the *angle*, which enables a nut to be turned in a confined space, and the *box* spanners enabling the nut to be readily turned from above or from the side, without slip. Tubular box spanners are light and strong, being suited for portable sets. The *structural* spanner has a long handle terminating in a tapered end. This is used to pull holes into line in erecting bridges and other structures, and when not in use the end is stuck into any convenient hole, ready to hand for the next usage. The *platelayer* or *track* spanner is also very long, but with parallel handle; it gives great power for dealing with fish-plate bolts. The *pin* and the *hook* spanners turn circular nuts, the one with a pin entering a drilled hole on the nut, the other a hook catching in a slot. The *cap wrench* or *axle-spanner* grips on four surfaces of a road wheel nut. A *ratchet* wrench enables nuts to be manipulated with a short stroke of the handle, for rapid working. In big repair shops and the automobile and other factories power-operated spanners are employed for quick loosening and tightening.

SPARK PHOTOGRAPHY, in which the illumination is provided by an electric spark of such short duration that even the most rapidly moving objects appear stationary, has many applications in the investigation of high speed phenomena. The record obtained is not an image, no lens being used, but is simply the silhouette of objects between the light source and the photographic plate. In order to secure a properly timed spark of suitable character there must be available a means of generating electrical energy at very high voltage, a means of storing such energy, apparatus for the regulation of the voltage at the proper time. The manner in which these components are associated is shown in the accompanying diagram.

The operation of the apparatus, which is all set up in a dark room, is as follows: Having put the film or plate in place, the operator sets the spark switch and starts the generator. The condensers, when charged, are automatically disconnected from the generator and a signal light is turned on as soon as the potential across them reaches the magnitude at which the regulator is set to function. The gun is then fired immediately. When the sound wave from the bullet or the propelling charge, according to circumstances, impinges upon the diaphragm of the interrupter, the electric circuit to the spark switch is momentarily opened. The switch arm then closes the so-called trigger gap at such time as the bullet or shot being photographed has arrived in front of the photographic plate. As the trigger gap is closed, the condensers discharge through the trigger gap, spark gap and damping resistance which are all connected in series. If the spark lasts while the bullet moves appreciably blurring will result. Since the spark discharge from a condenser is not of itself of the proper character, the so-called damping resistance is introduced in the spark circuit. In this way a single spark of great brilliance and lasting for only one or two millionths of a second is obtained.



Schematic Wiring Diagram of Spark Photography Apparatus

Some idea of the accuracy of the equipment may be obtained from the fact that as many as 80 consecutive shot shells have been photographed in one lot without a single failure.

Applications to Ballistics.—There is, perhaps, no question in the realm of the ballistics of small arms upon which there has been so great a diversity of opinion as that of acceleration of a projectile after leaving the muzzle of the gun; this effect has been supposed by some authorities to exist "at points from 20 to 30 ft. in advance of the muzzle." Plate II., fig. 3, shows the bullet of a .30 calibre Springfield rifle. In this photograph the bullet is out 11 in. from the muzzle and yet it has already out-distanced the outermost effect of the propelling charge.

No bullet is absolutely gas tight and figures show the gas which has leaked past the bullet while still in the barrel. Plate I., fig. 5, shows the .45 calibre Colt automatic pistol. Similar photographs show that no upward tilting of the muzzle occurs until the bullet is several feet from the muzzle. That is to say the so-called kick in no way affects the accuracy. Plate I., fig. 3 shows a modified .30 calibre bullet after passing through a soap bubble filled with a mixture of hydrogen and air which produces the distortion in the sound waves shown. Plate I., fig. 4 shows a steel ball after falling into a soap bubble which closed after it. Note small bubble between ball and top of film. Plate II., fig. 4 and 5 shows the muzzle of a .45 calibre Thompson sub-machine gun with the Cutt's compensator attached. (P. Q.)

SPARK or SPARKING-PLUG: *see* Internal Combustion Engine and Motor Cars.

SPARKS, JARED (1789–1866), American historian and educator, was born in Willington (Conn.), on May 10, 1789. He made a brilliant record in his studies and after labouring as a carpenter and teaching at a country school he graduated at Harvard in 1815. Private school teaching and a tutorship in mathematics and natural philosophy at Harvard were but incidents in his career. He refused a professorship at Bowdoin college for the pastorate of a Unitarian church in Baltimore. In 1821 he founded

The Unitarian Miscellany, and was chosen chaplain of the national House of Representatives, where he made many influential friends. Probably his natural bent towards writing as well as the state of his health was responsible for his leaving the ministry in 1823 and purchasing the *North American Review,* of which he had been acting editor in 1817–18 and which he edited until 1830. This periodical by good management he made a financial success and the arbiter of literature in New England. But although he founded *The American Almanac and Repository of Useful Knowledge* in 1830, the major portion of his energy after 1826 was devoted to historical scholarship. Born in the shadow of the great figures of the Revolution, he did his most important work in *The Life and Writings of George Washington* (12 vols., 1834–37) and *The Works of Benjamin Franklin; with Notes, and a Life of the Author* (10 vols., 1836–40). Another valuable project was *The Library of American Biography* (first series, 10 vols., 1834–38; second series, 15 vols., 1844–47), which he edited and to which he contributed a number of lives. Of lesser value are the *Life and Travels of John Ledyard* (1828); *The Diplomatic Correspondence of the American Revolution* (12 vols., 1829–30); *The Life of Gouverneur Morris* (3 vols., 1832); and *Correspondence of the American Revolution, being Letters of Eminent Men to George Washington* (1853). The esteem in which he was held in his day is shown not only by the large sale of his works but by his appointment in 1838 to the first American professorship of history at Harvard, and by his election to the presidency of that college in 1849. After his retirement in 1853 he lived quietly in Cambridge until his death on March 14, 1866.

See H. B. Adams, *The Life and Writings of Jared Sparks* (2 vol., 1893) and J. S. Bassett, *The Middle Group of American Historians* (1917).

SPARROW, a word originally meaning any small bird, now restricted to those of the types enumerated below.

(1). The house sparrow (*Passer domesticus*) is "the sparrow" *par excellence.* Thriving best in the neighbourhood of man, this bird is common throughout the northern parts of Europe and Asia and has been introduced into North America (in 1851) and the British colonies.

(2). The tree sparrow, or mountain sparrow (*P. montanus*), both sexes of which resemble the male house sparrow, but are distinguished by the rufous crown and doubly barred wings, is a local species in England. In China, it is abundant and replaces the house sparrow near houses and in towns.

(3). The hedge sparrow or dunnock (*Prunella modularis*), belonging to the thrushes (*q.v.*), is a little brown-backed bird with an iron grey head and neck. It is widely distributed throughout Europe.

(4). The reed-sparrow or reed-bunting is, as the second name implies, a bunting (*q.v.*).

(5). The numerous American sparrows are also buntings (*q.v.*). Among them may be mentioned the song sparrow (*Melospiza melodia*) of which about 20 sub-species are recognized. It has a fine song. The chipping sparrow (*Spizella passerina*) is a confiding, humble little bird, with no great attractions but his manners. The savannah sparrow (*Passerculus sandwichensis*) is abundant in the maritime provinces of Canada, but breeds south to Iowa. The grasshopper sparrow (*Ammodramus savannarum*) is also a common form, but its skulking habits and insect-like notes cause it to be overlooked. The lark sparrow (*Chondestes grammacus*) is common in the Mississippi valley east of the great plains; it has a pleasant if hurried song. The fox-sparrow (*Passerella iliaca*) has also a fine song; it breeds in north Canada and Alaska, wintering from Ohio southward.

SPARTA (Gr. Σπάρτη or Λακεδαίμων), an ancient city in Greece, the capital of Laconia and the most powerful state of the Peloponnese. The city lay at the N. end of the central Laconian plain, on the right bank of the Eurotas, S. of its junction with the Oenus (mod. Kelefína), commanding the only land-routes into Laconia, the Oenus and Eurotas valleys from Arcadia, and the Langáda Pass over Mt. Taygetus from Messenia. At the same time its distance (27 m. from its port, Gythium) made it invulnerable from the sea.

ARCHAEOLOGY

Until 1905 the visible ancient buildings at Sparta were the theatre, the "Tomb of Leonidas," a quadrangular building of immense blocks containing two chambers; the foundation of a bridge over the Eurotas; a curved structure since found to be a Hellenic retaining wall restored in Roman times, and some late Roman fortifications, buildings and mosaic pavements. Inscriptions, sculptures and other objects were collected in the museum, or built into houses or churches. Excavations were carried on near Sparta, on the site of the Amyclaeum (1890 Tsountas, 1904 Furtwängler) at the shrine of Menelaus in Therapne (1833, 1841, Ross; 1889, 1900, Kastriotis) and at the "round building" (1892 and 1893 American School at Athens). But no organized work was tried in Sparta itself.

Systematic exploration, however, began with the excavations of the British School at Athens, at Thalamae, Geronthrae, and Angelona near Monemvasia, in 1904, and at Sparta itself in 1906. A "small circus" described by Leake, was found to be a theatre-like building constructed soon after A.D. 200 round the altar and in front of the temple of Artemis Orthia. Here musical and gymnastic contests took place as well as the famous flogging-ordeal (*diamastigosis*). The temple, of the 2nd century B.C. overlies an older temple of the 6th century, and close beside it were found remains of a yet earlier temple, dating from the 9th or even the 10th century. The votive offerings in clay, amber, bronze, ivory and lead found in profusion within the precinct range from the 9th to the 4th century B.C.; they prove that Sparta reached her artistic zenith in the 7th century and declined in the 6th. In 1907 the sanctuary of Athena "of the Brazen House" (Χαλκίοικος) was found on the Acropolis immediately above the theatre, and though the temple is destroyed, fragments of capitals in Doric style remained; also the longest extant archaic inscription of Laconia, and numerous bronze nails, plates and votive offerings of great interest. The Greek city-wall, built in stages from the 4th to the 2nd century, has a circuit of nearly 6 m. (Polyb. ix. 21). The late Roman wall enclosing the Acropolis, probably dates from the years following the Gothic raid of A.D. 262. A number of points of Spartan topography, have been fixed in accord with the description of Pausanias. In 1910 the town of the "Mycenean" period on the left bank of the Eurotas a little to the S.E. was found to be roughly triangular, with an area approximately equal to that of Sparta, but nothing is left but foundations and potsherds. More recently, excavation of the theatre has yielded, besides inscriptions and small objects, a remarkable fifth century statue of a warrior.

HISTORY

Prehistoric Period.—Tradition relates that Sparta was founded by Lacedaemon, son of Zeus and Taygete. But Amyclae and Therapne (Therapnae) were in early times of greater importance than Sparta, the former a Minyan foundation a few miles to the south of Sparta, the latter the Achaean capital of Laconia and the seat of Menelaus. Eighty years after the Trojan War, according to the traditional chronology, the Dorian migration took place (*see* GREECE; *History* [*Ancient*]). A band of Dorians (*q.v.*) united with a body of Aetolians to cross the Corinthian Gulf and invade the Peloponnese from the north-west. The Aetolians settled in Elis, the Dorians pushed up to the headwaters of the Alpheus, where they divided into two forces, one of which, under Cresphontes, subdued Messenia, while the other, led by Aristodemus, made its way down the Eurotas valley and gained Sparta, which became the Dorian capital of Laconia. In reality this Dorian immigration probably consisted of a series of inroads and settlements rather than a single expedition. The newly founded state did not at once become powerful: the turning-point is marked by the legislation of Lycurgus (*q.v.*), who instituted that training which was its distinguishing feature and the source of its greatness. Nowhere else was the individual so thoroughly subordinated to the interest of the state. The whole education of the Spartan was designed to make him an efficient soldier. Obedience, endurance, military success—these were the aims constantly kept in view, and all other ends took a secondary place.

The Expansion of Sparta.—The first step, in the reign of

Archelaus and Charillus, was to secure the upper Eurotas valley, conquering the border territory of Aegys. Archelaus's son Teleclus is said to have taken Amyclae, Pharis and Geronthrae, mastering the central Laconian plain and the eastern plateau between the Eurotas and Mt. Parnon; his son, Alcamenes, by the subjugation of Helos, brought the lower Eurotas plain under Spartan rule. About this time, the Argives, whose territory included the whole east coast of the Peloponnese and the island of Cythera (Herod. i. 82), were driven back, and the whole of Laconia was incorporated in the Spartan state. Under Alcamenes and Theopompus a war broke out between the Spartans and the Messenians, which, after 20 years, ended in the capture of Ithome and the subjection of the Messenians, who were forced to pay half the produce of the soil as tribute. An attempt to throw off the yoke resulted in a second war, conducted by the Messenian hero Aristomenes (*q.v.*); but Spartan tenacity prevailed, and Messenia was made Spartan territory, its people being reduced to the status of helots (*q.v.*).

This extension of Sparta's territory was viewed with apprehension by her neighbours in the Peloponnese. Arcadia and Argos had vigorously aided the Messenians in their two struggles; only the Corinthians supported the Spartans, doubtless through jealousy of their neighbours, the Argives. At the close of the second Messenian War (*c.* 631 B.C.) no power could hope to cope with that of Sparta save Arcadia and Argos. In the 6th century Sparta made a vigorous attack on Tegea, the most powerful of the Arcadian cities, but it was not until the middle of the century that Tegea was forced to acknowledge Spartan overlordship, though retaining its independence. The final struggle for Peloponnesian supremacy was with Argos; but Argos was now no longer at the height of its power; it could not count on the assistance of Arcadia and Messenia, since the latter had been crushed and the former had acknowledged Spartan supremacy. A victory, won about 546 B.C., made the Spartans masters of the Cynuria, the borderland between Laconia and Argolis. The final blow was struck by King Cleomenes I. (*q.v.*), and left Sparta without a rival in the Peloponnese. By the middle of the 6th century, Sparta had come to be acknowledged as the leading state of Hellas and the champion of Hellenism. Croesus of Lydia had formed an alliance with her; to her the Greeks of Asia Minor appealed to withstand the Persian advance and to aid the Ionian revolt; Plataea asked for her protection; and at the time of the Persian invasion under Xerxes (*see* GRAECO-PERSIAN WARS) no state questioned her right to lead the Greek forces on land and sea. Of such a position Sparta proved herself unworthy. She could never rid herself of her Peloponnesian outlook sufficiently to throw herself heartily into the affairs of the greater Hellas. She was not a colonizing State, and had no share in the expansion of Greek commerce and Greek culture. Her military greatness formed her sole claim to lead the Greek race; that she should truly represent it was impossible.

Constitution.—Of the internal development of Sparta down to this time but little is recorded. This was attributed to the stability of the Spartan constitution, but it is, in fact, due also to the absence of historical literature at Sparta, to the small part played by written laws, expressly prohibited by an ordinance of Lycurgus, and to the secrecy of oligarchical rule. At the head of the state stood two hereditary kings, of the Agiad and Eurypontid families, equal in authority, though the Agiad king received greater honour in virtue of the seniority of his family (Herod. vi. 51, 52). This dual kingship was explained by the tradition that on Aristodemus's death he had been succeeded by his twin sons. Aristotle describes the kingship at Sparta as "a kind of unlimited and perpetual generalship" (*Pol.* iii. 1285*a*). Here also, however, the royal prerogatives were curtailed; the king lost the right of declaring war, was accompanied to the field by two ephors, and was supplanted by the ephors in the control of foreign policy. The kings became mere figure-heads, and the real power was transferred to the ephors and to the gerousia (*q.v.*). In the powers exercised by the assembly of the citizens or apella (*q.v.*) we cannot trace any development, owing to the scantiness of our sources. The Spartan was essentially a soldier, trained to obedience and endurance; he became a politician only if chosen as ephor for a single year or elected a life member of the council after his 60th year had brought freedom from military service.

Training of Citizens.—Shortly after birth the child was brought before the elders, who decided whether it was to be reared; if defective or weakly, it was exposed. Until their seventh year boys were educated at home; from that time their training was undertaken by the state and supervised by the *παιδονόμος*. This training consisted for the most part in physical exercises, with music and literature occupying a subordinate position. From the 20th year began the Spartan's liability to military service and his membership of one of the *ἀνδρεῖα* or *φιδίτια* (dining messes or clubs), to which every citizen must belong. At 30 began the full citizen rights and duties. Three conditions were requisite: Spartiate birth, the training prescribed by law, and participation in one of the dining-clubs. Those who fulfilled these conditions were the *ὅμοιοι* (peers), those who failed were called *ὑπομείονες* (lesser men), and retained only the civil rights of citizenship.

Social System.—Spartiates were debarred by law from trade or manufacture, which rested in the hands of the perioeci (*q.v.*), and were forbidden to possess either gold or silver, the currency consisting of bars of iron. Wealth was, in theory, derived entirely from landed property, and consisted in the annual return made by the helots, who cultivated the plots of ground allotted to the Spartiates. But this attempt to equalize property proved a failure; from early times there were marked differences of wealth within the state, and these became greater after the law of Epitadeus removed the legal prohibition of the gift or bequest of land. The number of full citizens, 8,000 at the beginning of the 5th century, had sunk by Aristotle's day to less than 1,000, and had further decreased to 700 in 244 B.C.

The Persian Wars and After.—The beginning of the 5th century B.C. saw Sparta at the height of her power; but after the Persian Wars the Spartan supremacy could no longer remain unchallenged. Sparta despatched an army in 490 B.C. to aid Athens in repelling the armament sent against it by Darius. But it arrived after the conflict had been decided at the battle of Marathon. In the second campaign Sparta assumed the command of the combined Greek forces by sea and land. Yet, in spite of the heroic defence of Thermopylae by Leonidas (*q.v.*) the glory of the decisive victory at Salamis (*q.v.*) fell in great measure to the Athenians, and their patriotism and energy contrasted strongly with the hesitation of the Spartans and their selfish policy of defending the Peloponnese only. By the battle of Plataea (479 B.C.), won by a Spartan general, the state partially recovered its prestige, but only so far as land operations were concerned; the victory of Mycale, won in the same year, was achieved by the united Greek fleet, and the capture of Sestos, which followed, was due to the Athenians. The perils and the glories of the Persian War were left to Athens, who, though at the outset merelv the leading state in a confederacy of free allies, soon began to make herself the mistress of an empire. Sparta for a time took no steps to prevent this. Moreover, Sparta's attention was occupied by troubles nearer home—the plots of Pausanias not only with the Persian king but with the Laconian helots; the revolt of Tegea (*c.* 473–471); the earthquake which in 464 devastated Sparta; and the rising of the Messenian helots, which immediately followed. The insulting dismissal of Athenian troops which had come to aid the Spartans in the siege of the Messenian stronghold of Ithome, the consummation of the Attic democracy under Ephialtes and Pericles (*q.v.*), and the conclusion of an alliance between Athens and Argos united with other causes to bring about a rupture between the Athenians and the Peloponnesian League. In the so-called first Peloponnesian War Sparta herself took but a small share beyond helping to defeat the Athenians at Tanagra in 457 B.C.

Peloponnesian War.—A fresh struggle, the great Peloponnesian War (*q.v.*), broke out in 431 B.C. This may be to a certain extent regarded as a contest between Ionian and Dorian, or between the democratic and oligarchic principles of government; but at bottom its cause was neither racial nor constitutional, but economic. The maritime supremacy of Athens was used for commercial purposes, and important members of the Peloponnesian confederacy, whose wealth depended largely on their commerce, notably Corinth and Megara, were being slowly but relentlessly crushed. Sparta remained unaffected, but she was forced to take action by the pressure of her allies. She did not prosecute the war with any vigour: her operations were almost confined to an annual inroad into Attica, and when in 425 B.C. a body of Spartiates was captured by the Athenians at Pylos, she was anxious to terminate the war on any reasonable conditions. That the terms of the Peace of Nicias (421), were rather in favour of Sparta than of Athens was due almost entirely to an individual Spartan, Brasidas (*q.v.*). The final success of Sparta and the capture of Athens in 405 were brought about partly by the treachery of Alcibiades. Funds were gained by subsidies from Persia, and Sparta found in Lysander (*q.v.*) an admiral of boundless vigour.

Spartan Empire.—The fall of Athens left Sparta once again supreme in the Greek world and demonstrated clearly her total unfitness for rule. Everywhere democracy was replaced by a philo-Laconian oligarchy, under a Spartan harmost or governor, and even in Laconia itself the narrow and selfish character of the Spartan rule led to a serious conspiracy. Under the energetic rule of Agesilaus, it seemed as if Sparta would pursue a Hellenic policy and carry on the war against Persia. But troubles soon broke out in Greece, Agesilaus was recalled from Asia Minor, and his schemes and successes were rendered fruitless. Further, the naval activity displayed by Sparta during the closing years of the Peloponnesian War abated when Persian subsidies were withdrawn. In 394 B.C. the Spartan navy under Peisander was defeated off Cnidus by the Persian fleet under Conon and Pharnabazus, and Sparta ceased to be a maritime power. In Greece itself, meanwhile, the opposition to Sparta was growing increasingly powerful, and the Spartans felt it necessary to rid themselves of Persian hostility. They therefore concluded with Artaxerxes II. the humiliating Peace of Antalcidas (387 B.C.), by which they surrendered to the Great King the Greek cities of the Asia Minor coast and of Cyprus. After a desultory war with Thebes over the independence of the Boeotian towns, the citadel of Thebes was treacherously seized by Phoebidas in 382 and held by the Spartans until 379 B.C. In 371 a fresh peace congress was summoned at Sparta. Again the Thebans refused to renounce their Boeotian hegemony, and the Spartan attempt at coercion ended in the defeat of the Spartan army at the battle of Leuctra and the transfer of the Greek supremacy from Sparta to Thebes.

Decline of Sparta.—In the course of three expeditions to the Peloponnese, conducted by Epameinondas (*q.v.*), the greatest soldier and statesman Thebes ever produced, Sparta was weakened by the loss of Messenia and by the foundation of Megalopolis as the capital of Arcadia. On Epameinondas's fourth expedition Sparta was again within an ace of capture, but the danger was averted; and though at Mantineia (362 B.C.) the Thebans, together with the Arcadians, Messenians and Argives, gained a victory over the combined Mantinean, Athenian and Spartan forces, yet the death of Epameinondas in the battle more than counterbalanced the Theban victory. But Sparta had neither the men nor the money to recover her lost position, and the continued existence on her borders of an independent Messenia and Arcadia kept her in constant fear for her own safety. No Spartiate fought on the field of Chaeroneia (338 B.C.). After the battle, however, she refused to submit voluntarily to Philip of Macedon, and was forced to do so by the devastation of Laconia and the transference of certain border districts to the neighbouring states of Argos, Arcadia and Messenia. During the absence of Alexander the Great in the East, Agis III. revolted, but the rising was crushed by Antipater, and a similar attempt after Alexander's death was frustrated by Demetrius Poliorcetes in 294 B.C. Twenty-two years later the city was attacked by Pyrrhus (*q.v.*), but the formidable enemy was repulsed. About 244 B.C. an Aetolian army overran Laconia, carrying off, it is said, 50,000 captives.

Attempts at Social Revolution.—This and other ignominious defeats of Sparta showed that she had shared, but in an unusual degree, in the general decay of Greece. On the accession of Agis IV. (*q.v.*) in 244 B.C. the citizen body had by the concentration of wealth in a few hands shrunk to a few hundred: the rest of the inhabitants were in their debt and their power. The Lycurgan constitution was ignored and Phylarchus (Plutarch's chief authority) gives us the usual picture of luxury and degeneracy. Agis by popular agitation was able to carry a resolution through the apella for a restoration of the Lycurgan discipline, together with a redivision of lands and a cancellation of debt. His fellow-king Leonidas opposed, but a section of the wealthy landowners, led by Agis's uncle Agesilaus, were in favour of a cancellation of debts, especially mortgages. With their assistance Agis was able to conciliate the ephors, remove Leonidas and replace him by his son-in-law Cleombrotus. The land was to be divided into "an inner ring about Sparta of 4,500 Spartan lots, and that in the outer ring into 15,000 lots for Perioeci; as there were nothing like 4,500 Spartans he proposed to fill up the number from Perioeci and selected metics in sympathy with Spartan institutions" (W. W. Tarn in *The Hellenistic Age*, 1923, p. 134). Agesilaus persuaded him to divide his programme into two halves, the cancellation of debts being carried through first. Immediately after this measure had been passed, Agesilaus with the other ephors sent Agis north with an army to assist the Achaean league against the Aetolian league. During his absence the two sections of the wealthy class reunited and the division of lands was prevented. Cleombrotus was expelled and Agesilaus brought back Leonidas. Agis on his return declined to use force to prevent the reaction directed by the Ephorate, took sanctuary and was killed by a trick. To prevent a recurrence of a social revolution, Leonidas forcibly married Agis's widow to his son Cleomenes, who was, however, converted by his wife and the Stoic Sphaerus to Agis's views. Thirteen years after Agis's death he came to the throne as Cleomenes III. (*q.v.*). He picked a quarrel with the Achaean league in order to be sent out in command of mercenaries, returned to Sparta, killed 14 of his opponents and exiled eighty. He carried through the division of land as contemplated by Agis (reserving 80 lots for the exiles), cancelled debts, and withdrew all the ephors' chairs except one, which he occupied himself. His war with the Achaean league now became a series of sensational victories, but the league finally secured the aid of Antigonus of Macedonia who forced Cleomenes to flee to Egypt.

Sparta fell back into its previous abject condition, until the rise of the tyrant Nabis, of whom we have only extremely hostile accounts. He abolished debts, redistributed land, taxed the wealthy heavily for the expense of the Lycurgan common meals, and extended the scope of the revolution by liberating helots. His stern reign is marked by another sudden renaissance of Sparta's military power: Sparta was indeed the only Greek power which was able to resist the legions of Flamininus the conqueror of Macedon. Flamininus failed to capture Sparta and in his final settlement left Nabis undisturbed in Laconia, though not in Argos. The experiment was brought to an end by the assassination of Nabis by the Aetolians: in the ensuing confusion Philopoemen (*q.v.*) the general of the Achaean league captured the city, destroyed the Lycurgan constitution of Nabis, and attached the state to the Achaean league. By his dexterity he was able to frustrate later attempts at revolution; and after the annexation of Greece by Rome Sparta has no history worth recording.

Mediaeval Sparta.—In A.D. 396 Alaric (*q.v.*) destroyed the city and at a later period Laconia was invaded and settled by Slavonic tribes. The Franks, on their arrival in the Morea, found a fortified city named Lacedaemonia occupying part of the site of ancient Sparta, and this continued to exist, though greatly depopulated, even after Guillaume de Villehardouin had in 1248–49 founded the fortress and city of Misithra, or Mistra, on a spur of Taygetus some three miles north-west of Sparta. This passed shortly afterwards into the hands of the Byzantines, who retained it until the Turks under Mohammed II. captured it in 1460. In 1687 it came into the possession of the Venetians, from whom it was wrested in 1715 by the Turks.

The Modern City.—In 1834, after the War of Independence, the modern town of Sparta was built on the ancient site from the designs of Baron Jochmus, and Mistra decayed until now it is almost deserted. Sparta is the capital of the prefecture (*νομός*) of Lacedaemon. Pop. (1923) 6,648.

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SPARTACUS, leader in the Gladiatorial War against Rome (73–71 B.C.), a Thracian by birth. He served in the Roman army, but seems to have deserted, for we are told that he was taken prisoner and sold as a slave. Destined for the arena, he, with a band of his fellow-gladiators, broke out of a training school at Capua and took refuge on Mt. Vesuvius (73), where they were joined by other runaway slaves. They defeated two Roman forces in succession, and by the end of the year were 90,000 strong, and in possession of most of south Italy. The next year both consuls were sent against them; Spartacus defeated both of them, and fought his way successfully to the Alps. But the slaves refused to leave Italy, and after a half-hearted move towards Rome, they returned to Lucania. Eventually his large army divided; the Gauls and Germans were first defeated, and Spartacus, after successfully fighting in the retreat, fell fighting in a pitched battle (71), and the revolt was over. A large body of the slaves who escaped northwards were cut to pieces by Pompey on his way home from Spain. Spartacus was both competent and, apparently, humane. His reputation has suffered from the terror his name inspired throughout Italy.

The story has to be pieced together from the vague and somewhat discrepant accounts of Plutarch (*Crassus*, 8–11; *Pompey*, 21), Appian (*Bell. civ.*, i. 116–120), Florus (ii. 8), Livy (*Epit.* 95–97), and the fragments of the *Histories* of Sallust, whose account seems to have been full and graphic.

SPARTANBURG, a city of South Carolina, U.S.A., the county seat of Spartanburg county; in the north-western part of the State, on Federal highways 29 and 176. It is a station on the air-mail route from New York to Atlanta, and is served by the Charleston and Western Carolina, the Clinchfield, the Southern, and the Piedmont and Northern railways. Pop. 22,638 in 1920 (35% negroes); estimated locally at 33,000 in 1928, with an additional 11,000 in the immediate suburbs. It is 875 ft. above sea-level, in the heart of the beautiful Piedmont section, a leading theatre of industrial development in the South, and is one of the large textile centres of the country. It is the seat of Wofford college for men (Methodist Episcopal; 1850), Converse college for women (1889), and the Textile Industrial Institute (estab. 1911) whose students spend alternate weeks in the classroom and in the local textile mills. The city has seven cotton mills, with a total of 304,088 spindles and 7,712 looms (1928). Spartanburg has also large fertilizer plants, cottonseed-oil mills, and other manufacturing industries. It is an important distributing point for Northern manufacturers, and has a large wholesale and retail trade. Bank debits in 1927 aggregated $179,181,000. Since 1913 the city has had a commission-manager form of government. Spartanburg was founded in 1787 and incorporated as a city in 1831.

SPARTEINE, one of the few liquid alkaloids (*see* ALKALOIDS) was isolated by Stenhouse (1852) from broom tops. Sparteine, $C_{15}H_{26}N_2$, boils at 325° C, has a specific rotation $[\alpha]^{D}-16{\cdot}42^\circ$, and is a strong base, forming salts which are difficult to crystallize owing to their ready solubility in water. Knowledge of the constitution of sparteine is principally due to Moureu and Valeur, who have assigned to it a constitutional formula which represents it as containing two quinuclidine nuclei and so brings it into relationship with the cinchona alkaloids (*see* CINCHONA). It resembles coniine (*q.v.*) in physiological action.

SPARTINA. A genus of grasses (Gramineae) belonging to the tribe Chlorideae. Of the seven or eight species, most are North American, where the Fox grass (*S. patens*) and Salt Thatch (*S. alterniflora*) are common on the salt marshes of New England. In Europe *S. stricta* occurs on the salt flats of south-east England, France, Portugal and the Adriatic. *S. alterniflora* has been known at Southampton since 1829, where it was probably introduced by shipping from America. The genus is remarkable for the sudden appearance of a new distinct form at Southampton in 1870, *Spartina Townsendii*, H. and G. Groves. This tall-growing and robust form has spread widely in recent times on the soft tidal muds of both sides of the English channel (Southampton water, Portsmouth, Poole harbour, etc., and in the Vire, Seine and other French rivers). *Spartina Townsendii* is exceptional in colonizing soft mud previously bare, for the vigour of its spread, and for its power of holding silt and raising the level of the mud. Since 1924 it has been introduced into Holland and planted in large numbers on the bare muds of the Scheldt, in Zeeland, and elsewhere, with a view to hastening the time when such ground could be banked (poldered) and used for agriculture.

(F. W. O.)

SPASM: *see* CRAMP; MUSCLE AND NERVE.

SPASMODICS, THE, a name given to a group of English poets in the '40s and '50s of the 19th century. It was first applied by W. E. Aytoun in *Blackwood* (May 1854) in a mock review of his own satire, *Firmilian: a Spasmodic Tragedy* (E. A. Poe had used the word "spasmodist" five years earlier). The writers usually classed as spasmodics are P. J. Bailey (*Festus*, 1839), Ernest Jones, the Chartist song-writer, Ebenezer Jones, also a Chartist (*Songs of Sensation and Event*, 1843), Sydney Dobell (*The Roman*, 1850; *Balder*, 1854) and Alexander Smith (*A Life Drama*, 1853; *City Poems*, 1857). But it would be difficult to exclude some of Mrs. Browning's early work (*Seraphim*, 1838; *Drama of Exile*, 1845), before she had assimilated her husband's influence, and Tennyson's *Maud* (1855) is in its violence, sentiment and frequent lapses of taste not far removed from the spasmodic manner. In the '40s the romantic impulse was exhausted and the Augustan notions of form discredited; but Tennyson and Browning had not risen to acknowledged ascendancy, and M. Arnold had not formulated the new canons of criticism. The interim was a time of false starts, of poets whose aspirations, excited by Byron and Shelley, were unrestrained by any tradition of style or any effectual contemporary criticism.

SPEAKER, a title of the presiding officer in the legislatures of various countries. In the English parliament the lord chancellor acts as Speaker of the House of Lords, but should his office be in commission the Crown usually appoints a Speaker to supply his place, a case in point being that of Sir L. Shadwell, vice-chancellor, who in 1835 was appointed Speaker during the time the Great Seal was in commission.

The Speaker of the House of Lords need not necessarily be a member of the house; Brougham in 1830 sat on the woolsack as Speaker in his capacity of lord chancellor, being then plain Mr. Brougham, his patent of nobility not having yet been made out. The House of Lords has also deputy Speakers who are appointed by commission. The duties of the Speaker of the House of Lords are defined by a standing order as follows: "The lord chancellor, when he speaks to the house, is always to speak uncovered and is not to adjourn the house, or do anything else as mouth of the house, without the consent of the Lords first had, except the ordinary thing about bills, which are of course, wherein the Lords may likewise overrule; as for preferring one bill before another, and such-like; and in case of difference among the Lords, it is to be put to the question; and if the lord chancellor will speak to anything particularly he is to go to his own place as a peer." The Speaker of the House of Lords, as compared with the Speaker of the House of Commons, is an official without power; even his seat, the woolsack, is technically outside the house. Contrary to the practice in the Commons, he acts as a strong party man, making speeches on behalf of Government measures as a peer.

THE HOUSE OF COMMONS

From time immemorial the Speaker of the House of Commons has been the guardian of its powers, dignities, liberties and privileges which the house has won for itself in a period extending over seven centuries. Chosen by his fellow-members, subject to the approval of the Crown, to preside over their deliberations, the Speaker is entrusted with the duty of enforcing multifarious rules and orders, the outcome of long years of experience. These include the putting every question on bills and motions before the house. They empower the chair to accept or refuse the closure, to check irrelevance or tedious repetition, to quell disorder, to issue warrants for the issue of new writs, to reprimand, or, if may be, to commit offenders against its rules.

Often, also, it is the duty of the Speaker to decide on the spur of the moment, what is and what is not a parliamentary expression. In recent times at least one occupant of the chair had constantly by his side a list of admissible parliamentary expletives. From time to time new adjectives and nouns have to be adjudicated upon but it is within the discretion of the chair to determine how far they must be taken with the context and the circumstances of the moment, since it is possible for a word to be used in the heat of the moment in a manner calculated to give offence which, on another occasion, might pass without objection from any quarter of the house.

The most weighty decisions have from time to time to be taken at short notice by the chair, on its being suddenly confronted with an unprecedented situation. These decisions require, in addition to infinite tact, patience and courage, the prompt exercise of that peculiar authority and understanding of men which the confidence and respect of the house at large can alone confer.

The difficulties which confronted Shaw-Lefevre, who was first called to the chair in 1839, when the evolution of the non-partisan Speaker was all but complete, have increased tenfold since that date. A multiplicity of causes have fundamentally changed the temper and spirit of the House of Commons at the present day. The successive lowerings of the franchise, the formation of small subsidiary parties acting independently of the official whips, the heavy strain of practically continuous sessions, the altered mode of procedure mostly tending to enhance the power of the Government of the day at the expense of the independent member, have increased the ever-growing responsibilities of the chair. Tradition, however, binds the Commons together with amazing strength and so long as the peculiar and essential functions of the chair—in ruling by general consent rather than by compulsion, in upholding freedom of speech without allowing it to degenerate into licence—are maintained, it seems safe to predict that the proud heritage of seven centuries of liberty and progress will be handed on unimpaired to future generations of a free and self-governing nation.

The place of the Speaker in the scale of social precedence has been defined by order in council so recently as 1919, as ranking next after the prime minister and the lord president of the council and coming before all peers of the realm except the archbishops. Unlike the lord chancellor who, in his capacity of the Speaker of the House of Lords, is entitled to take part in debate and speak in favour of the Government of which he is a member, the Speaker of the Commons, free from all party ties during his tenure of the chair, takes no part in the discussions upon bills or motions and only gives his casting vote in the event of the numbers in a division being equal.

HISTORY

The Middle Ages.—The ancient office of Speaker, the *Parlour* or Moderator of the House, does not emerge from the twilight which shrouds its origin until the last of Edward III.'s many parliaments. Yet it would seem that some corresponding official charged with the duty of reporting to the Crown the decisions of the Commons existed at least half a century earlier though, as yet, he is nowhere definitely described as their presiding officer. In 1327 the Commons had demanded, no doubt by some accredited agent of their own choice, that their petitions should thenceforth be enrolled as statutes and in 1329, growing bolder still, they refused to assent to a levy equivalent to that already voted by the Lords until the parliament should be dissolved and another one summoned (*Rot. Parl.*, vol. i., p. 104), a request to which the king was graciously pleased to accede. The intermediary on this occasion between the elected representative of the people and the Crown would appear to have been Monsieur William Trussell who in 1346 found honourable burial in Westminster Abbey. In 1340 he announced a naval victory to the Commons and undertook on their behalf to raise wools for the king's aid, whilst in 1343 the Rolls relate that the knights of the shire and the borough members replied in the White hall of the palace of Westminster, by the mark of the same presiding officer, to a message from the pope.

In 1363, though the Commons then had their own clerk—one Robert de Melton, whose annual salary was 100s., it has not been possible to ascertain who filled the chair thus early. The name of a Speaker is first recorded in the Rolls of Parliament for Jan. 1377. Sir Thomas Hungerford, knight of the shire for Wilts, who died Dec. 3, 1397, is then described as the "Chivaler qui avoit les paroles pour les Communes d'Engleterre en cest Parlement." (*Rot. Parl.*, vol. ii., p. 374.) In a house mainly controlled by John of Gaunt, for the king was now in his dotage and nearing his end, the Speaker composed a daring speech to the throne at the close of the session, calling attention to various grievances and alleged infringements of the liberties of the king's subjects, both male and female. He also delivered seven "Billes to the clerk of the Parliaments, to which, however, no reply was vouchsafed. 'A cause q le dit Parlement s'estoit de partir et finir a mesme le jour devant q rien y fust plus fait en ycelles.'"

A surprisingly large number of Speakers died a violent death. Sir John Bussey, the last of the Plantagenet Speakers, was beheaded in 1399 after the surrender of Bristol to Henry, duke of Lancaster, afterwards Henry IV. William Tresham was murdered in 1450, Thomas Thorpe beheaded in 1461, Sir John Wenlock killed at the battle of Tewkesbury in 1471; Sir Thomas Tresham, son of William, was beheaded at the same place. William Catesby shared a like fate after the battle of Bosworth in 1485, Empson and Dudley paid the penalty of their crimes on the scaffold in 1510, but since Sir Thomas More was foully done to death on the perjured evidence of Rich in 1535, no occupant of the chair has been either killed in battle or brought to the block. Sir John Trevor was expelled from the house for taking bribes in 1695.

Tudor Period.—With the close of mediaeval monarchy and the advent of a more personal element in the relations of the throne towards parliament much of the sturdy independence which had animated the earlier occupants of the chair disappeared, at all events for a time. Patriots like de la Mare who used their position in the house to call attention to the urgent necessity of maritime defence, independent leaders like Arnold Savage and Tiptoft, who did not shrink on occasion from admonishing the sovereign on his shortcomings, compare not unfavourably with the servile tribe of Speakers who monopolized the chairs in the Tudor period.

The Dudleys and Empsons of Henry VII., the Riches and Audleys of his successor on the throne and the Snagges and Puckerings of Elizabethan memory would have been impossible under the Plantagenets. The opening of the Black or Reformation parliament in Nov. 1529, the longest known to that date, extending as it did over six and a half years, synchronized with a period of degradation of the House of Commons unparalleled before or since that time, although under Speaker Audley (whose promotion coincided with Wolsey's disgrace) only the outworks of the Church were laid siege to, after his transference to the woolsack in 1533, when the chair was filled by Sir Humphrey Wingfield and, in the next parliament by the despicable Richard Rich, a series of confiscatory Acts designed to ensure the final breach with Rome were drawn up by the privy council, acquiesced in by a subservient House of Lords and forced through the House of Commons. Speakers Audley, Wingfield and Rich eventually benefited largely by the dissolution of the monasteries, Audley acquiring Christ Church priory in London and the abbey of Walden in Essex, Rich being rewarded with the spoils of St. Bartholomew's priory at Smithfield, whilst Wingfield obtained large grants of Church lands. To such a degree of subserviency to the Crown was the house reduced under Henry VIII. that when Wingfield was committed to the Tower during the session of 1539–40, for advising Sir John Skelton how to evade the Statutes of Uses in his will, his imprisonment passed without remonstrance by the house at large.

Onslow.—The emoluments of the chair at the close of the 16th century were so small that the natural trend of a lawyer's ambition was towards the better paid offices of his profession, and not until the reign of Charles II., when Sir Edward Seymour, an aristocratic Tory, was called to the chair, did the house revert to the practice of choosing a country gentleman to preside over its deliberations. Thus for more than a century and a half the direct road to the chair led through Westminster hall and not through the gateway of St. James's palace, as Sir Robert Walpole told Arthur Onslow when in early life he expressed a desire to become Speaker. His ambition was realized in 1728 and by common consent he is held to have been one of the greatest Speakers the house has ever known. He was the first to realize the supreme importance of the independence and impartiality of the chair, whereas most of his predecessors had been pluralists or expectant office holders. He raised the character of his position in the State by relinquishing the lucrative office of treasurer of the navy and contenting himself with the modest income derived from fees on private bills. His patriotic action contrasts very favourably with that of Speaker Grenville in the next century when, on becoming prime minister of "all the talents," he obtained the sinecure office of auditor of the Exchequer, worth £4,000 a year, for 40 years.

For length of service Arthur Onslow's 33 years in the chair easily holds the record, though Speaker Manners-Sutton remains to this day the only man who has been Speaker in seven successive parliaments, narrowly missing, by only ten votes, being chosen for the eighth time in 1835.

19th Century.—In modern times one of the most conspicuous successes in the chair was Speaker Shaw-Lefevre (Lord Eversley) with whose appointment in 1839 the evolution of the non-partisan Speaker was all but complete. Nature had marked him out as the fittest representative of an assembly of English gentlemen and from the first he won the approval of all parties. He could call unruly members to order with a smile which disarmed anger, yet, when compelled to exercise a sterner authority, his manner could be both resolute and unbending. Lord John Russell said of him: "He was the best Speaker I ever knew. Where there was not a precedent he made one, adding so as to prevent any further discussion, according to the well known practice of the House, a formula which pleased everyone." Shaw-Lefevre died in 1888, in his 97th year, at which date Speaker Peel had been twice called to the chair, in 1884 and again in 1886, and Speaker Lowther (Lord Ullswater) was already a member of the house. When Denison was chosen to succeed him and asked Lord Eversley if there was anyone he could call to his assistance in a difficulty he was told: "You must learn to rely entirely upon yourself." During the last year of his tenure of the chair Denison enjoyed the invaluable assistance of Sir Thomas Erskine May (Lord Farnborough), who became clerk of the house in 1871, but in his interesting diary privately printed in 1900, Denison has left it on record that he spent the first few years of his Speakership "like a captain of a steamer on the Thames, standing on the paddle box, ever on the look-out for shocks and collisions. The house is always kind and indulgent, but it expects its Speakers to be right. If he should be found often tripping, his authority would soon be at an end."

A list of Speakers, most of whom are separately noticed, from 1600 is appended. The date of election is given in brackets:—

Sir J. Croke (1601).
Sir E. Phelips (1604).
Sir R. Crewe (1614).
Sir T. Richardson (1621).
*[1]Sir T. Crewe (1624).
Sir H. Finch (1626).
Sir J. Finch (1628).
Sir J. Glanville (1640).
Sir T. Hanmer (1714).
*Sir S. Compton (1715).
(*Earl of Wilmington*).
*[2]A. Onslow (1728).
*Sir J. Cust (1761).
*Sir Fletcher Norton (1770).
(*Lord Grantley*).
*C. W. Cornwall (1780).

*Speaker in more than one parliament.

[1] Brother of Sir R. Crewe.

[2] Nephew of Sir R. Onslow, Speaker in 1708, and great-great-great-grandson of R. Onslow, Speaker in the second parliament of Elizabeth.

*[1]W. Lenthall (1640).
H. Pelham (1647).
Rev. F. Rous (1653).
Sir T. Widdrington (1656).
B. Whitelocke (1656. temp. *locum tenens*).
C. Chute (1659).
Sir L. Long (1659).
T. Bampfylde (1659).
W. Say (1660).
Sir H. Grimston (1660).
Sir E. Turnour (1661).
Sir J. Charlton (1673).
*Sir E. Seymour (1673).
Sir R. Sawyer (1678).
Sir W. Gregory (1679).
*Sir W. Williams (1680).
[2]Sir J. Trevor (1685).
H. Powle (1689).
P. Foley (1695).
Sir T. Littleton, Bt. (1698).
*R. Harley (1701).
(*Earl of Oxford*).
J. Smith (1705).
Sir R. Onslow, Bt. (1708).
W. Bromley (1710).
W. W. Grenville (1789).
(*Lord Grenville*).
*[3]H. Addington (1789).
(*Viscount Sidmouth*).
Sir J. Mitford (1801).
(*Lord Redesdale*).
*C. Abbott (1802).
(*Lord Colchester*).
*[4]H. C. M. Sutton (1817).
(*Viscount Canterbury*).
*J. Abercromby (1835).
(*Lord Dunfermline*).
*C. Shaw Lefevre (1841).
(*Viscount Eversley*).
*J. E. Denison (1857).
(*Viscount Ossington*).
*H. B. Brand (1872).
(*Viscount Hampden*).
*A. W. Peel (1884).
(*Viscount Peel*).
*W. C. Gully (1895).
(*Viscount Selby*).
*J. W. Lowther (1905).
(*Viscount Ulleswater*).
*J. H. Whitley (1921).
E. A. Fitzroy (1928).

*Speaker in more than one parliament.

[1] Speaker of the Long Parliament.

[2] Convicted of bribery and expelled. 1695.

[3] Afterwards Prime Minister. Was first Speaker of the Commons of the United Kingdom.

[4] Speaker in seven parliaments.

The title of Speaker is also applied to the presiding officer of the various legislative assemblies in the British colonies, that of president being applied to the presiding officer of the upper houses—legislative councils, as they are usually called. In Canada, however, the presiding officer both of the Senate and the House of Commons is termed Speaker. In the United States the Speaker of the House of Representatives is one of the most important officials in the government. For a full description of his powers *see* UNITED STATES: *Constitution and Government.*

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(A. I. D.)

SPEARMINT (*Mentha viridis*), a species of mint (*q.v.*) used for culinary and other purposes, distinguished by its smooth sessile leaves and tapering flower-spikes. The flowers are pale blue, and appear from July to September. Spearmint has been introduced into the United States where it has become widely naturalized in moist waste grounds. The volatile oil from spearmint is also used as a medicine. *See* MINT; PEPPERMINT.

SPECIE POINT: *see* GOLD POINT.

SPECIES. The nature of species is a question of considerable importance in general biology and the species is regularly employed as a classificatory unit in systematic botany, zoology and mineralogy. The word *species* has, however, an important history outside those sciences. It was the Latin equivalent of the Greek *εἶδος ἰδέα.* This meant primarily shape or visible form, but was extended to cover the sensible character of things generally, and also the intelligible. For the former use compare the term "sensible species" or characters in things perceived, because reproduced in the organs of sense. To the supposition that we see these reproductions is partly due the doctrine that the mind perceives directly only its own ideas. So Locke says (*Essay Concerning Human Understanding*, Introduction, § 8) that he uses the word idea to express whatever is meant by *phantasm, notion, "species."* As intelligible character, *εἶδος* or *species* was the common essence of individuals or instances, as we say, of the same kind. As such it was an object of thought, not of sense; universal, not individual: and, unlike its instances, exempt from generation and decay. Its relation to its instances (which may be compared to that of a law to the events exemplifying it) was a subject of dispute both in Greek and scholastic philosophy. There were also disputes about the relation of species to their common genus, of which they are determinations (so that Aristotle compared the relation of genus to species with that of matter to form), and to the properties connected and accidents conjoined with their specific nature in instances of a species. Boetius' Latin translation of the *Isagoge* (Introduction) written by Porphyry (born A.D. 232) to the *Categories* of (or ascribed to) Aristotle made these questions familiar long before the revival of Aristotelian learning in the West. In particular it was disputed whether species and genera were anything real independently of our minds, or only common names, or else notions of ours, the products of our classifying activity. A settlement of these questions is not necessary to the work of the systematic biologist; but they must be faced if we are really to understand what we mean by the evolution of species; for this evolution is a process of which no persisting material thing is the subject. (H. W. B. J.)

BIOLOGICAL SPECIES

In systematic zoology and botany the term at present denotes a group of individual animals or plants which is allotted a more or less definite place in the hierarchy of classification between the genus and the variety. A species may be divisible into several varieties or sub-species and a genus may contain one or more species. As the differences between varieties are often very difficult to recognize, it is the species that to the untrained observer usually seem to represent the simplest distinct assemblages or "kinds" in the animal and plant kingdoms. Thus the missel-thrush (*Turdus viscivorus*) can be recognized as distinct from the song thrush (*T. philomelus*) with greater or less ease, but their varieties are only regularly perceptible after intensive study.

Aristotle was the first to use the term "species" in natural history and it was employed by him in the logical sense outlined above, *i.e.*, as denoting a lower division of a higher class. Groups which rank as species in certain of his larger classes are themselves subdivided into species. Thus the crabs and squills are treated as species of Crustacea and the crabs are again subdivided into species. For many centuries after Aristotle the species-concept was employed in this manner. It is true that differences between closely related organisms, such as the wild and cultivated races of plants, were appreciated by the Greek naturalists and herbalists (*e.g.*, Hippo of Rhegium, 423 B.C.), but the early naturalists were not concerned with the production of a "natural" scheme of classification, and names were bestowed upon animals and plants without any reference to such a system. But it would not be true to say that the early naturalists and pharmacologists had no knowledge of the diversity of nature. Many of them were fully acquainted with their local floras; students such as Dioscorides were able to enumerate as many as 1,000 kinds of plants. Our modern classification is based on the principle of relationship and it was probably not until botanists began to cultivate plants experimentally and to collate their results with herbarium collections that the importance of relationship was grasped. Progress upon these lines was made by the Swiss botanist, Caspar Bauhin (1550–1624). Towards the end of the 17th century Martin Lister, an English naturalist, who founded the special study of conchology, employed the species concept in his *Historiae Conchyliorum* (1685) very much as it is used now. Certain groups recognizable as genera in modern classification were subdivided by him into subordinate groups (not actually called species) which were according to the custom of the time designated by their distinctive characters. It is, however, to John Ray, another English naturalist, and a contemporary of Lister, that we owe the first serious discussion as to the status and nature of species and the use of the criterion of mutual fertility as a test of specific identity. The position of the species as the lowest member of a classificatory system was exactly defined by C. N. Lang (1670–1740). At this period there seems to have been no attempt to delimit species one from another with any strictness of definition. A notable feature was a growing interest in their origin, and, as Bateson (1913) has pointed out, there was a distinct tendency to believe that they could arise spontaneously. This belief was, however, checked by the influence of C. Linné (*see* LINNAEUS). The celebrated Swedish naturalist in his *Philosophia Botanica* (1751, §157) made use of the following definition: *species tot numeramus quot diversae formae in principio sunt creatae*, which may be freely rendered "our classification contains just so many species as there were different forms created in the beginning." This famous aphorism is accompanied in the text by a quotation from an earlier work, the *Classes Plantarum* which leaves no ambiguity as to the meaning of *in principio—species tot sunt quot diversas formas ab initio produxit infinitum Ens* ("there are as many species as there were different forms produced in the beginning by the Infinite Being"). Linné thus regarded species as archetypal—as definite entities immutable and fixed in the mould of the original creation. The quotation proceeds: *quae formae secundum generationis inditas leges produxere plures at sibi semper similes* ("these forms according to the laws of reproduction have produced more [sc. individuals] always like themselves"). It must be observed that the aphorism and its accompanying quotation, when read in conjunction with the definition of variety, (1) define the origin of species and (2) propose as criteria of specific status the test of breeding true to type and the structural uniformity of the constituent individuals.

For nearly a century after Linné's death the doctrine of the fixity of species was upheld by the majority of biologists. The effect of Darwin's exposition of the causes of evolution and the evidence he produced in favour of natural selection very naturally led to the rejection of the Linnaean doctrine. The implications of Darwin's theory plainly pointed to the conclusion that varieties are incipient species and that species are progressively developed by the selection and accumulation of individual variations from a parent stock, aided in some measure by isolation. The line between variety and species is often imperceptible and, in Darwin's words, the term species "is arbitrarily given" and "does not essentially differ [in meaning] from the term variety." He held that the only criterion by which we can decide whether a doubtful form is to be ranked as a species or as a variety is "the opinion of naturalists having sound judgment and wide experience." It had previously been urged that the sterility of hybrids resulting from certain crosses afforded a good general criterion of specific distinctness. Darwin showed that this criterion could not be accepted, as the degree of sterility of various species when crossed is so different "that for all practical purposes it is most difficult to say when perfect fertility ends and sterility begins." It should be clearly understood that the acceptance of this opinion concerning species does not mean that the naturalist is unable to recognize such distinct and sharply defined groups as may actually occur in nature. What was abandoned was the belief in the special creation of species and the less definitely expressed but implicit conception of a criterion by which species could be regularly recognized as distinct, *e.g.*, from varieties.

Since the publication of the *Origin of Species* up to the present time many zoologists and botanists have resolutely followed Darwin in regarding the criterion of specific status as an arbitrary matter having a purely systematic value and in believing that species cannot be regularly discriminated from other categories as a distinct and standardized evolutionary grade. On the other hand there have been many students who, influenced by advances in our knowledge of the laws of heredity, have been less disposed to deny to the species a special and peculiar status. Alexis Jordan and H. de Vries showed that some of the Linnaean species were not homogeneous in hereditary constitution but were composed of a number of subdivisions or "elementary species." According to de Vries these arise not by slow progressive selection, but by sudden discontinuous change (mutation). The origin of new forms, whether they be "species," "subspecies" or "races" is discussed in the article EVOLUTION. It may be stated, however, that, although mutation in de Vries' original sense has not been shown to be of general occurrence, new forms have arisen as the result of crossing. These are recorded among plants and it may be noted that they sometimes fulfil the ordinary criterion of species. A more exact knowledge of the mechanism and laws of heredity was developed in the years following the republication of G. Mendel's celebrated investigations in 1900 (*see* HEREDITY, MENDELISM). Experimental pedigree culture and work such as that of Johannsen on Pure Lines (*q.v.*) yielded evidence of the same type of hereditarily constant strains as were demonstrated by Jordan and de Vries. The species thus recovered some of its lost prestige, at least in so far as the existence of ultimate units seemed to be established. In 1913 Bateson could speak of "the universal presence of specificity" among animals and plants. Most biologists at the present time, however, are unwilling to admit that species can be discriminated from varieties by a universal criterion.

Some points concerning variation and other matters may make the reason for this conclusion clearer and should at the same time indicate the difficulty encountered in trying to fit into rigid categories the variation that is found in nature. (1) A distinction must be drawn between the species described in systematic zoology and botany, or known to the casual observer, and the "natural population." The first is represented by the usually limited number of individuals accessible to the naturalist or encountered by the observer and is only a sample of the natural population found in nature. Very often the species of the systematist are represented by a few specimens only and it is rarely that the distribution and variation of species in nature are known with any exactness. (2) When such natural population are studied in detail it is often found that they are far from homogeneous. Not only do the individual organisms referred to a species differ somewhat among themselves in single characters, but also the combinations of characters which they exhibit are often very diverse. A form designated as a species may be split up into local races which differ in the extent to which they are differentiated one from another. (3) It is sometimes possible to recognize distinct and discontinuous groups; but forms diagnosed as species are often found to grade by a series of intermediate forms into other groups and species thus connected by intermediates and having many characters in common are only recognizable by the fact that certain combinations of characters are more frequently found than others. The difficulty of defining species with exactness has been shown with particular clearness in the study of certain fossil animals. The intensive study of series of such forms obtained from strata succeeding each other in regular sequence usually shows a gradual change of one form into another and sometimes the "lineages" or successive phases of individual characters are so inextricably confused as to make it impossible to recognize species in the ordinary systematic sense. (4) Intermediate forms may be of two kinds: "mid-intermediates," *i.e.*, forms in which all the characters represent a blend of two more extreme types (as grey is intermediate between black and white), and forms which represent various combinations of some of the characters found in two divergent stocks. The former may owe their intermediate appearance to the local environment and both kinds of intermediacy may be due to the effects of hybrid crossing. (5) The recognition of species by a morphological criterion is embarrassed by the occurrence of sexual dimorphism, *i.e.*, the occurrence of strongly marked differences in structure or colour between the males and females of a single species. (6) The criterion of specific distinctness usually adopted is that of structural difference. Evolutionary divergence, however, is manifest in many other attributes of animals and plants—in the products of their metabolism, their reactions, habits, distribution, etc. It is found that the various modes of distinctness—structural, physiological, habitudinal, etc.—are not very closely correlated. For example, forms which are morphologically distinct may be mutually fertile or have identical physiological properties or activities. Although it is customary to regard structure as the surest clue to relationship it is nevertheless to be borne in mind that structural differences do not constitute the only type of divergence and that, while our classification aims at expressing genetic relationship, it does not necessarily express the functional diversity of animal and plant life. It is perhaps desirable to emphasize the purely arbitrary nature of the criterion of specific status. Although at any one time it is possible to recognize tolerably distinct assemblages of individuals on which it is convenient to confer specific rank, nevertheless the limits of such "species" are, when considered in the light of evolutionary history, incapable of exact definition.

In systematic zoology and botany a species is designated by two names, the generic name, indicated by an initial capital letter, and the specific, which is always now printed without a capital in zoology, though in botany the initial letter is a capital, if derived from a proper name. Both names are printed in italics and may be followed by the name of the author who published the first description of the species. Thus *Corvus corax* Linné (or Linn.) is the specific designation of the raven. Owing to complications introduced by certain inevitable errors the nomenclature of species and genera is subject to a code of international rules.

The first described specimen of a species is known as the "type" of the species ("co-type" and "paratype" being used for various grades of "types"), a term which must not be confused with "typical," *i.e.* average.

In mineralogy the classificatory system is not based upon descent and relationship. Certain fundamental kinds of minerals known as "species" are recognized and defined according to their chemical composition and crystalline form. The larger groups are quite arbitrary and depend upon the purpose for which the classification is to be used. Some of the species of minerals are clearly defined. (*See* MINERALOGY.)

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SPECIFIC GRAVITY is the ratio between the density (mass per unit volume) of a body and the density of some substance assumed as a standard. For liquids and solids the standard is distilled water at 4 deg. C. In the centimetre-gram-second system of units the numerical values for the density and the specific gravity of any substance are the same. In the English system the density of water is 62·4 pounds per cubic foot, while its specific gravity is still unity. (*See* PHYSICS, ARTICLES ON.)

SPECIFIC PERFORMANCE, an equitable doctrine under which a court of equity, in certain exceptional cases where the normal legal remedy, *i.e.*, damages, would not be a sufficient compensation, orders by a defaulting party a specific or actual performance of the thing which he had contracted to do. The court as a general rule will refuse this relief where it would be unable to superintend or enforce the execution of its judgment. Specific performance is usually confined to executory agreements, *i.e.*, a conveyance or a lease of land; it is not usually enforced in the cases of personal acts or in those of contracts for personal service. The doctrine of specific performance in the United States follows very largely that of England.

See *Ency. Eng. Law,* tit. "Specific Performance"; J. Story, *Equity Jurisprudence* (1836); Sir E. Fry, *Treatise on Specific Performance of Contracts* (6th ed., 1921).

SPECTACLES, the name given to lenses of any required form which are supported in front of the eyes to assist vision. They may be required to correct errors of refraction, or to correct imbalance of the ocular muscles, or to cut off injurious or unpleasant light or glare. The lenses for the first two purposes are usually made of crown glass, but in the early days, when it was not easy to obtain glass of good quality, free from striae (*i.e.*, streaks of glass of a different refractive index, due to imperfect mixing of the constituents), they were also made of quartz, or rock crystal as it was called. Some years ago quartz lenses were revived by the opticians, and sold at fancy prices, on the erroneous plea that they were cooler to the eyes.

Professor M. von Rohr has discussed the history of Spectacles in several papers. (*See* Thomas Young Oration, Trans. Optical Soc. 1923–4 No. 2 and also in 1926–7 No. 3.) Briefly, it appears that Roger Bacon explained how to magnify writing by placing a segment of a sphere of glass on the book with its plane side down in his Opus Majus 1266. A portrait of Cardinal Ugone in a fresco in a church at Treviso painted in 1352, shows two mounted lenses with their handles riveted together and fixed in front of his eyes, so evidently a form of spectacles was known by this time. Up to the invention of printing in the middle of the 15th century, very few other than the monks could read, but the advent of the printed book greatly stimulated the demand for spectacles, and the trade in them grew rapidly during the 16th century, especially in North Italy and South Germany where there were glass workers, and by about 1600 opticians were to be found in most of the towns of any size on the continent. The early mounts were made of horn and leather, and by about this time metal began to be used. The nomenclature of the lenses varied; in Venice it is possible that the numbering represented the power of the lens, with a unit of about 0·6 diopters. Elsewhere they were either numbered to indicate the age for which they were supposed to be used, or according to the radius of the tool in which they were ground. In Germany spectacles were made for the very low price of 2½ to 4 farthings, and were extensively exported. We have no information of the beginning of the optical trade in England, but in 1629 a charter was granted by Charles I. to the Spectacle Makers' Guild. The invention of the method of grinding a number of lenses together on one large block, which Mr. Court has shown was made by Marshall between 1690 and 1693 (Trans. Opt. Soc. 1926–7, p. 122), gave the London opticians a very great advantage over their foreign rivals, as it enabled them to produce lenses of a better quality; and during the 18th century they acquired a great reputation, and were able to charge as much as sixteen guineas for the best double-jointed standard gold spectacles (gold case included) (Trans. Opt. Soc. 1923–4, p. 64). They introduced the fashionable monocle about this time.

Bifocals, that is, lenses of which one portion has a higher power than the remainder, appear to have been first made for Benjamin Franklin about 1760.

Astigmatism, that is, a variation in the refractive power of the eye in different meridians, was first recognised by Thomas Young, who found it present in his own eyes. He found he could correct it by looking obliquely through his spectacles, so it must only have been slight. Sir George B. Airy in 1825, who had one eye so badly astigmatic as to be unusable, showed that the astigmatism could be corrected by a spherocylindrical lens, and had such a lens made for himself by Fuller, an Ipswich optician, in 1827. Cylindrical lenses, however, were seldom prescribed or supplied until towards the end of the 19th century.

In the last few years great improvements in the construction of bifocals have been made. The early bifocals were made by cutting away a portion of the weaker lens, which corrected the wearer's error for distant vision, and replacing it by a part of a stronger lens, adapted for his reading distance. The two partial lenses were mounted together in the frame, so that when he looked up he looked through the weaker lens, and when he looked down, he saw through the stronger one. The first improvement was to cement an extra lens over the lower part of the weak lens, so as to increase its power by the required amount over this area.

In another form of bifocal lens, the surface of a single lens is ground to two different curvatures, by using a rotating hollow brass tube and emery to grind with, and an ebonite tube with rouge to polish with. If well done this lens is very satisfactory.

In another form, a hollow is first ground and polished in the crown lens; then a flint lens is ground and polished to the same curve. The flint is laid in the hollow in the crown lens, great care being taken to avoid including dust or air, and the two are fused together in an electric furnace. The outer surface is now ground all over to the same curvature, and the included flint lens is therefore almost invisible, but as it has a higher refractive index than the crown, this part of the lens will have a higher power, determined by the curvature of the dividing surface between the crown and the flint. This combination, being a convex flint and a concave crown, is non-achromatic. So lastly instead of a flint glass, a boro-silicate crown has been substituted, and as this glass has a lower dispersive power than the crown, although it has a higher refractive index, the combination is partly achromatized.

The refractive errors of the eyes to be corrected by spectacles are of three kinds: (i.) those due to malformation of the eye, (ii.) those due to old age, (iii.) those due to want of proper coordination of the muscles of the eye.

(i.) The first of these may be again divided into two main types: (a) The curvature of the cornea or of the lens may be too great or too small in relation to the distance of the retina from them. This error can be corrected by the use of a concave or a convex spherical lens, respectively.

(b) The cornea, or sometimes the lens, may not be symmetrical about its axis, being more curved in one meridian than in the one at right angles. This makes it impossible for the eye to form a point image of a bright point, the eye is therefore said to be "astigmatic." As already mentioned, this defect can be corrected by adding a cylindrical lens to increase the power of the weaker meridian, or to reduce that of the stronger, as may be more convenient. If the error was a large one, the eye will not have attempted to correct it; but if it was small the eye will usually have tried to overcome it, and this will generally have caused more or less severe headaches. The prescription of the requisite glasses will remove these headaches.

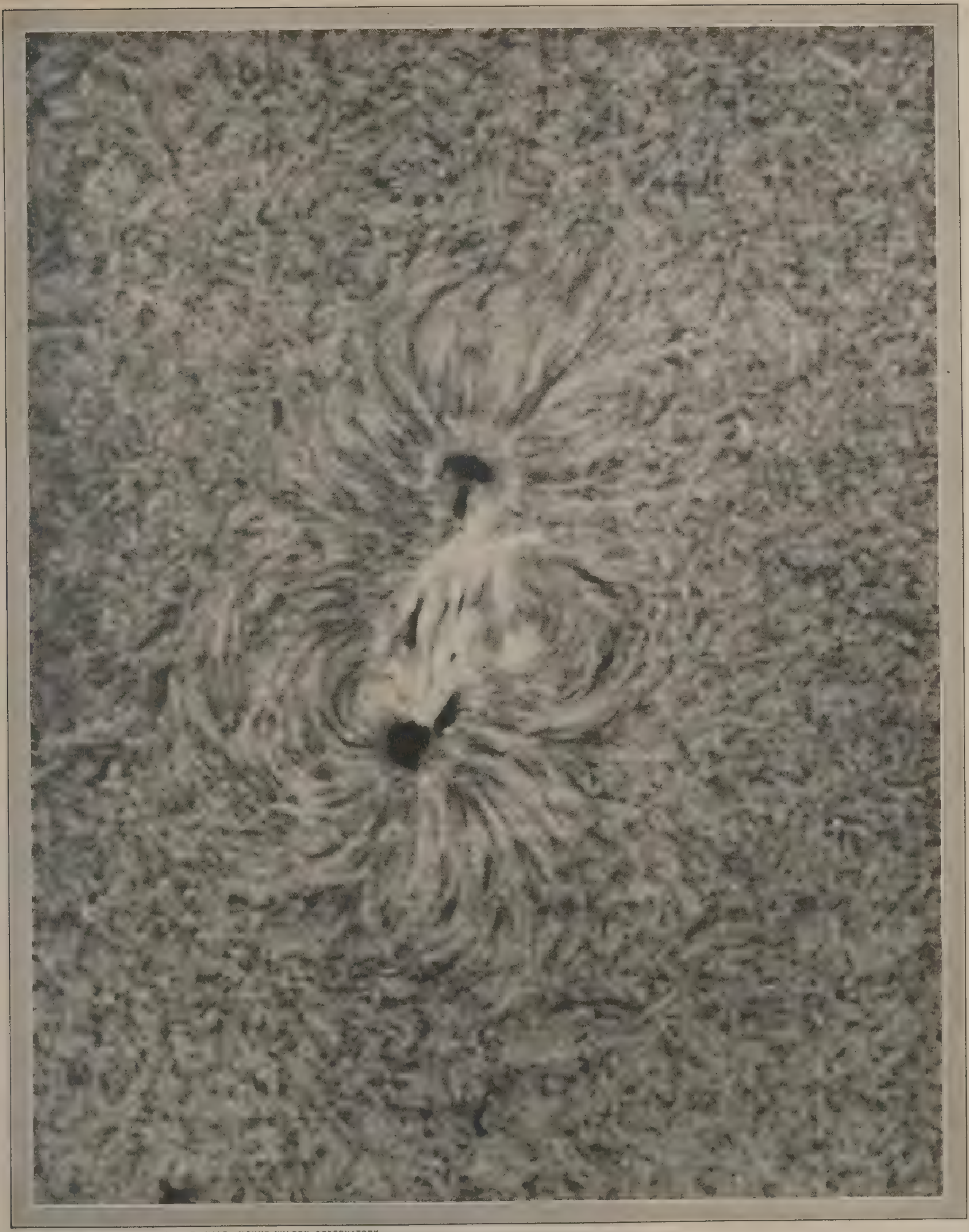
In a number of cases the malformation of the one eye is different from that of the other. A child that has one good and one bad eye, often learns to squint in order to throw the image in the bad eye out of the field. Correcting the bad eye in such a case at an early date will prevent the development of the squint. In other cases both eyes may need correction, and it is usually possible to correct both eyes fully, if the case is taken early enough.

(ii.) The effect of age is gradually to lessen the ability of the lens of the eye to alter its power, and to see clearly objects at different distances. This loss of power continues progressively through life. In the case of a person with normal sight, at about the age of fifty he begins to find it impossible to focus anything nearer than about 25 in., and therefore reading begins to be difficult. A long-sighted person will find difficulty in reading at an earlier age. As a man gets older the addition required for reading will gradually become greater, and ultimately at about the age of 70 all power of altering the focus of the eye is lost. A short-sighted person may never require glasses for reading.

(iii.) If some of the eye muscles are unequal so that the axes are normally not parallel to one another, the ganglia which coordinate the movements of the eyes, will have a strain thrown upon them, which may often cause trouble. This is especially the case if the axis of one eye points higher up than the other, as we have not learnt to move the eyes up and down independently. In this case severe headache may result which a prism, or a decentration of the lens, will relieve.

Lastly, spectacles may be required to cut off harmful rays of light. In the high Alps and the tropics, there is an excess of ultra-violet light, which has a harmful effect on the retina, and may even cause blindness; certain special glasses are on the market which cut off these rays. Also in some occupations the workers are exposed to similar rays, as for instance in acetylene- or arc-welding, and must protect their eyes either by wearing coloured glass goggles or by holding a screen containing coloured glass before their face. These goggles are generally glazed with ordinary blue or green glass, or sometimes with a coloured celluloid film mounted between two plain glasses. Glass blowers and metal founders are exposed to great heat radiation, this is largely cut off by any glass, but to give a pleasanter light, a blue or green tinted glass is sometimes used. (R. S. Cl.)

SPECTROHELIOGRAPH, an instrument for photographing the sun with monochromatic light. In its simplest form it consists of a direct-vision spectroscope, having an adjustable slit (called "camera slit" or "second slit"), instead of an eyepiece, in the focal plane of the observing telescope. This slit is set in a position such that it transmits a single line of the spectrum; *e.g.*, the K line of calcium. A fixed image of the sun is formed on the collimator slit of this spectroscope, and a photographic plate, with its plane parallel to the plane of the solar image, is mounted almost in contact with the camera slit. The spectroscope is then moved parallel to itself, admitting to the collimator slit light from all parts of the sun's disk. Thus a monochromatic image of the sun, formed of a great number of successive images of the spectral line employed, will be built up on the plate. As the only light permitted to reach the plate is that of the calcium line, the resulting image will represent the distribution of calcium vapour in the sun's atmosphere. The calcium clouds, or flocculi, thus recorded are invisible to the eye, and are not shown on direct solar photo-



BY COURTESY OF PROFESSOR G. E. HALE, MOUNT WILSON OBSERVATORY

HYDROGEN WHIRLS IN THE SUN

These hydrogen whirls surrounding a large bipolar sun spot were photographed at the Mount Wilson Observatory of the Carnegie Institution of Washington, with the 13-ft. spectroheliograph, Aug. 30, 1924. Photographs of the hydrogen layers of the sun's atmosphere show that sun spots are vortical in nature and that their movement may be clockwise or anti-clockwise

graphs taken in the ordinary way. These, on account of the brilliant reversals of the H and K lines to which they give rise, and the protection to the plate afforded by the diffuse dark bands in which these bright lines occur, are easily photographed with a spectroheliograph of low dispersion. In the case of narrower lines, however, higher dispersion is required to prevent the light of the continuous spectrum on either side of the dark line from blotting out the monochromatic image.

A five foot spectroheliograph which gives excellent results with the lines of calcium, hydrogen and iron has been used since 1905 in conjunction with the Snow (horizontal) and 60ft. tower telescopes of the Mt. Wilson Solar observatory. It was constructed in the observatory instrument shop in Pasadena. The instrument consists of a heavy cast-iron platform mounted on four steel balls, which run in V guides of hardened steel. Most of the weight of the instrument is floated on mercury contained in three troughs which form part of the cast-iron base. The platform carries the two slits, the collimator and camera objectives and the prism-train. An image of the sun, about 6·7in. in diameter, is formed by the telescope on the collimator slit. The collimator slit is long enough (8½in.) to extend entirely across the solar image and across such prominences of ordinary height as may happen to lie at the extremities of a vertical diameter. After passing through the slit the diverging rays fall upon the 8in. collimator objective which is constructed in the manner of a portrait lens in order to give a sharp field of sufficient diameter to include the entire solar image. The rays, rendered parallel by the collimator objective, meet a plane mirror made of silvered glass, which reflects them to the two prisms. These are of dense flint-glass (Schott 0·102), and each has a refracting angle of 63° 29′. Their width and height are sufficient to transmit (at the position of minimum deviation) the entire beam received from the collimator. A grating, ruled on speculum metal with about 15,000 lines per inch, is substituted for the mirror when higher dispersion is required. After being deviated 180° from the original direction, the dispersed rays fall on the camera objective, which is exactly similar to the collimator objective. This forms an image of the solar spectrum in its focal plane on the camera slit. Beyond the camera slit, and almost in contact with it, the photographic plate-carrier is mounted on a fixed support. In order to bring a spectral line upon the camera slit, the slit is widely opened and the plane mirror is rotated until it is possible to see the line. A cross-hair, in the focal plane of an eyepiece, is then moved horizontally until it coincides with the line in question. The slit is narrowed down to the desired width, and moved as a whole by a micrometer screw until it coincides with the cross-hair. The eyepiece is removed and the photographic plate placed in position. An electric motor, belted to a screw connected with the spectroheliograph, is then started. (Two alternative screws, of different pitch, are provided to give different speeds.) The screw moves the spectroheliograph at a uniform rate across the fixed solar image. Thus a monochromatic image of the sun is built up on the fixed photographic plate.

The spectroheliograph, originally designed for photographing only the solar prominences, disclosed, in its first application by Hale at the Kenwood observatory (Chicago, 1891, 1892), a new and unexplored region of the sun's atmosphere. Photographs of the solar disk, taken with the H or K line, showed extensive luminous clouds (flocculi) of calcium vapour, vastly greater in area than the sunspots. About this time Deslandres introduced at the Paris observatory, the velocity spectrograph, which permits the motion in the line of sight of the calcium vapour at various levels to be measured on photographs of the H or K line in successive sections of the sun. By setting the camera slit of a spectroheliograph so as to admit to the photographic plate the light of the denser calcium vapour, which lies at low levels, or that of the rarer vapour at high levels, the forms of the flocculi corresponding to various superposed regions of the atmosphere can be recorded. The lower and denser vapour appears as bright clouds, but the cooler vapour, at higher levels, absorbs the light from below and thus gives rise to dark clouds.

The first photographs of the sun in hydrogen light were made with the spectroheliograph at the Yerkes observatory in 1903. These reveal dark hydrogen flocculi, which, like the dark calcium flocculi, lie at a level above that of the bright calcium flocculi. They also show less extensive bright flocculi, usually in the immediate neighbourhood of sunspots, and frequently eruptive in character. These rise from a low level, and sometimes reach considerable elevations in the form of eruptive prominences.

In such an exploration of the sun's atmosphere it might be anticipated that definite currents, or some evidences of atmospheric circulation analogous to those familiar in terrestrial meteorology, would be discovered. In the early work neither the forms nor the motions of the calcium flocculi revealed the existence of such currents, but in the higher region shown by the hydrogen photographs the distribution of the dark flocculi suggested the operation of definite forces, though their full effect was not recognized until the spring of 1908. At that time monochromatic photographs of the sun were first made by Hale and Ellerman on Mt. Wilson with the red ($H\alpha$) line of hydrogen, previous hydrogen photographs having been taken with $H\beta$, $H\gamma$ or $H\delta$ in the blue or violet. On account of the relatively great strength of $H\alpha$ at a considerable distance from the photosphere, the new photographs recorded flocculi at high levels previously unexplored. The forms and motions of these flocculi show that great vortices exist in the solar atmosphere above sunspots, which resemble terrestrial cyclones or tornadoes. About 75% of these high-level vortices indicate clockwise rotation in the southern hemisphere and counter-clockwise rotation in the northern, as in the case of terrestrial cyclones. The detection of these vortices led, in 1908, to the discovery of magnetic fields in sunspots, apparently due to electric convection in the primary vortices at lower levels which are the cause of the spots themselves. The long dark flocculi also shown on hydrogen spectroheliograms, identified as prominences projected against the surface of the sun, were subsequently called "filaments" by Deslandres, who has studied them extensively at Meudon. With a spectroheliograph of high dispersion the centre of the hydrogen line $H\alpha$ shows the "alignments" discovered by Deslandres, which constitute a network of wide mesh associated with the filaments.

Spectrohelioscope.—The spectrohelioscope renders visible to the eye many of the phenomena of the solar atmosphere photographed with the spectroheliograph and also permits their velocities in the line of sight to be measured. It thus combines some of the functions of the spectroheliograph and the velocity spectrograph. Its principle was suggested by Young in 1870, and tried provisionally by him for the observation of prominences at the sun's limb. He discarded it, however, when the use of a wide slit was proposed for this purpose by Zollner and Huggins. Hale, who revived and developed the method (1924), succeeded with its aid in observing the bright and dark hydrogen flocculi on the sun's disk, and in analyzing and measuring the motions of the gas in eruptions and vortices.

Imagine a narrow slit, rapidly oscillating, between the eye and a telescopic image of the sun. Through persistence of vision, the image can be seen in white light. Introduce a spectroscope, which excludes from the slit before the eye all light except that of the red hydrogen line. We then have a spectrohelioscope. For satisfactory observations of the hydrogen atmosphere against the disk, fairly high dispersion is necessary. Hale uses a spectroscope of 13ft. focal length, having a plane grating ruled with about 15,000 lines to the inch, giving a first order spectrum which is very bright in the red. He has employed various means of moving the slits, one of which is a spinning disk pierced with 50 radial slits 0·004in. wide. A 2in. solar image is formed on one side of the disk and the observer sees the hydrogen image of a portion of the sun through a low-power eyepiece focussed on the diametrically opposite slits. J. A. Anderson and Sinclair Smith have suggested devices for producing an exactly similar monochromatic image with a spectroscope having fixed slits. These consist of a rotating prism of square section (Anderson) or an oscillating plane mirror (Smith) which cause a portion of the solar image to move rapidly across the fixed first slit of the spectroscope. The second slit is then viewed through another prism or mirror, moving at precisely the same rate and giving a fixed monochromatic image in the eyepiece.

The hydrogen lines on the sun's disk are frequently distorted by the rapid motion of the gas toward or from the observer. For example, a mass of hydrogen descending into a vortex above a sunspot is indicated by a local displacement of the lines, which frequently indicate a velocity of 60km. sec. In such a case the distorted portion of the line would fall outside the narrow slit of the spectroheliograph, and the image of the rapidly moving gas would not be recorded. The spectrohelioscope not only brings these moving gases into view but also indicates their velocity. A "line-shifter," consisting of a plane parallel-sided glass plate mounted behind the second slit, displaces the line toward red or violet when rotated. In all regions where he suspects motion, the observer frequently shifts the line on the slit, thus "tuning-in" so as to pick up the wave-lengths as altered by the motion of the luminous gases. In this way, for example, a rapidly ascending mass of hydrogen, near the middle of the sun (revealed by a line outside the $H\alpha$ line on its violet side), may be watched as it shoots upward, curves over in a long arch nearly parallel for some distance with the surface (its line shown near the centre of the $H\alpha$ line), and descends in a continuous arch toward the sun or is caught in a vortex and whirled downward (the line being seen outside the $H\alpha$ line on its red side). A divided arc attached to the line-shifter gives the velocity of the gas.

The spectrohelioscope affords a rapid means of detecting and analysing eruptions or other important solar phenomena, as the entire limb and disk can be examined in a few minutes. Eight or more of these instruments will soon be used systematically at as many solar observatories, distributed around the world, thus permitting the sun's atmosphere to be kept under nearly constant observation. In this way it is hoped to increase our knowledge of the connection between solar eruptions and such geophysical phenomena as the aurora, the magnetic storm and certain interruptions in radio transmission, which probably depend upon the bombardment of the earth's atmosphere by electrified particles projected from the sun.

Descriptions of spectroheliographs and results by Hale, Deslandres, Evershed, Newall and others have appeared in various papers in *Astronomy* and *Astrophysics, Astrophysical Journal, Comptes rendus, Bulletin astronomique, Monthly Notices of the Royal Astronomical Society* and the publications of the Yerkes, Meudon, Kodaikanal, Cambridge and Mt. Wilson observatories. Papers on the spectrohelioscope may be found in the *Publications of the National Academy of Sciences, Nature, Astrophysical Journal* and *Publications of the Astronomical Society of the Pacific.* (G. E. H.)

SPECTROHELIOSCOPE: *see* SPECTROHELIOGRAPH.

SPECTROSCOPY (from Lat. *spectrum,* an appearance, and Gr. σκοπεῖν, to see), has for its province the investigation of spectra, which are the appearances observed when the radiations from a luminous source are separated into their constituent parts. Such separation can be effected by the use of a prism, or by a diffraction grating, and instruments which are designed for the convenient use of these appliances are called spectroscopes.

This important branch of physics came especially into prominence through the work of Kirchhoff and Bunsen in 1859, when it was primarily regarded as providing a new method of investigating the chemical nature of substances, and was called spectrum analysis. A number of elements new to chemistry were soon afterwards discovered by this method, which was found to be extremely sensitive, so that, for example, one three-millionth of a milligram of sodium could be assigned to that element with certainty. Being independent of the distance of the luminous source, the spectroscopic method was clearly applicable to the sun and other celestial bodies, and the science of Astrophysics came into existence.

It was soon realized, however, that spectrum analysis was not so simple a matter as it first appeared. The early experiments apparently suggested that each element had its characteristic and invariable spectrum, irrespective of whether it existed in the free state or in combination with other elements. But as inquiry was extended it was found that many compounds as well as elements gave their characteristic spectra, and, further, that even an element could give different spectra according to the physical conditions under which it was excited to luminosity.

The spectrum has thus become much more than a key to chemical composition; it has also become a key to the physical conditions under which the corresponding radiation is excited; and, as was clearly foreseen by some of the earlier workers, it has gone far to reveal the structure of atoms and molecules. The old name being no longer appropriate, the word "Spectroscopy" was introduced to cover the whole range of spectroscopic investigations, apparently by Sir Arthur Schuster in a lecture delivered at the Royal Institution in 1882.

1. EXPERIMENTAL BASIS

THE PRISM

The Simple Prism.—The production of a spectrum by the use of a prism depends upon the fact that rays of light of different colours, or wave-lengths, are refracted differently on entering or emerging obliquely from one medium to another of different density. Thus, in fig. 1 the ray of light AP, consisting of a mixture of red and violet light, will be split up into its two components by the prism, the red following the path PDR, while the violet, being more refracted than the red, will follow the path PEV. A composite ray of light is accordingly *dispersed,* as well as refracted, in passing through a prism. If the source of light be white, the spectrum will show a succession of colours like those of the rainbow; namely, red, orange, yellow, green, blue, indigo and violet. Beyond the visible violet there is a long range of spectrum called the ultra-violet, and there is similarly a region called the infra-red beyond the visible red end of the spectrum.

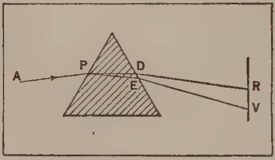


FIG. 1.—DISPERSION BY A PRISM

The essential parts of a simple prismatic spectroscope are represented diagrammatically in fig. 2. Light from the source under examination enters the instrument through a narrow slit at S, which is placed at the principal focus of a lens A. Parallel rays of light of mixed colour thus fall on the prism, and each component bundle of rays continues parallel in its passage through the prism and on emergence into the air beyond. The different bundles, however, are refracted differently, and, when they pass through the lens B are focussed at different points, so as to form a spectrum. The spectrum may then be observed with a suitable eyepiece, or it may be photographed direct. The lens B and the eyepiece are ordinarily combined in the form of a telescope, which can be rotated about the centre of the prism, so that different parts of the spectrum can be observed. When the eyepiece is replaced by a camera, the instrument is called a spectrograph.

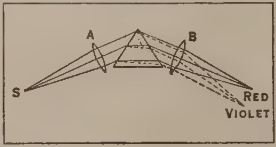


FIG. 2.—PRISMATIC SPECTROSCOPE

When produced in this way the spectrum consists of a succession of images of the slit, depending upon the nature of the source, and while the slit may be of any shape, a narrow straight slit is ordinarily used because it gives the least confusion of overlapping images. It is because a straight slit is most generally used that we speak of spectrum *lines.*

When a ray of light leaves the prism at the same angle as that at which it enters, the prism is said to be at minimum deviation for that particular colour or wave-length. This position can readily be determined by turning the prism until the line under observation advances as far as possible in the direction of the red. When a collimator is used, it is not essential for good definition that the prism should be at minimum deviation, but it is usually most convenient to place it in this position, so that a previous condition of adjustment can easily be restored.

Constant Deviation Prism.—A convenient form of prism which is optically equivalent to a 60° prism of the same kind of glass has been utilized in the Hilger wave-length spectrometer, which is illustrated in fig. 3. The prism takes the form shown in fig. 4, and though made in one piece of glass it may be considered to be made up of two prisms with refracting angles of 30°, acting in conjunction with a totally reflecting prism ABC.

When such a prism is rotated about a vertical axis, different wave-lengths may be observed in a fixed direction at right angles to the incident ray, and a prism of this form is consequently called a constant deviation prism. Measurements are made on a large drum which forms the head of a fine tangent screw by which the prism is rotated, the divisions of the spiral scale being such as to indicate wave-lengths directly.

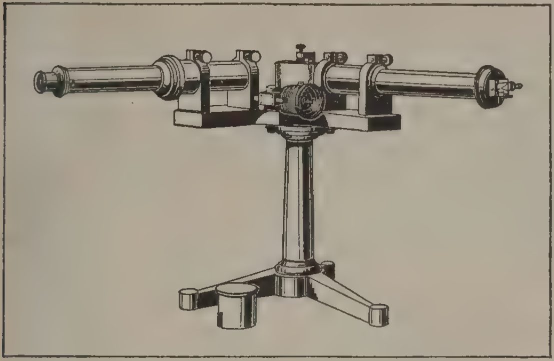
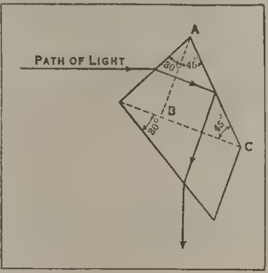


FIG. 3.—HILGER WAVE LENGTH SPECTROMETER



BY COURTESY OF HILGER

FIG. 4.—CONSTANT DEVIATION PRISM

Compound Prisms.—It is often convenient to have an instrument in which the viewing telescope is in direct line with the collimator, and, of the various ways of obtaining this, the most common arrangement is that in which prisms of different kinds of glass are combined to give dispersion without deviation. This is possible because in different kinds of glass dispersion and deviation are not proportional; flint glass, for example, giving a greater dispersion in proportion to deviation than crown glass. Such a combination is illustrated in fig. 5a, the central flint prism being supposed to have a refractive index of 1·751 and the outside crown glass prisms 1·520. These combinations may give quite a large balance of dispersion, because the flint glass prism has a much larger angle than is possible when a prism of the same kind of glass is used alone. Such prisms are used extensively in pocket spectroscopes, which dispense with an observing telescope, as well as in larger instruments. To give increased dispersion, these direct-vision prisms are often constructed with two prisms of flint and three of crown glass, cemented together, and two or more such combinations may be used in line with each other. Since direct-vision can only be obtained for a particular wave-length, the observing telescope must be capable of movement to permit observations of different parts of the spectrum.

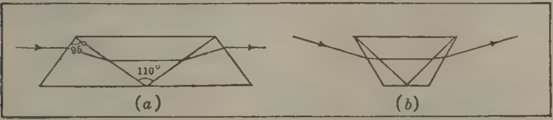


FIG. 5.—COMPOUND PRISMS

Another kind of compound prism, called the Rutherfurd prism, (fig. 5b.) is not designed to give direct vision, though somewhat similar in construction. A flint glass prism of refracting angle about 90° (which could not be used alone) is flanked by two prisms of crown glass with the angles chosen so that the light will pass conveniently through the flint prism. Sometimes, the central prism is replaced by a hollow prism filled with carbon bisulphide.

VARIETIES OF SPECTRA

Emission Spectra.—Self-luminous sources yield *emission* spectra, which are of different types according to the nature of the source. The light from an incandescent solid body such as a gas mantle, or an electric glow lamp, is spread out into a band showing all the colours of the rainbow. The colours from red to violet merge into each other by insensible gradations, and the spectrum is said to be *continuous.* With rare exceptions, all incandescent solids and liquids give a spectrum of this kind, and it follows that such substances cannot be distinguished from one another so long as they remain in the solid or liquid state.

The effects are very different when the substances examined are in the state of luminous gas or vapour. They then emit special kinds of light by which they can be identified, whether they are subjected to experiment in our laboratories or are situated in a celestial body far away in the depths of space. The spectra are *discontinuous,* consisting of a number of bright lines or bands of different colours on a dark background. No two substances yield the same spectrum and it follows that the chemical nature of substances can be determined by an examination of their spectra. This is the foundation of spectrum analysis. Thus, glowing hydrogen is characterized by a bright line in the red, besides others in the more refrangible parts of the spectrum, and since these are exhibited by nothing but hydrogen, they serve to indicate the presence of hydrogen wherever it occurs in the luminous state. Each of the other elements also has its distinctive family of spectrum lines, some consisting of comparatively few lines, while others give hundreds or thousands of lines.

The distinction between line and band spectra is of great importance. A line spectrum consists of a succession of images of the slit of varying intensity, which are mostly well separated from each other. In a band spectrum, a great number of fine lines—called band lines—are closely crowded together in each band, especially near the so-called head of the band, so that they can only be separated with comparatively powerful instruments. The difference may be best understood by reference to the photographs of portions of the line and band spectra of nitrogen which are reproduced in Plate I., 1a and 1b. A succession of bands with well-marked heads, as in nitrogen, gives a fluted appearance to the spectrum, and bands of this kind are often called *flutings.* There are other bands of less regular appearance, and others which do not appear to be resolvable into lines. Line spectra are characteristic of atomic emissions, while band spectra originate in molecules. (*See* BAND SPECTRA.)

Absorption Spectra.—In contrast to emission spectra there is another class of spectra known as *absorption spectra.* A piece of glass which appears red by transmitted light owes this appearance to its property of transmitting red light and of absorbing the light of other colours of which white light is composed. (*See* COLOUR.) Such a piece of glass gives continuous absorption over a certain range of the spectrum, while a piece of neutral-tinted glass exhibits a partial continuous absorption throughout the whole of the visible spectrum. There are, however, many substances which, at ordinary temperatures, give characteristic absorption bands by which they can be identified. Among solid substances, glass coloured with salts of neodymium shows a beautiful set of dark bands when white light is passed through it before entering the slit of the spectroscope. (*See* Plate I., 2a.) Solutions of permanganate of potash, chlorophyll, blood and of many aniline dyes similarly show absorption bands which are characteristic in each case. Several gases and vapours in a non-luminous state at ordinary or moderate temperatures also yield absorption spectra peculiar to themselves. Iodine vapour, produced by slightly warming crystals of iodine in a test-tube, and nitrogen peroxide are good examples. Oxygen and water vapour similarly show their presence in our atmosphere by the appearance of their characteristic low-temperature absorption bands in the spectrum of sunlight.

Absorption spectra are also given by gases and vapours in a luminous state, when they are placed in the path of the rays from a white source at a higher temperature. Kirchhoff's famous experiment of 1859 proved that a luminous vapour has the property of absorbing precisely the same kind of light that it emits at the same temperature; so that if such a vapour (a sodium flame, for example) lies in front of a source at a higher temperature, and giving a continuous spectrum, the result is a continuous spectrum crossed by dark lines. An example of absorption is shown in Plate I., 2b, which represents the absorption of the vapour in a heated tube containing potassium. This result is of fundamental importance in Astrophysics because the spectrum of the sun and the spectra of most of the stars show dark lines or bands on a bright continuous background. The experiment of Kirchhoff proves that the substances which produce such dark lines can be identified, just as surely as if the lines were bright, by the process of matching the dark lines by emission spectra produced in the laboratory.

SOURCES FOR SPECTROSCOPIC OBSERVATION

While any luminous body is a suitable subject for spectroscopic investigation, there are several methods of exciting substances to luminosity which are especially convenient, or are of a character to give valuable information about the emitting atoms or molecules. Apart from the spectra of gases, and such phenomena as fluorescence, the three chief sources employed in a laboratory are the bunsen or oxyhydrogen flame, the electric arc and the electric spark. In general, the same substance will show differences in its spectrum when examined in these different ways, but some lines are usually common to the three sources. Lines which occur in the flame are distinguished as flame lines, but only those which have their greatest intensity in the arc are properly called arc lines; lines which are more strongly developed, or only appear, in the spark are called spark lines. The spark lines thus defined are the "enhanced lines" of Sir Norman Lockyer, and the distinction is now of great importance. In the language of modern spectroscopy, flame lines are the more easily excited lines of the neutral atom in question, while the arc usually exhibits the complete spectrum of the neutral atom together with the more easily excited lines of the ionized atom; the spark gives a special development of the lines of the ionized atom, besides retaining the more persistent lines of the neutral atom. Portions of the spark and arc spectra of strontium are shown in Plate I., 3a and 3b; it will be seen, for example, that the line at λ4,607, which is a flame line, is reduced in intensity in the spark, while the enhanced lines at λ4,078 and λ4,216 are relatively much intensified in the spark.

Flames.—The simplest procedure for the observation of flame spectra is to make use of a bunsen burner, and to introduce the various substances to be studied by means of a platinum wire, or on the charred end of a match. This method suffices to give spectra of the alkali and alkaline earth metals, and of thallium salts, as well as of numerous compounds such as copper chloride.

At the relatively low temperature of flames a large number of substances give banded spectra, as the molecules of the elements or compounds introduced are only partially dissociated into their component atoms. Some of these bands are due to oxides which are produced in the flame.

The Electric Arc.—A very valuable source for the observation of spectra is the electric arc, which, besides the advantage of great luminosity, will fuse and volatilize any substance which may be introduced between the poles. For the investigation of metallic spectra it is best to use poles made of the metals themselves, if they do not melt too readily, in order to avoid contamination. In general, however, some of the substance is placed on the lower (positive) pole of the carbon arc. The bands of the Swan spectrum of carbon and those of cyanogen which are given by the carbon itself would often be troublesome but for the fact that they tend to disappear if a sufficient amount of material be introduced. Lines due to impurities in the carbon rods can be distinguished by observing or photographing the spectrum before the introduction of the substance under examination. Acheson graphite rods can often be used with advantage, as the impurities are usually very slight. Rods of pure silver have also been used as a means of supporting the substance.

The appearance of so-called "reversed lines" in arc spectra is quite common. This is accounted for by a broadening of a line from the denser vapour in the core of the arc, and the superposition upon it of a narrower absorption line produced by the cooler and less dense vapour in the surrounding region.

It should be further noted that different parts of an arc show considerable variations in spectrum. The fully developed arc spectrum is restricted to the central core, while the surrounding "arc-flame" yields a spectrum corresponding to a lower temperature. The arc-flame may, in fact, often be conveniently used in place of the oxy-hydrogen flame. These differences are readily observed when an image of the arc is focussed on the slit of the spectrograph. By the same method it may be observed, more especially when the poles of the arc are metallic, that certain lines only appear, or are better developed in the immediate neighbourhood of the poles; these are the so-called "polar lines," and are generally found to be lines which are more strongly developed in the spark.

There is also a peculiar slight disturbance in the positions of some of the lines near the poles of an arc, called the "pole effect," which makes it necessary to establish a standard source when the iron arc is used to provide standards of wave-length. In the "Pfund arc," which has been recommended by the International Astronomical Union, the anode is below and consists of a bead of iron oxide supported on a massive rod of iron, while the cathode above is a rod of iron 6–7 mm. in diameter, having a massive cooling cylinder of copper or brass close to the end of the rod. The current may be five amperes or less at 110–250 volts, and the arc 12–14 mm. in length. Only the central zone at right angles to the axis of the arc, not exceeding 1½ mm. in width is to be used.

The "vacuum arc" is an important modification of the ordinary arc in which the arc is enclosed in a vessel which can be exhausted. Under these conditions the spectrum tends to approach that given by the spark, and the lines are very sharply defined. The same arrangement may also be used for passing the arc in any desired gas, such as hydrogen.

The Electric Spark.—The luminosity for observations of spark spectra is usually produced by discharges from an induction coil between terminals made of the substance to be examined, or between terminals of platinum on which the substance is supported. Transformers suitable for the purpose are also available. As shown in fig. 6, a Leyden jar or other condenser, J, is connected in parallel with the leads A and B from the coil to the terminals, S, which are separated by only a few millimetres. Without this condenser, the luminosity is very feeble and the spectrum consists almost entirely of bands of nitrogen.

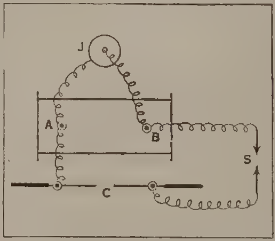
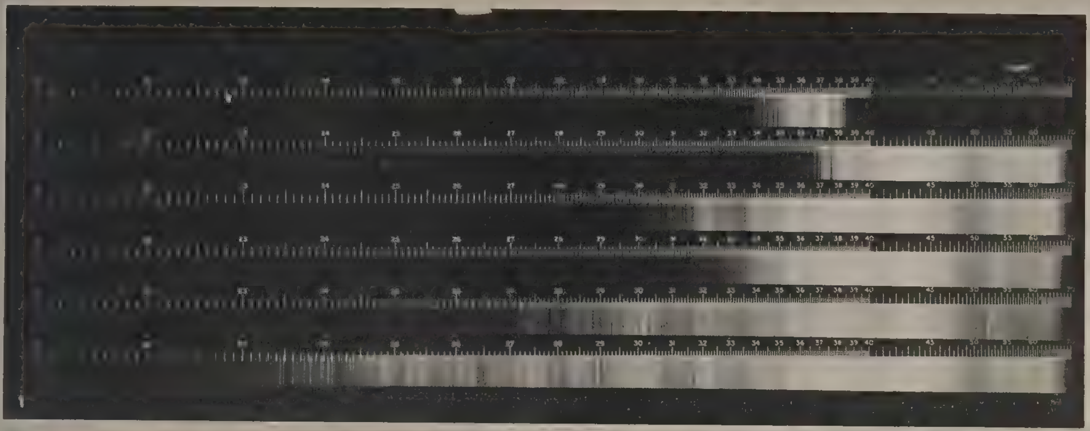


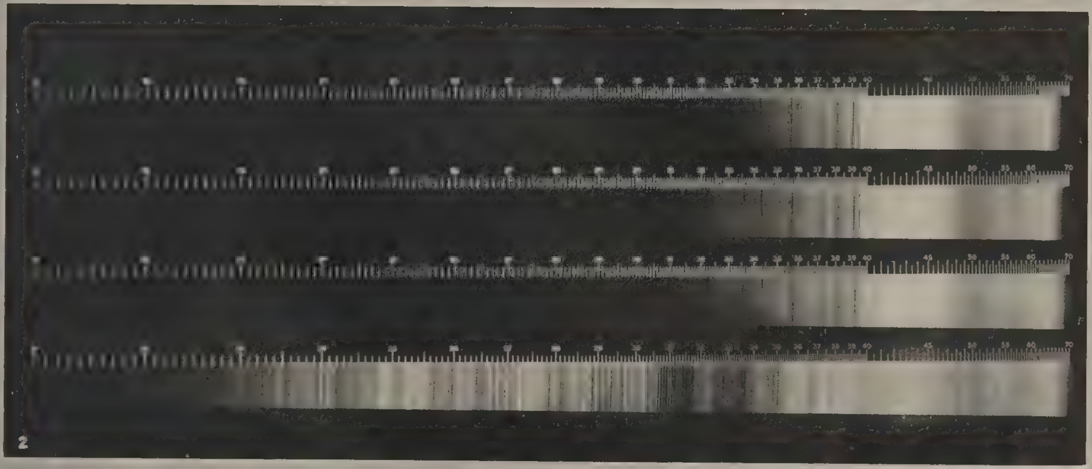
FIG. 6.—THE ELECTRIC SPARK

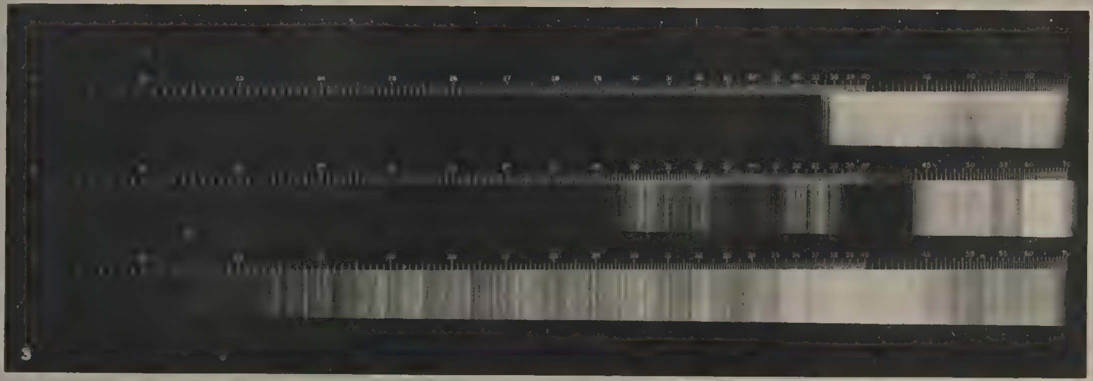
The intensity of the discharge can be greatly varied by making use of an auxiliary spark gap, shown at C in fig. 6; the longer this gap the greater the potential to which the condenser must be charged before the discharge will pass.

The condensed spark yields lines special to the substance under examination, and, in addition, lines due to atmospheric nitrogen and oxygen. The air lines are common to all the spectra observed in this way and can therefore readily be identified as such. Air lines can also be eliminated by passing the spark in a closed vessel containing hydrogen, the spectrum of which is much simpler than that of air. The spectra of gases surrounding the spark can be abolished altogether by introducing a self-induction coil in series with the spark, as between C and S in fig. 6, in accordance with the investigations of Schuster and Hemsalech.

Vacuum Tubes.—The spark discharge as described above can clearly be used to obtain the spectra of gases. Under these conditions, however, the gas lines are mostly too broad for accurate measurement, and observations are accordingly more generally







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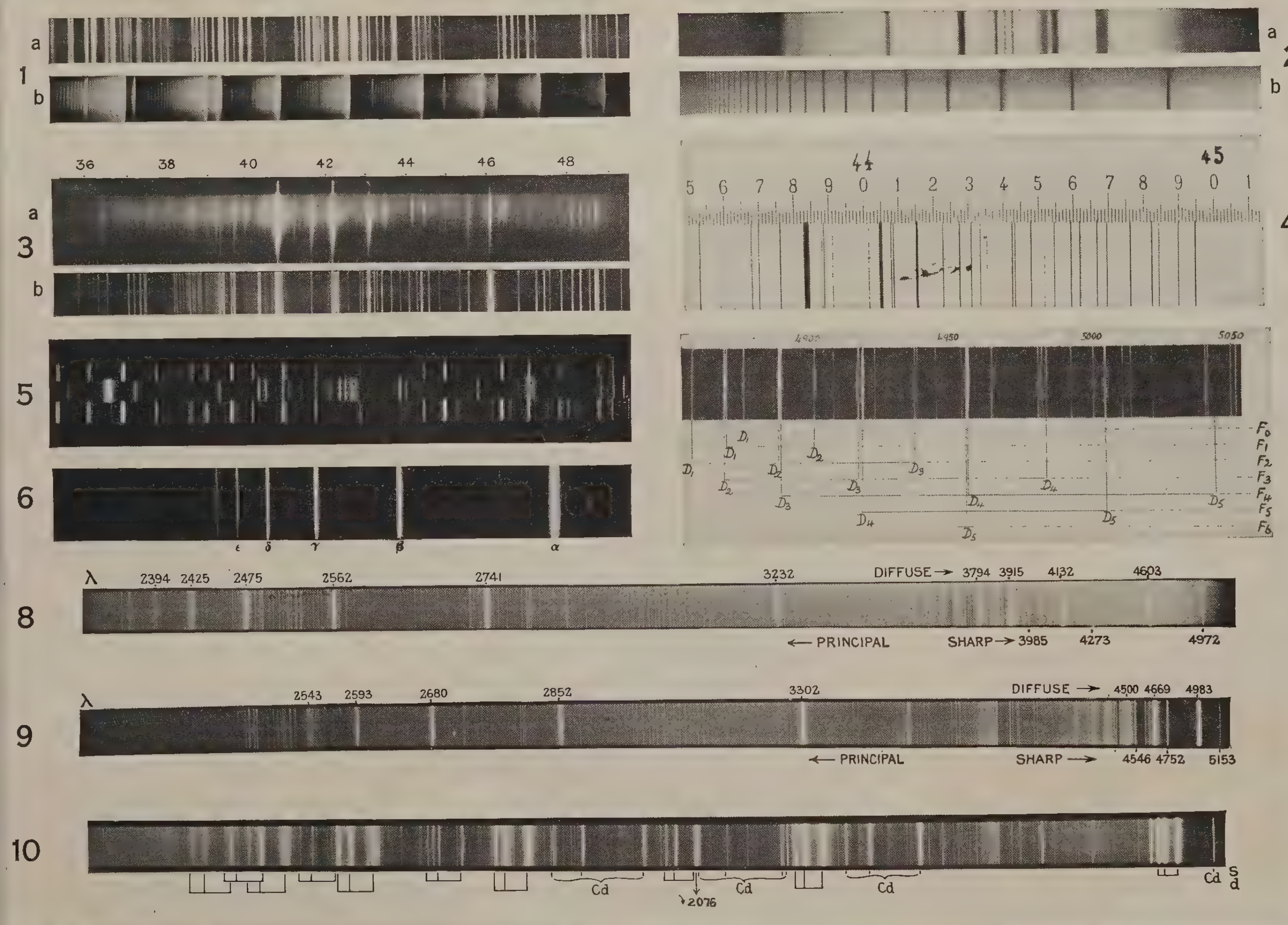
SPECTRA ON A QUARTZ SPECTROGRAPH

1. Spectrum on a quartz spectrograph with a metallic arc giving numerous lines in the ultra-violet as follows: the lowest spectrum shows quartz spectrograph without anything in it; 2nd line, with Vita glass; 3rd line, with plate glass; 4th line, with optical crown glass; 5th line, with dense flint optical glass; 6th line, with Wood's glass
2. Another set of spectrographs with: lowest line, metallic arc; 2nd line, solar spectrum; 3rd line, solar spectrum with Vita glass; 4th line, solar spectrum with plate glass
3. A third set of spectrographs with: lowest line, metallic arc; 2nd line, blood; 3rd line, carbon disulphide

SPECTROSCOPY


1
a
b
2
a
b
3
a
b
36
38
40
42
44
46
48
4
44
45
5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
5
6
ε δ γ β α
7
4900
4950
5000
5050
D_1 D_2 D_3 D_4 D_5
F_0 F_1 F_2 F_3 F_4 F_5 F_6
8
λ
2394 2425 2475 2562 2741 3232
DIFFUSE → 3794 3915 4132 4603
← PRINCIPAL
SHARP → 3985 4273 4972
9
λ
2543 2593 2680 2852 3302
DIFFUSE → 4500 4669 4983
← PRINCIPAL
SHARP → 4546 4752 5153
10
Cd
Cd
Cd
2076
Cd
S
d

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SELECTED PORTIONS OF TYPICAL SPECTRA

1. Spectra of nitrogen; (a) line spectrum, (b) band spectrum. 2. Absorption spectra; (a) neodymium glass, (b) potassium vapor. 3. Spectra of strontium; (a) spark, (b) arc. Flame lines are reduced in intensity in the spark spectrum, while "enhanced" or "spark" lines are intensified. 4. Portion of photographic map of iron-arc spectrum, from which approximate wave-lengths may be obtained. 5. Spectra of iron and oxygen (middle), placed in juxtaposition for comparison and determination of wave-lengths. 6. "Red" spectrum of hydrogen, showing Balmer series of lines peculiar to this element in the visible and near ultra-violet regions. 7. Arc spectrum of iron, under high dispersion, showing a multiplet of 15 lines and plan of its structure. 8. Arc spectrum of lithium, showing the constituent principal, sharp and diffuse series. The lines, apparently single, are very close doublets. 9. Arc spectrum of sodium, similar to that for Lithium. The terms principal, sharp, and diffuse refer to the appearance of the lines composing the respective series. 10. Arc spectrum of zinc and cadmium, showing triplet systems

made with the gases at reduced pressures in so-called "vacuum tubes." Such tubes are made in great variety according to the object of the experiments undertaken. Fig. 7a represents a form called the Geissler or Plücker tube, which can be purchased ready prepared for spectroscopic examination. It consists of two glass tubes of about three inches in length and half an inch in diameter, connected by a short length of capillary, and having a platinum wire sealed in at each end. The tube is exhausted and the desired gas admitted through a side tube, which is sealed off with a blowpipe when suitable conditions are established. When the electrodes are connected with an induction coil, a bright discharge passes through the tube, varying in colour and spectrum with the gas which has been introduced. The discharge is especially brilliant in the capillary tube, where the current density is greatest, and the spectrum shown by this is usually different from that given by the wider parts of the tube. The spectrum of the same gas also varies according as the discharge is passed with or without a condenser in the secondary circuit, the changes being comparable with those observed in passing from arc to spark.

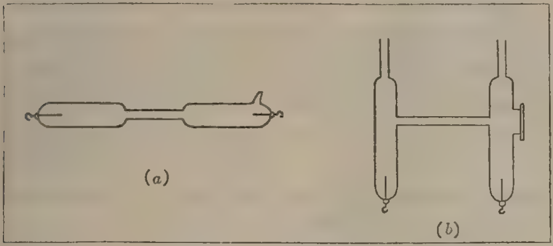


FIG. 7.—GEISSLER TUBES

Another common form of tube is shown in fig. 7b; this is designed to give an "end on" view along the capillary, and since glass is not transparent to ultra-violet light, a side tube with a quartz window is often added as shown in the diagram. With this form of tube the spectrum appears with greater intensity. Sometimes the whole vacuum tube is made of fused silica glass. In most experimental work, the vacuum tubes are not sealed, but remain in connection with the exhaustion pump and the source of the gas under investigation, so that the pressure and other conditions can be conveniently controlled. Much care is necessary to obtain pure gases in the tubes.

When mixed gases are under examination, it frequently happens that a particular discharge will not produce spectra of all the gases present. Thus, an uncondensed discharge through a vacuum tube containing residual air will show the bands of nitrogen but will give no indication that there is any oxygen in the tube. Both gases, however, are revealed by their line spectra when the condensed discharge is passed through the mixture. In analysing a mixture of gases it is accordingly necessary to observe the spectrum under varying conditions of electrical discharge, and variations of pressure are also desirable.

Other Sources.—The methods of exciting substances to luminosity above described provide the observer with a wide range of exciting energies, but numerous additional methods have also been adopted. Thus, the electric furnace, in the form of a carbon tube heated by heavy electric currents, has been very effectively employed by A. S. King at the Mount Wilson laboratory. In this way the temperature of the emitting vapour is well under control and the order of appearance of the lines is a valuable aid in investigations of the structure of the spectrum. Interesting results have also been obtained by King with arcs in air using a current of the order of 1,000 amperes at 100 volts. Similar experiments by J. W. Ryde, with currents up to 250 amperes, have been of special value in revealing with great intensity the line spectra of neutral carbon and nitrogen, which were previously only partially known. Our knowledge of these spectra had previously been considerably extended by T. R. Merton by observations of carbon compounds, or of nitrogen, when mixed with a large proportion of helium. A further application of Merton's method, though better results were obtained with argon admixture, was made by J. C. McLennan and G. M. Shrum in experiments on oxygen which led them to their important discovery that a line of neutral oxygen observed under these conditions was identical in position with the green line which is most characteristic of the spectrum of the aurora.

SPECTROSCOPIC MEASUREMENTS

The need for some means of expressing the positions of lines in the spectrum is sufficiently evident. In the more common forms of spectroscope the observing telescope is provided with cross-threads which can be brought into coincidence with any given spectrum line, and the position of the telescope is then read off on a graduated circle. Such readings will evidently give the relative positions of the lines on an arbitrary scale, but readings for the same lines on different instruments will not be directly comparable. Similarly, when dealing with photographs it is only possible to measure directly the relative positions in arbitrary units.

Wave-lengths.—Measurements of spectra which have been observed or photographed become directly comparable with each other when they have been converted to the scale of wave-lengths of the light which produces them. The credit of introducing this scale into spectroscopy is due to A. J. Ångström, who mapped the spectrum of the sun in terms of wave-lengths in 1868. The same procedure was subsequently adopted by his colleague Thalén in connection with the spectra of the elements, and since that time the positions of spectrum lines in all spectroscopic tables have been stated in wave-lengths. The unit of wave-length in spectroscopy is the ten-millionth of a millimetre, or 10^{-8} centimetre. It is called the tenth-metre (10^{-10} m.) or "angstrom," and is now ordinarily indicated, when necessary, by writing A after the figures indicating the wave-lengths. In these units, the visible spectrum ranges from about 3,900A at the violet limit to about 7,600A in the extreme red. When it is stated, for example, that the wave-length of the red line of hydrogen is 6,562·79A, it is to be understood that it amounts to $6,562{\cdot}79\times10^{-8}$ cm. Wave-lengths, especially in connection with the invisible infra-red part of the spectrum, are also often expressed in terms of the *micron* (μ), which is one-thousandth of a millimetre; thus the wave-length of the red hydrogen line might be written $0{\cdot}656279\mu$.

Absolute wave-lengths cannot be determined directly by the use of prisms, but are determined by observations made with diffraction gratings or by interference methods. In ordinary spectroscopic work, however, whether with prisms or gratings, no attempt is ever made to determine the wave-lengths directly. The wave-lengths required are deduced by interpolation between standard lines which have previously been determined with sufficient accuracy.

Wave-numbers.—More especially in connection with investigations of regularities in spectra it is important to express the positions of spectrum lines in "wave-numbers" instead of in wave-lengths. The most fundamental figures in this connection for theoretical purposes are the "oscillation frequencies," since these are independent of the medium through which the light passes. Oscillation frequency may be defined as the number of waves which pass a given point in one second, and is equal to the velocity of light (c) divided by the wave-length (λ) in vacuo, i.e., $n=c/\lambda$. Since the velocity of light is very great (nearly 300,000 kilometres per second), and the wave-lengths very small, oscillation frequencies are represented by extremely large numbers. Thus, for red light of wave-length 6,500A the frequency is about 462 billions per second, while for violet light of wave-length 4,200A it is 713 billions per second. Difference in colour, it will be noticed, depends upon difference in the frequency of the waves that reach the eye. These oscillation frequencies are not directly measurable but can be deduced from the measured velocity of light combined with measurements of wave-lengths. They are unsuitable for ordinary spectroscopic use on account of their great magnitude. It is accordingly the practice to replace the actual frequencies by "wave-numbers," representing the numbers of waves in the length of a centimetre. Since the wave-number is dependent on the wave-length, it will vary with the medium in which the vibrations are propagated, and in the calculation of wave-number from wave-length it is therefore necessary to express the wave-length *in vacuo*. If a wave-length has been measured in air it must be corrected to vacuum conditions for the determination of the corresponding wave-number. This correction is based upon measurements of the refractive index of air for different wave-lengths, and convenient tables have been prepared for its application. When corrected to vacuum in this way the calculated wave-numbers are strictly proportional to the corresponding oscillation frequencies.

Standard Wave-lengths.—The primary standard of wave-length in modern spectroscopy is based upon interferometer measurements of the red line of cadmium, under standard conditions, in relation to the standard metre. The unit of wave-length thus arrived at is called the International Angstrom, and is very close to 10^{-10} metre. The standard conditions are air at 15° C and 760 mm. pressure, $g=980{\cdot}67$, and the wave-length of the red cadmium line, adopted by international agreement, is then 6,438·4696I.A. This has been deduced from the work of C. Fabry and A. Perot, and is in close agreement with the value determined by A. A. Michelson. (*See* INTERFEROMETER.) The older spectroscopic tables are on the scale of Rowland, which was based upon slightly erroneous absolute wave-lengths for the two yellow lines of sodium; such tabulated spectra can be approximately corrected to the international scale by subtracting quantities ranging from 0·25 at 7,000A to 0·06 at 1,950A.

The most useful secondary standards, especially for work with large instruments, are provided by the arc spectrum of iron, which includes many hundreds of lines. Many of these have been measured with respect to the red cadmium line in various laboratories, and a number of secondary standards for general use have been recommended by the International Astronomical Union (*Transactions*, vol. III., 1929).

Interpolation of Wave-lengths.—The secondary standards, which have thus been determined by interferometer methods may obviously be used for the determination of the positions of lines in any other spectra by interpolation, employing ordinary spectrographs. For this purpose, photographs are taken of the source under examination through one portion of the slit, and an arc spectrum of iron through one or both of the adjacent portions, so that two spectra in juxtaposition, or slightly overlapping, are obtained as illustrated in Plate II., fig. 5. Lines of other elements thus become, in turn, available for use as tertiary standards, and may be used with instruments which give too small a dispersion to resolve satisfactorily the complicated spectrum of iron.

When a prismatic spectrum is used, the dispersion increases rapidly as the wave-length diminishes, and simple linear interpolation between standards will not give correct results. When the spectra do not permit of very accurate measurement, the interpolation may be performed graphically, using measurements of the lines under investigation and a number of lines of known wave-length in conjunction. The same procedure may be adopted for measurements of a photograph with a finely divided scale, if a comparison spectrum which includes lines of known wave-length has also been impressed on the plate, or if a sufficient number of known lines are included in the spectrum under examination.

For more accurate determinations, photographs are measured with a photo-measuring micrometer. This consists of a microscope of moderate or low power which can be made to traverse the photograph by means of an accurate screw of small pitch, so that the cross-threads are brought successively into coincidence with the desired lines; the positions of the lines are then read off on a scale which counts complete turns of the screw, and a divided drum head which registers fractions of a turn. As before, lines of known wave-length, which are generally provided by a comparison arc spectrum of iron, must be included in the measurements. Interpolation may then be most conveniently performed with the aid of a formula first proposed by A. Cornu and afterwards brought into more general notice by J. Hartmann. The wave-length, λ, and the scale reading, s, are here supposed to be related by the hyperbolic formula

$$\lambda=\lambda_0+C/(s+s_0).$$

Three lines of known wave-length, and the corresponding scale readings are thus required in order to determine the constants λ_0, C and S_0; one should be chosen near each end, and the other near the middle of the region investigated.

The wave-lengths so determined will not be quite exact, because the formula does not accurately represent the dispersion of the spectrum on the plate, except over a small range. The imperfection of the formula, however, can be corrected by including a number of well distributed known lines in the measurements. The differences between the calculated and known values of these lines are then plotted to give a "curve of errors," which can be used to give the corrections to the calculated wave-lengths of the lines under observation. This procedure might, of course, be adopted with any approximate formula, but the Cornu-Hartmann formula has the advantage that the corrections are small.

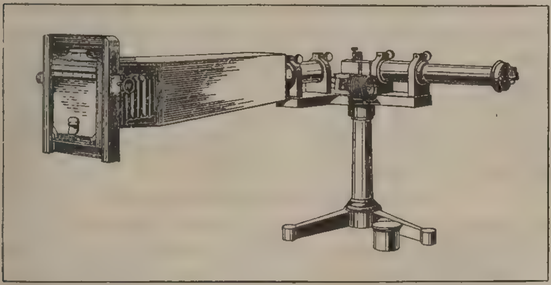
The dispersion in spectra produced by gratings is much more uniform—that is, the spectra are more nearly *normal*—than in those produced by prisms. By certain arrangements, the scale of a grating apparatus can be made quite normal for visual observations, but in all photographs there is a slight departure from a uniform scale. Interpolation may then be made by following the procedure which has been outlined for prismatic spectra, except that the Cornu-Hartmann formula is replaced by a linear interpolation formula, such as $\lambda=\lambda_0+bs$, where λ_0 and s can be calculated from two of the standard lines which are included in the measurements. The necessary corrections for lack of normality are then given by a curve of errors similar to that described for prismatic spectra.

A good photographic map of the iron arc spectrum, which is indispensable in practical spectroscopy, has been prepared by C. Fabry, ranging from $\lambda 2{,}327$ to $\lambda 6{,}700$. A small portion of this is reproduced in Plate II., fig. 4; approximate wave-lengths can be read off from the map and the corresponding accurate wave-lengths obtained from tables.

PHOTOGRAPHIC SPECTRA

Spectroscopic work of precision is now almost invariably carried on by photographic methods. A photographic record of a spectrum has many obvious advantages; it can be examined as often as desired by any number of persons without the need for repeating the experimental arrangements, and it can be more conveniently and more accurately measured. Moreover, with appropriate instruments, the invisible ultra-violet part of the spectrum can be included in the photographic record, and by the use of specially prepared photographic plates a considerable portion of the near infra-red region, extending as far as $\lambda 10{,}000$A, or 1μ, can also be photographed. The additional region in the ultra-violet thus opened up is of considerable importance from the point of view of spectrum analysis, and both regions are of great significance in connection with investigations of the structure of spectra. The photographic plate has a further important advantage arising from the power of integrating successive impressions, whereas the eye can only take account of momentary effects on the retina; spectra which are too faint for satisfactory direct observation may thus be made available for investigation by photographs taken with long exposures.

Spectrographs.—In their optical arrangements, spectrographs are similar to the spectroscopes intended for visual observations. It is, in fact, only necessary to replace the observing telescope by a camera provided with a suitable object glass as shown in fig. 8. If the object glass of the telescope itself were utilized and the spectrum could be photographed on a perfectly transparent plate, it will be clear that when viewed with the eyepiece as magnifier, the spectrum would be identical with that directly observed, apart from the absence of colour. Photographic plates, however, have a granular structure and lines which might be just separated visually would not appear separated on the plate. Thus, to obtain a photographic resolution equivalent to the visual, it is necessary to use a camera lens of considerably greater focal length than that of the ordinary telescopic objective, so that the spectrum may be magnified before it reaches the photographic plate. It is desirable, though not essential, that the collimating lens should have a focal length not very different from that of the camera lens, and with the ordinary construction such instruments are apt to be unwieldy. Long focus spectrographs are accordingly now most frequently built up on the plan suggested by Littrow. In this form the same lens serves as collimator and camera lens, and light passing through the prism is returned along the same path either by a plane mirror behind the prism, or by a half-prism silvered on the back, as shown in fig. 9. In such an instrument the slit, S, is placed at the side and light entering it is directed along the axis of the lens by a small reflecting prism *p*, and it is easy to arrange matters so that the spectrum enters a narrow aperture in the camera at P just above the level of the reflecting prism. The Littrow arrangement has the advantage that each dispersing prism acts as two prisms, and in addition, the instrument may be made of great rigidity.



BY COURTESY OF HILGER

FIG. 8.—A SIMPLE SPECTROGRAPH

Since there is nothing on a photographic plate to indicate the wave-lengths of any of the lines, except that many lines can be identified by their peculiar groupings, it is usually necessary to photograph a known spectrum, which has already been accurately measured, in juxtaposition with that under observation.

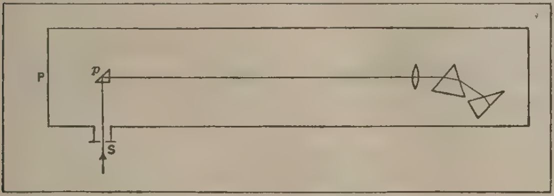


FIG. 9.—LITTROW SPECTROGRAPH

The Infra-Red.—Since glass is not transparent to the ultra-violet and infra-red rays, or only to a small extent, prisms and lenses made of other substances are requisite for the exploration of these parts of the spectrum. Prisms of rock salt, which are largely used for the infra-red, will transmit as far as wave-length 150,000A, or 15μ, whilst a fluorite prism will transmit as far as 9μ, and one of sylvine as far as 23μ. To reduce loss of intensity by absorption, concave mirrors are used in place of lenses for collimation and image formation. A delicate thermopile, which is connected with a highly sensitive galvanometer, reveals the presence or absence of spectrum lines as the spectrum is moved across it by rotating the prism. Readings on the scale of the prism table are then convertible to wave-lengths with the aid of standards which have been determined by the use of gratings. By the use of a large concave grating in place of a prism, F. Paschen has measured many spectra as far as 3·1μ. With the aid of Eastman Kodak's neocyanine and kryptocyanine plates, the infra-red spectrum can now be directly photographed as far as 1μ.

The Ultra-Violet.—As regards the ultra-violet, which may be considered to begin at about λ3,900, prisms of light flint glass will transmit to the neighbourhood of λ3,300, while prisms of the so-called *uviol* glass will extend this to about λ 2,900. Beyond this, if prisms are used, it is necessary to construct them from natural crystals, usually Iceland spar or quartz, and principally the latter. With an instrument built up from prisms and lenses of quartz, it is possible to photograph as far as about 2,100A with ordinary plates and to about 1,840A with specially prepared plates. It is in fact possible to *see* the whole of this part of the spectrum by allowing it to fall on a fluorescent screen such as is used in X-ray observations. The need for special plates for the most refrangible part of this region is due to the fact that gelatine absorbs the short waves before they can reach the sensitive salts which are embedded in it. An extremely useful method is that introduced by Duclaux and Jeantet, in which an ordinary plate is coated with an oil, such as paraffin, or nujol, which becomes fluorescent under the stimulus of ultra-violet light so that the spectrum is actually photographed in light of longer wave-length; when this method is applied the oil must be removed, as by washing the plate with benzene, before development. Plates prepared by Schumann's method, in which the gelatine is reduced to the smallest quantity that will allow adherence of the silver salts to the glass, however, are the most suitable for the extreme ultra-violet. Such plates are now prepared commercially by the firm of Adam Hilger, Ltd., London.

As quartz has the property of double refraction, it is necessary to cut prisms of this material so that the optic axis of the crystal is at right angles to the refracting edge and parallel to the base. Even then, however, there would be a slight doubling of the spectrum lines arising from the property of quartz by which it rotates the plane of polarization. This is overcome by Cornu's device (fig. 10) in which one half of the prism is made from right and the other from left-handed quartz. The two lenses in a quartz spectograph are also of opposite rotations, and in order that a long range of spectrum may be in good focus, the photographic plate must be inclined to the axis of the camera, and bent to an appropriate curve in the plate-holder.

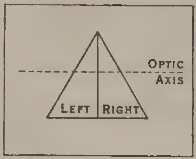


FIG. 10.—CORNU PRISM

The Schumann Region.—For wave-lengths still shorter than 1,840A, fluorite is the most useful substance at present known. With prisms and lenses of this material it is possible to photograph as far as 1,200A, providing that Schumann plates are used and that the absorption of air is eliminated by exhausting the spectrograph and allowing no air to intervene between the source and the slit. Victor Schumann was the first to investigate by this method and the region from 1,850A to 1,200A is conveniently called the Schumann region. Even one millimetre of air at atmospheric pressure will absorb all light of wave-lengths less than about 1,700A. Among the sources which are available for investigations in this region, the slit being covered with a thin plate of fluorite, are the "vacuum arc" (an electric arc in an exhausted vessel), the spark in an atmosphere of hydrogen (this gas being transparent for short waves), vacuum tubes, and the "vacuum spark" of Millikan and Bowen in which short sparks are produced by heavy discharges between terminals in a high vacuum. In each case, the vessel containing the source is sealed to the slit plate of the instrument.

The Extreme Ultra-Violet.—The region of the spectrum lying beyond the limit set by fluorite can at present only be investigated by the use of concave diffraction gratings, in which no lenses are used, and the path of the rays from the source to the photographic plate is entirely *in vacuo*. With such instruments the spectrum has been photographed as far as 136A by Millikan and Bowen, and the region beyond this—the soft X-ray region—has been photographed by Jean Thibaud, using a grating near grazing incidence.

CHEMICAL ANALYSIS BY THE SPECTROSCOPE

Qualitative Analysis.—Spectroscopic methods provide an important aid to chemical analysis, especially when an element is present only in small proportion, or when only a small quantity of a substance is available for examination. The principles involved in qualitative analysis are embodied in what has been stated before, and it is only necessary to add a few supplementary remarks. In the first place, it should be understood that although refined measurements extending over the greatest possible range of spectrum, and including spectra emitted under very varied conditions, are necessary for exhaustive investigations of the structure of spectra, the procedure for purposes of chemical analysis is much simpler. Such analysis can, in fact, be carried on to a considerable extent without any attempt at precision in the determination of wave-lengths by either visual or photographic methods.

For visual observations with an ordinary spectroscope, the graphical method of interpolation is sufficiently accurate for the identification of many spectrum lines. It is more convenient, however, to use a wave-length spectrometer, in which the scale is so constructed that wave-lengths of fair accuracy can be read off directly. Then again, familiarity with the spectra of various elements often enables an experienced observer to identify lines at sight; for, in addition to the help given by colour, lines frequently occur in groups which can be identified in the same way that constellations are recognized among the stars.

An iron arc spectrum is photographed beside the spectrum under investigation, and estimates of wave-length, accurate enough for purposes of identification, can be made by reference to the scale on a wave-length map of the iron spectrum. If the spectrum is a complicated one, and some of the constituent elements have been identified in this way, it is convenient to take additional photographs with these elements as comparisons. Measurements and calculations of wave-lengths are then necessary only for the lines which remain unidentified. As the most sensitive lines of many of the elements lie in the ultra-violet, a quartz spectrograph is usually the best instrument for chemical applications.

It is sometimes convenient, or necessary, to analyse solutions by the spectroscopic method. If the electric arc be employed, it is generally sufficient to soak the tips of the carbon poles in the solution before striking the arc. It is usually more satisfactory, however, to use the condensed spark, in which case the lower electrode may be formed by a bundle of fine platinum wires standing in the liquid and projecting slightly above its surface, while the upper electrode is a stouter piece of platinum wire.

For the analysis of refractory substances, such as silicates, the method introduced by A. de Gramont gives excellent results. The substance is first fused with four or five times its weight of sodium or lithium carbonate, and is placed in a small platinum cup which forms the lower electrode for the passage of a condensed spark. The cup is heated by a bunsen flame while the discharge passes. In photographic work, the spectrum of the fusion material would naturally be photographed separately, so that its contribution to the final spectrum could easily be recognised.

Abridged tables of spectra, including the brightest and most sensitive lines of the various elements, have been compiled to facilitate chemical identifications. (*See* Bibliography.)

Quantitative Analysis.—Several of the earlier workers with the spectroscope were attracted by the possibility of discovering methods by which spectrum analysis might yield quantitative results. Such methods as were proposed, however, were too restricted in their application, or subject to too many experimental uncertainties, to be of much practical service. The advance in the theory of spectra has somewhat improved the outlook, but even now the most successful methods are of limited application and of an entirely empirical character.

The most systematic efforts to establish a procedure for quantitative analysis are probably those made at the United States Bureau of Standards by W. F. Meggers and others (*Scientific Papers*, No. 444). The method is based partly on the work of de Gramont, who made a prolonged study of the so-called *raies ultimes* of the elements, these being the last lines to disappear as the proportion of an element in a mixture is reduced towards the vanishing point. As an example of the procedure adopted, the method of estimating a small percentage impurity of zinc in tin may be considered. A graded series of alloys is first prepared, of tin containing zinc in the proportions 0·001, 0·01, 0·1, 1·0, and 10·0 per cent., and their spark spectra are compared under identical conditions. The lines of zinc will obviously increase in intensity with respect to those of tin as the quantity of zinc increases, and the correlation of the intensities with the known percentage composition of the specimens provides a scale for the analysis of similar alloys of unknown composition. Similar methods have been successfully employed in the quantitative analysis of samples of gold and platinum, and give promise of useful application in numerous problems of practical importance.

DISPERSION AND RESOLVING POWER OF PRISMS

Dispersion.—The dispersion at any point in the spectrum is defined as the rate of change of the angle of deviation with respect to a small change in the wave-length. Thus, if θ be the angle of deviation from the original path of the light, the dispersion is represented mathematically by $d\theta/d\lambda$. Since θ varies with the refractive index of the glass (μ), and the refractive index varies with the wave-length (λ), we may write

$$\text{Dispersion} = d\theta/d\lambda = d\theta/d\mu \cdot d\mu/d\lambda.$$

Dispersion thus depends upon two factors. The second, $d\mu/d\lambda$, depends solely upon the optical properties of the glass of which the prism is composed and may be calculated from observations of the refractive indices for different wave-lengths, when expressed in a formula. If the refractive indices be approximately represented by an equation of the form $\mu = a + b/\lambda^2$, the constants a and b being deduced from measured values of μ for different wave-lengths, $d\mu/d\lambda = -2b/\lambda^3$. The negative sign merely implies increase of μ with decrease of λ, and it follows from the formula that the dispersive power varies roughly in proportion to the inverse cube of the wave-length. For example, the dispersion at $\lambda 3{,}500$ in the near ultra-violet is about eight times that at $\lambda 7{,}000$ in the extreme red.

The other factor in the expression for the dispersion of a prism, $d\theta/d\mu$, depends upon the angle of the prism, and on the way in which it is presented to the incident light. If, as in fig. 11a, the angles of incidence and emergence be represented by i_1 and i_2, the internal angles of refraction by r_1 and r_2, the angle of the prism by α, and the angle of deviation by θ, it is readily deduced from the fundamental relation $\sin i = \mu \sin r$ that

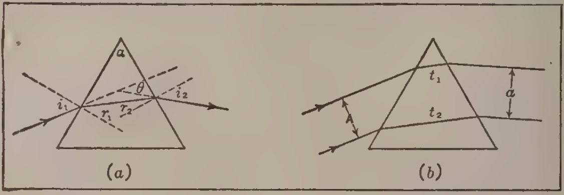


FIG. 11.—DISPERSION AND RESOLVING POWER OF PRISM

$$\frac{di_2}{d\mu} = \frac{\sin(r_1 + r_2)}{\cos r_1 \cos i_2}$$

or, since $d\theta = di_2$, and $r_1 + r_2 = \alpha$,

$$\frac{d\theta}{d\mu} = \frac{\sin\alpha}{\cos r_1 \cos i_2}.$$

This expression clearly shows the dependence of the dispersion on the angle of the prism and the angle of incidence, but, following Lord Rayleigh, a very convenient geometrical equivalent can be deduced; namely,

$$\frac{d\theta}{d\mu} = \frac{t_2 - t_1}{a}$$

where t_2 and t_1 are the lengths in the prism traversed by the extreme rays, and a is the breadth of the emergent beam. When the prism is at minimum deviation and the beam is large enough to cover it, $t_2 - t_1$ is equal to the length of base of the prism. The whole dispersion may now be written,

$$\text{Dispersion} = \frac{d\theta}{d\lambda} = \frac{t_2 - t_1}{a} \cdot \frac{d\mu}{d\lambda}.$$

The same expression can also be deduced directly by an application of Fermat's principle of optical distances.

When there is more than one prism, the sum of the values of t_2-t_1 is to be taken, and in direct vision of compound prisms, the algebraical sum is taken, the crown glass prisms being regarded as negative.

Resolving Power.—The power of separating closely adjacent spectrum lines is called the resolving power of the prism. (*See* LIGHT.) As now employed this is a theoretical quantity, representing the separating power when the slit is indefinitely narrow, and is given numerically by $R=\lambda/d\lambda$, where $d\lambda$ is the difference of wave-lengths of two lines which can just be divided. R does not increase indefinitely as the slit is narrowed, because the image of the slit is broadened by diffraction. The actual image is a diffraction pattern, as roughly shown, with the corresponding intensity curve in fig. 12. Most of the light is concentrated in the central band, and the secondary bands can be disregarded. If f be the focal length of the camera lens, and a the effective breadth of the beam passing through it (the effective beam being supposed of rectangular cross section) the half-breadth (ρ) of the central band is given by the elementary theory of diffraction as $\rho=f\lambda/a$. It is to be observed that the shorter the wave-length the narrower is the band, while a reduction of aperture is accompanied by a broadening.

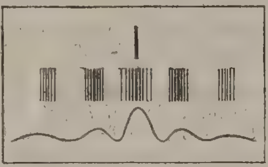


FIG. 12.—DIFFRACTION IMAGE OF A SLIT

The condition for resolution may be conveniently explained by reference to fig. 13, where the spectrum is supposed to be thrown on a screen by the second lens. The wave-lengths of two closely adjacent lines from light entering the slit at s being λ and $\lambda-d\lambda$, the corresponding separation by the prism is $d\theta$. Each line appears as a diffraction band, of which the intensity curves are shown, and resolution is just effected when the maximum of one band falls on the minimum of the other, that is, when the distance between the centres of the two bands is ρ. Under these conditions the integration of the two bands gives a curve with two maxima and if the intensity of these be taken as unity, that of the minimum between is 0·8. Experience has shown that this difference is sufficient to resolve lines, and the condition for resolution is thus $d\theta=\rho/f_2=\lambda/a$; or, $\lambda=a\cdot d\theta$. In this expression, it should be remembered, a is not necessarily the diameter of the image lens, but the effective breadth of the beam which enters it. By definition, $R=\lambda/d\lambda$ and we thus find $R=a\cdot d\theta/d\lambda$, or in Rayleigh's form,

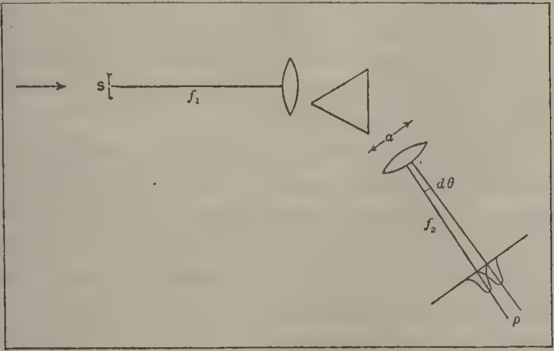


FIG. 13.—RESOLVING POWER OF SPECTROGRAPH

$$R=(t_2-t_1)\cdot d\mu/d\lambda.$$

When there are several prisms, the algebraical sum is to be taken as in the case of dispersion. A prism of ordinary flint glass of about 1 cm. base is thus found to have a resolving power for sodium yellow light of about 1,000, while a prism of 10 cm. base would have a resolving power of 10,000.

Purity of Spectrum.—In practice, it is necessary to give the slit a finite breadth, and the actual separating power must accordingly always be less than the theoretical resolving power. The actual separating power is called the *Purity* and is defined by $P=\lambda/\Delta\lambda$ where λ is the wave-length of the light in question and $\Delta\lambda$ the difference in wave-length of two lines which are just divided. While R is constant for a given instrument under the same conditions, P refers to the actual separating power in the spectrum obtained from it with the particular slit width employed and with any modified position of the prism P and R are related by the formula:

$$P=R\frac{\lambda}{\lambda+As/f_1},$$

where A is the breadth of the incident beam, s the width of the slit and f the focal length of the collimating lens.

DIFFRACTION GRATINGS

Types of Gratings.—The diffraction grating is of great importance to the spectroscopist as providing him with the means of producing spectra of great dispersion and purity. The first gratings were made by Fraunhofer about 1820, by winding thin wire over two fine screws of equal pitch kept an inch or two apart by bars of metal; the wires were soldered to the screws, and the whole framework was sawn in two along the axes of the screws, so as to make two gratings. With these wire gratings Fraunhofer was able to measure the wave-length of sodium light with considerable accuracy.

Modern gratings are made by ruling equidistant parallel lines with a diamond point on a plate of glass or speculum metal. Those in most general use have about 15,000 lines per inch, but good gratings with 30,000 lines per inch have been ruled and may sometimes be used with advantage. Among the most successful in the production of gratings was H. A. Rowland, of Baltimore, many of whose gratings are still in use and are highly prized. Excellent gratings have also been ruled by R. W. Wood with Rowland's engine, by Prof. A. Michelson, of Chicago, and at the British National Physical Laboratory. The well known "Thorp gratings" are celluloid replicas of Rowland gratings and find extensive uses in physical laboratories.

Gratings ruled on glass are called "transmission gratings." In these, the rulings act in the same way as the wires in Fraunhofer's gratings. Most gratings, however, are ruled on speculum metal and are called "reflection gratings"; speculum metal is chosen because it has the valuable property of reflecting light of all wave-lengths, so that the ordinary grating can be used for ultra-violet and infra-red as well as for visible spectra. Transmission gratings may also be used, but less effectively, as reflection gratings.

Elementary Theory.—The production of spectra by a grating may be best explained by the consideration of a transmission grating, consisting of alternate opaque and perfectly transparent spaces, as coarsely illustrated in fig. 14. A parallel beam of light of a single wave-length from a slit and collimator, with the slit parallel to the rulings, is supposed to fall at normal incidence on the grating. Some of the light will pass directly through the grating in the direction of incidence and may be brought to a focus as an image of the slit—called the central image—by a suitable lens. Each clear space, however, may be considered to be divided up into an indefinitely large number of small "elements," each of which may be supposed to act as a source of light, giving rise to cylindrical wavelets. Some of the light is, therefore, found in other directions besides that of the incident light. To investigate what happens in the direction AP, inclined at an angle θ to the incident light, let CB be drawn from the edge of an aperture C in the direction at right angles to AP, which is drawn from the edge of the adjacent aperture A. If now θ be such that AB be just the length of one wave, the light coming from A in the direction AP will differ in phase by one whole wave from that proceeding from C, and the two will reinforce each other. The first, second, and succeeding elements of the first aperture will thus be respectively reinforced by the corresponding elements of the second aperture, so that the waves from the whole of the two apertures will reinforce each other in the direction AP. Similarly for other pairs of consecutive apertures across the whole grating, so that the light proceeding in the direction AP may be focussed as a second image of the slit in light corresponding in colour to that of the incident light. A similar image will obviously be formed at the same distance on the other side of the normal. Other images of the slit will also be formed in directions at larger angles to the normal, such that AB is equal to other integral multiples of the wave-length. The appearances with monochromatic light will accordingly be as roughly indicated in fig. 14c.

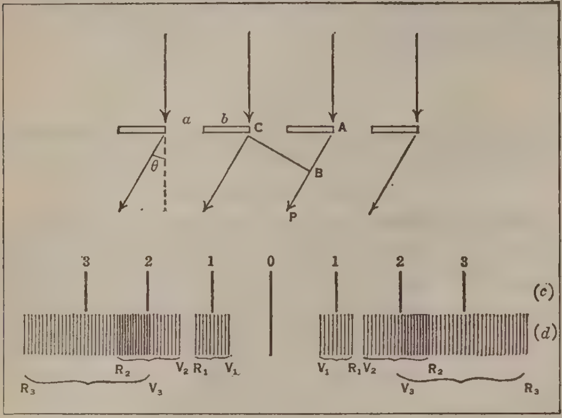


FIG. 14.—THEORY OF GRADING

If the breadth of an aperture be a and that of a bar b, $(a+b)$ is called the grating space, and the directions in which the various images of the slit appear are defined by the condition

$$(a+b)\sin\theta = m\lambda$$

where $m=0, 1, 2. \ldots$ The central image is represented by $m=0$, while $m=1, 2 \ldots$ correspond to spectra of the first, second and higher orders. The complete theory, in agreement with observation, shows that in directions other than those in which AB is an integral number of wave-lengths the luminosity is negligible if the number of apertures is large.

The explanation of dispersion by a grating readily follows, since the formula shows that the angle θ increases or decreases with the wave-length. When composite light falls on the grating, it is clear that the shorter violet waves will give an image closer to the central image than the longer red waves. Thus, with white light, the appearances will be as roughly represented in fig. 14d. The dispersion increases and the intensity decreases with the order of the spectrum. The spectra of the different orders show a certain amount of overlapping, since $m\lambda$ may be given the same value in different ways. For example, λ7,000 in the first order will be coincident with λ3,500 in the second order; and λ4,000 in the third order would coincide with λ6,000 in the second. The overlapping of spectra impart complicates the use of a grating, but in practice one or the other can usually be cut out by a colour filter.

When the light does not fall normally on the wire grating, but is inclined at an angle i to the normal, it is readily found that the condition for the production of a spectrum line of wave-length λ is given by

$$(a+b)(\sin i \pm \sin\theta) = m\lambda.$$

It should be noted that when $i=\theta$ the grating is at the position of minimum deviation, the deviation then being $(i+\theta)$. The condition for coincidences in different orders of the spectrum, as before, is $m\lambda = m'\lambda'$ where m and m' are integers. It will be observed also that the determination of wave-lengths by the use of a grating merely requires a knowledge of the grating space, and the measurement of angles.

The Reflection Grating.—As for the transmission grating, the angles of incidence and diffraction are connected with the wave-length of the line observed by the relation:

$$\pm m\lambda = (a+b)(\sin i + \sin\theta),$$

where i and θ are each counted + or—according as they are measured in the conventional positive or negative direction from the normal to the grating, and m is similarly counted + or— with reference to the directly reflected light, for which $m=0$. In using this formula for calculation, it is usually convenient to express the grating space in angstrom units. Thus, in a grating having 14,438 lines per inch (most frequently occurring in Rowland gratings), there are 5,684 lines per centimetre, and since an angstrom unit is 10^{-8} cm. $(a+b)$ is 17,600 angstrom units. The formula shows, for example, that at normal incidence $(i=0^\circ)$, the greatest possible wave-length observable in the first order (corresponding with $\theta=90^\circ$) is 17,600A; also represented by 8,800A in the second order, 5,866 in the third order, and so on. Greater wave-lengths, however, can be observed by changing the angle of incidence; thus, if $i=30^\circ$ $(\sin i=0{\cdot}5)$, the limiting wave-length $(\theta=-90^\circ, \sin\theta=-1)$ will be 35,200A in the first order $(m=-1)$, 7,040A in the fifth order $(m=-5)$, and so on.

Dispersion.—If θ be the angle of diffraction, dispersion is defined as before by $d\theta/d\lambda$, and since for a given position of the grating, the angle of incidence (i) is constant, the grating formula at once gives

$$d\theta/d\lambda = m/(a+b)\cos\theta.$$

The equation shows quite clearly how the dispersion varies directly with the order of the spectrum, and inversely as the grating space; the closer the rulings the greater the dispersion, irrespective of the total number. Again, it will be observed that the dispersion is smallest when $\theta=0$, $(\cos\theta=1)$; *i.e.*, when the spectrum is observed in a direction normal to the plane of the grating. In this position also the dispersion is most nearly uniform throughout the whole spectrum, since it varies with $\cos\theta$, and in the neighbourhood of $\theta=0$ this changes very slowly. The spectrum given by a grating, unlike that given by a prism, is accordingly "normal" in so far as $\cos\theta$ can be considered constant.

Resolving Power.—As in the case of the prism, the resolving power of a grating is a theoretical quantity expressing the separating power when the slit is indefinitely narrow, and is represented symbolically by $R=\lambda/d\lambda$. It is given in a simple form by:

$$R = m\,N$$

or, the resolving power is equal to the product of the order number of the spectrum and the total number of rulings. It should be remembered, however, that N in this formula involves the aperture and grating space.

If a grating has 15,000 lines per inch and a ruled surface extending over two inches, the resolving power will be 60,000 in the second order. Thus, at λ6,000 the theoretical separating power would be 0·1A, while at λ3,000 it would be 0·05A. The resolving power increases towards the shorter wave-lengths because the diffraction bands become narrower.

The Concave Grating.—A very important contribution to the appliances for exact spectroscopy was made by Rowland in the introduction of concave gratings. These are ruled on concave speculum mirrors, which are generally of spherical form, but sometimes paraboloidal, and the rulings are intersections of equidistant parallel planes with the surface. The collimator and observing telescope are in this way dispensed with, because the ruled surface diffracts the rays from the slit to a focus. The instrument is equally good for the whole range of spectrum, since speculum metal is a good reflector for all wave-lengths and there are no lenses to produce absorption.

As with plane gratings, if i be the angle of incidence and θ that of diffraction, the formation of spectra involves the condition

$$\pm m\lambda = (a+b)(\sin i + \sin\theta)$$

and, to take the most general case, if ρ be the radius of curvature, R the distance from the slit to the centre of the grating, and r the distance from there to the focus, it may be shown that

$$r = \frac{\rho R\cos^2\theta}{R(\cos i+\cos\theta)-\rho\cos^2 i}$$

$$R = \frac{\rho r\cos^2 i}{r(\cos i+\cos\theta)-\rho\cos^2\theta}$$

Thus, if the slit be anywhere on a curve defined by the polar co-ordinates R and i, the spectra will be focussed on the conjugate curve defined by r and θ.

An important special case is that in which $R=\rho \cos i$, for then $r=\rho \cos\theta$ and the two curves coalesce in a circle of diameter ρ This is often called the Rowland circle, and (fig. 15a) if such a circle be drawn with the line joining the centre of the grating with the centre of curvature as diameter, and the slit S be at any point on this circle, the spectra of various orders will be focussed on the circumference of the circle. In Rowland's beautiful method of mounting, the slit is placed directly above the point of intersection of two firmly supported rails GS and SF, at right angles to each other, while the grating, G, is supported on a girder GF equal in length to the radius of curvature. The ends of the girder rest on little carriages which run on the rails, and since G, S and F always lie on the Rowland circle, different parts of the spectrum are focussed at F as the girder is moved from one position to another. With this construction, $\theta=0$ and $\therefore$ $m\lambda=(a+b) \sin i$; that is, the wave-length focussed at F is proportional to SF. In other words, as observed with an eyepiece and cross-threads the spectrum is truly normal, and the rail SF may be graduated directly on a uniform scale of wave-length. When a photographic plate is substituted for the eyepiece, it is placed in a holder that will bend it to the curvature of the Rowland circle, so that the whole of the spectrum is in focus. The spectrum is then only normal in so far as $\cos\theta$ can be considered equal to unity, because θ is only zero for the centre of the plate.

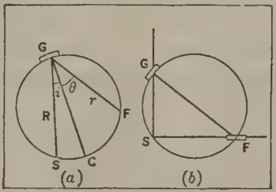


FIG. 15.—(A) MAGNIFYING POWER OF GRATING; (B) THE CONCAVE

Rowland's largest gratings have a radius of 21 ft. and a ruled surface 6 in. wide, the rulings being about 2 in. in length. These give a first order visible spectrum about 5 ft. long.

On account of the oblique incidence of the light falling on the grating, there is a considerable amount of astigmatism, so that even a point slit gives lines of considerable length, especially in the higher orders.

Numerous other constructions for concave grating spectrographs have been devised.

The Eagle mounting utilizes the spectrum seen in the direction of incidence, being essentially a Littrow spectrograph with a concave grating in place of a prism and lens; to bring different parts of the spectra under observation, the grating can be rotated and moved towards or from the plate, and the plate holder can be tilted to fit the Rowland circle. This mounting greatly reduces the astigmatism as compared with Rowland's arrangement, and therefore gives brighter spectra, and has the advantage that it can be enclosed in a rectangular box; higher orders of spectra can also be photographed.

When a collimator is used, so that parallel light falls on a concave grating, there is no astigmatism, and the spectrum is consequently brighter. In this form, slit, grating and plate are no longer on the Rowland circle and good focus can only be obtained over a moderate range of spectrum. The linear dispersion is reduced to about one-half of that given by Rowland's arrangement.

The Echelon Grating.—Since the resolving power of a grating is proportional to the product (mN) of the order of the spectrum and the total number of rulings, it may be increased in either of two ways. The first is to increase the number of rulings, but a limit is set to this by the practical difficulty of maintaining the rulings at a constant distance apart. The alternative method, which cannot be carried far with gratings of ordinary construction, is to use higher orders of spectrum. This, however, is very effectively done by a form of grating called the *echelon*, which was devised by Michelson in order to throw most of the light into one or two spectra of very high order. A number of glass plates of equal thickness (usually about a centimeter) and equal breadth, but each shorter than its predecessor by an equal amount (which may be about a millimeter) are superposed on each other to form a series of steps, like a staircase. Parallel light from a collimator, with the slit parallel to the edges of the steps, is then passed through the larger end. At each step the light is retarded by an equal amount, and diffraction spectra are produced when the light is focussed by a lens in the usual way.

Echelon gratings have been very successfully produced by Adam Hilger, Ltd., London, and an example given by this firm will illustrate the possibilities of such gratings. If the number of plates be 21, thickness, 10 mm., and height of step, 1 mm., while the refractive index for $\lambda 5{,}890$ is 1·5746, the instrument should be capable of separating lines about this wave-length which differ by only 0·027 angstrom units; in other words, the resolving power would be 218,000, and the order of spectrum observed would be the 10,380th. The successive orders are very close together, and on this account the light from the source is first passed through a spectroscope so that an image of the spectrum is focussed on the slit of the echelon instrument; only a very small range of wave-lengths then passes through. The lines are usually observed in the direction of the incident light, and under these conditions practically all the light is concentrated in a single order.

The echelon is clearly not intended for ordinary spectroscopic observations, but it is very valuable for analysing the fine structure of individual lines, small displacements of lines produced by pressure or other change of experimental conditions, and for revealing the close components into which a line may be split under the influence of a strong magnetic field. (*See* ZEEMAN EFFECT.)

Other High-Resolution Instruments.—Other instruments in which the effect of a large path-difference is used to produce high resolution are the Fabry-Perot interferometer and the Lummer-Gehrcke parallel-sided glass or quartz plate. (*See* LIGHT.) In each of these instruments, light from the original source is divided into a number of component beams of comparable intensity, which re-unite after having traversed paths differing successively by equal distances of perhaps a few centimetres. Reinforcement, giving a bright line or fringe, will take place when the effective path difference of neighbouring beams is an integral multiple of the wave-length, and it is readily seen that large path differences correspond to high resolution. For consider two neighbouring wave-lengths, λ and $\lambda+d\lambda$. The path difference, e, corresponding to m waves of the one will be equal to $m\lambda$, and that corresponding to m waves of the other will be $m(\lambda+d\lambda)$. The difference between these two quantities—*i.e.*, the interval between the positions of reinforcement for the two waves—will thus be $md\lambda=e{\cdot}d\lambda/\lambda=e/\mathrm{R}$, where R is the resolving power. If, therefore, this interval be regarded as constant, at the value which just allows the wave-lengths to be distinguished, it is clear that R increases proportionately to e.

Absolute Measurement of Wave-length.—An instrument such as the Fabry-Perot interferometer, in which large and adjustable path differences are employed, provides a means of obtaining accurate measurements of wave-length, or, alternatively, of measuring the standard metre in terms of a given wave-length of light. For, from the equation $e=m\lambda$ already given, it is clear that if m can be measured we have the ratio e/λ and if e be equal to the standard metre we have the ratio between it and the wave-length of the light used. This experiment was carried out with great accuracy, first by Michelson and later, in a somewhat modified manner, by Fabry and Perot. The general method is described in the article INTERFEROMETER.

2. ANALYSIS OF SPECTRA

THE HYDROGEN SPECTRUM

The Balmer Series.—As a general rule the spectrum of an element presents no obvious regularity of structure. It appears to be a miscellaneous collection of lines with no element of order in their positions or intensities. The spectrum of hydrogen, however, furnishes a conspicuous exception to this rule. In the visible and near ultra-violet regions, this spectrum consists entirely of a regular succession of lines which occur at continuously diminishing intervals as the shorter wave-lengths are approached, and at the same time show a steady falling off of intensity. (Plate I., No. 6.) Such a succession is known as a *series* of lines. It should be remarked that hydrogen has two distinct spectra, produced under different conditions of excitation. Under weak stimulus it yields a "blue" open band spectrum with no evidence of simple structure; a stronger stimulus, however, produces a much simpler "red" spectrum. It is the latter which contains the series here referred to.

The regularity of the hydrogen spectrum led in the early days of spectroscopy to many attempts to interpret the lines as analogous to the fundamental and harmonic vibrations in acoustics. They failed because the wave-lengths or frequencies of the lines were not in the ordinary harmonic ratios and could be expressed by no formula in any way consistent with such an interpretation. It was not until 1885, in fact, that any reasonably accurate formula was suggested. In that year Balmer pointed out that the wave-lengths of the four lines of the series then known were accurately represented by the expression:

$$\lambda_m = 3645{\cdot}6(1-4/m^2)$$

if m were given the respective integral values, 3, 4, 5 and 6. All doubt as to the significance of this relationship was removed by the fact that several further prominent lines, photographed by Sir William Huggins in the ultra-violet spectra of the stars, were found to be represented by the same formula when the value of m was increased successively by steps of unity. The series has consequently come to be known as the Balmer series of hydrogen.

It is of advantage in theoretical discussions to express results in frequency, or wave-number, instead of wave-length. In these terms, if ν_m represents the wave-number of a line of the series, the Balmer formula becomes—adopting later and more accurate measurements:—

$$\nu_m = 27419{\cdot}67 - 109678{\cdot}3/m^2$$

or

$$\nu_m = R/2^2 - R/m^2$$

where $R = 109678{\cdot}3$.

One or two important conclusions at once follow from this formula. In the first place, the strong red line at $\nu 15233{\cdot}22$ ($\lambda 6562{\cdot}793$), corresponding to $m=3$, is actually the first line of the series, for if $m=0$, 1, 2, we obtain infinite, negative, and zero values for the wave-numbers, and these can have no physical significance. Secondly, no line of the series can occur further in the ultra-violet than $\nu 27419{\cdot}67$ ($\lambda 3645{\cdot}982$), corresponding to $m=$infinity. The series is therefore wholly contained between the limits of wave-length, 6562·793 and 3645·982.

Other Series of Hydrogen.—The Balmer series is not, however, the complete "red" spectrum of hydrogen. In the extreme ultra-violet a similar series has been found (the Lyman series), and in the infra-red, yet another (the Ritz-Paschen series). The wave-numbers of the lines in these series respectively obey the equally simple formulae—

$$\nu_m = R/1^2 - R/m^2;\ (m=2, 3, \cdots)$$

$$\nu_m = R/3^2 - R/m^2;\ (m=4, 5, \cdots).$$

The natural deduction that a series, $\nu_m = R/4^2 - R/m^2$ might exist has been confirmed by F. S. Brackett, who has observed the first lines of such a series in the far infra-red. The difficulties of observation in this region are such as to prohibit the detection of further series of the same form.

It appears, therefore, that the wave-number of any line in the hydrogen spectrum can be expressed as the difference of two quantities. In any one series the larger of these quantities is constant, and represents the wave-number of the line of shortest wave-length that the series can theoretically contain. It is known as the *limit* of the series. The other quantity varies from line to line, and is known as the *term*. Clearly there is no fundamental difference between a limit and a term, for the limit of the Balmer series is a term of the Lyman series; the limit of the Ritz-Paschen series is a term of both the Balmer and the Lyman series; and so on. We can, therefore, generalize our results by saying that the hydrogen spectrum is associated with a number of terms of the form R/m^2 where m is any integer, and that the difference between any two of these terms corresponds to a possible line in the spectrum. The classification of the lines into separate series is thus somewhat arbitrary, and owes more to the visible appearance of the spectrum than to ultimate distinctions. In considering the nature of the spectrum, attention must naturally be concentrated on the terms, the lines being regarded as rather complex, derivative expressions of these simple fundamental quantities. From this point of view we may say that the whole of the hydrogen spectrum is expressed by the symbol R/m^2, where m ranges from one to infinity.

SPECTRA OF OTHER ELEMENTS

Series Formulae.—Evidence that series more or less resembling those of hydrogen occur in the spectra of other elements came from the pioneer investigations of J. R. Rydberg, H. Kayser and C. Runge. The spectra of the alkali metals (lithium, sodium, potassium, etc.) in particular can be almost completely analysed into series having the same general characteristics of convergence to limiting wave-numbers and continuous decrease of intensity, as the hydrogen series. (*See* Plate I., Nos. 8, 9, 2b.) A similar structure has been found in many other spectra also. None of these series, however (with one or two important exceptions which will be described later) can be represented by formulae quite so simple or so exact as those for hydrogen, although very close approximations can often be made. Rydberg's formula

$$\nu_m = A - R/(m+\mu)^2$$

(where A is the limit of the series; R—the "Rydberg constant"—has approximately the same value as for hydrogen; m takes successive integral values; and μ is a fraction, constant for each series) is sufficiently accurate for descriptive purposes, and will be so employed here, but more exact representation is given by the inclusion of an additional constant (α) as in the formula of W. M. Hicks—

$$\nu_m = A - R/(m+\mu+\alpha/m)^2.$$

Types of Series.—The series which were found intermingled in the various spectra were classified by Rydberg into types, characterised by the general appearance of the lines. Thus, in each of several spectra, a *principal*, a *diffuse* and a *sharp* series were found; a fourth series, the *fundamental*, was isolated later. The significance of these names has now almost disappeared, although the names themselves are still sometimes used, and the initial letters P, D, S, F are in general use to distinguish the different types of terms, and occasionally the series themselves. Other types of terms, which have been recognized only in recent times, are represented by the letters, G, H, . . . in alphabetical order, with no corresponding names.

The various series occurring in a spectrum are not independent of one another. Thus the S and D series converge to the same limit, and the difference between this and the limit of the P series is equal to the wave-number of the first P line. In other words, the first term of the P series is the common limit of the S and D series, and the first term of the S series is the limit of the P series. These reciprocal relations between the S and P series are known as the *Rydberg-Schuster law*. Again, the limit of the F series is the first term of the D series—a relation known as *Runge's law*. The four series are thus interconnected.

We may therefore express the various formulae, in the order in which they are now usually given, as follows:—

$$\text{S series}\quad \nu_m = \frac{R}{(1+p)^2} - \frac{R}{(m+s)^2}$$

$$\text{P series}\quad \nu_m = \frac{R}{(1+s)^2} - \frac{R}{(m+p)^2}$$

$$\text{D series}\quad \nu_m = \frac{R}{(1+p)^2} - \frac{R}{(m+d)^2}$$

$$\text{F series}\quad \nu_m = \frac{R}{(1+d)^2} - \frac{R}{(m+f)^2}.$$

Here s, p, d, f, are the values of μ for the respective series, and it has been assumed, for simplicity of representation, that the value of m yielding the limit of each series is unity. For brevity the formulae are mostly written:—

S series $\nu_m = 1P - mS$

P series $\nu_m = 1S - mP$

D series $\nu_m = 1P - mD$

F series $\nu_m = 1D - mF$.

It appears, therefore, that, as with hydrogen, the consideration of the spectrum may be simplified by the substitution of terms for lines, the wave-number of each line taking part in a series being given by the difference of two terms. Instead, however, of a single sequence, R/m^2 of terms, there are in general four sequences—S, P, D, F—and possibly more. As before, there is no fundamental reason why the particular differences of terms constituting the prominent series should be differentiated from other differences of terms. This was first realized by Ritz, whose well-known "combination principle" asserts that in addition to the series already described, a spectrum might contain lines represented by such expressions as $m_1S - m_2P$, $m_1D - m_2F$, etc. Many such lines have been observed. There appears, however, to be a restriction on the possible combinations, which is expressed by what is called a *selection rule*. For the alkali spectra it may be stated as follows: If the sequences of terms be written in the order, S, P, D, F, G, H . . . , then a term of any sequence may combine only with a term of either of the neighbouring sequences. Thus, any S term may combine with any P term, but not with another S term or with any term of the other sequences. A P term, however, may combine with an S or a D term; and so on.

MULTIPLICITY OF TERMS

Systems of Terms.—For simplicity it has been assumed in the foregoing description that each member of a spectrum series consists of a single line. This is sometimes the case, but more often the lines are double, triple, or even more complex. For example, in the spectra of the alkali metals the series consists of a succession of double lines, which in the spectra of the lighter elements are so close together as to appear single under small dispersion. (*See* Plate I., Nos. 8 and 9.) In zinc and certain other elements there are series of triplets. The complications which this multiplicity introduces, though they were originally disentangled from observations of the lines themselves, can be best described by considering the terms, for the relations are there seen in their greatest simplicity.

It appears that terms may be classified in *systems*, known as singlets, doublets, triplets, etc., up to a limit which is theoretically indefinite but in practice rarely exceeds the multiplicity of octets. In a singlet system, all the terms, of whatever type, are single, like those considered in the last section. In a doublet or triplet system, all the terms are double or triple except the S terms, which are single in each case. In a quartet system, all the terms are quadruple except the S terms, which are single, and the P terms, which are triple. These and other apparently irregular complexities are special examples of a general rule, viz.—The multiplicity of a term is as large as possible subject to (a) never exceeding the multiplicity indicated by the name of the system to which it belongs; and (b) never exceeding 1 for an S term, 3 for a P term, 5 for a D term, 7 for an F term, etc. From this rule the multiplicities of the terms in any system can be at once written down.

Term Notation.—It is necessary now to elaborate the symbol representing a term so that it shall, first, indicate the system to which a term belongs, and secondly, in the case of a component of a multiple term, distinguish it from the other components. The system is indicated by an index at the top left hand corner, and the component number by a suffix on the right. For example, in a quartet system, the P terms are represented by m^4P_1, m^4P_2, m^4P_3. The particular figures used as suffixes are of no importance so far as the mere identification of terms is concerned, but for other reasons a definite scheme has been generally adopted, which is given in the following table for multiplicities up to 8:—

Inner Quantum Numbers (*j*)

Odd Multiplicities				
Terms	Singlet $r=1$	Triplet $r=3$	Quintet $r=5$	Septet $r=7$
S	0	1	2	3
P	1	0 1 2	1 2 3	2 3 4
D	2	1 2 3	0 1 2 3 4	1 2 3 4 5
F	3	2 3 4	1 2 3 4 5	0 1 2 3 4 5 6
G	4	3 4 5	2 3 4 5 6	1 2 3 4 5 6 7

Even Multiplicities				
Terms	Doublet $r=2$	Quartet $r=4$	Sextet $r=6$	Octet $r=8$
S	1	2	3	4
P	1 2	1 2 3	2 3 4	3 4 5
D	2 3	1 2 3 4	1 2 3 4 5	2 3 4 5 6
F	3 4	2 3 4 5	1 2 3 4 5 6	1 2 3 4 5 6 7
G	4 5	3 4 5 6	2 3 4 5 6 7	1 2 3 4 5 6 7 8

Selection Rules.—The reason for adopting these particular figures is that in combinations between multiple terms, another "selection rule" comes into operation, so that the combinations which are numerically possible do not all occur. Consider, for example, a combination between a P and a D term in a quartet system. The former is triple and the latter quadruple, and if each P component combined with each D component to give a spectrum line there would thus be 12 lines in all. As a matter of fact, however, only 8 appear, and by choosing the suffix numbers according to the above table, these particular lines can be indicated by a very simple rule, viz.—only those combinations occur for which the suffix numbers differ by zero or unity. Thus, writing the component terms as co-ordinates, and putting a cross at the position of each possible combination, we find the following group of eight lines as a typical quartet PD combination, or *multiplet*, as it is called:—

	m^4D_1	m^4D_2	m^4D_3	m^4D_4
m^4P_1	×	×		
m^4P_2	×	×	×	
m^4P_3		×	×	×

Such a group of lines, it must be understood, is the analogue of a single line in a singlet system, and a succession of such groups in which the P component terms are the same and the D terms have consecutive values of *m*, constitutes a diffuse series in a quartet system.

It will be convenient at this stage to summarise and somewhat amplify the foregoing analysis, and at the same time to introduce a nomenclature derived from theoretical considerations which is in common use. A term is completely specified by four quantities:—(1) Its *type*—S, P, D, etc. This is sometimes represented by its *azimuthal quantum number*, and indicated by the letter *k*. For an S term, $k=1$; for a P term, $k=2$, and so on. (2) Its *principal quantum number*, *n*, for which a serial number *m* is usually substituted in series formulae as above. (3) Its *system*—generally called the *multiplicity*, and denoted by the letter *r*. (4) Its *suffix number*, or *inner quantum number*, represented by *j*. In expressing a term, the azimuthal quantum number is rarely used, the corresponding type symbol, S, P, D, etc., being retained instead: thus, 4^3D_2 represents the second component of a D term in a triplet system for which the serial number is 4. A perfectly general representation of a term is n^rk_j.

When two terms combine to give a spectrum line they must satisfy the following conditions simultaneously:—(1) The difference of the *r* values must be 0 or ±2. This means that terms of different multiplicities may combine with one another, but the multiplicities must be both even or both odd. (2) The difference of the *k* values must be ±1. (3) The difference of the *j* values must be 0 or ±1. There is one exception to the third rule; namely, that if the *j* value is 0 for both terms, the combination does not occur. These three conditions do not involve the *n* values, which take no part in restricting the possible combinations of terms. It should be mentioned that there are also certain definite relations between the intensities of the lines in a particular combination of multiple terms, which are connected with the values of the inner quantum numbers. In theoretical discussions, intensities rank only second to wave-numbers, and much attention has been given to their exact measurement by Ornstein and others. The second and third selection rules are illustrated in fig. 16, which shows the structure of some of the doublet and triplet combination groups. The *k* rule, for example, forbids the combination SD, and the *j* rule reduces the number of lines in each group as compared with the number which is arithmetically possible, except in the SP group. The strongest lines of a group are those for which *j* changes in the same direction as *k*, and the intensity diminishes with the values of *j* which are involved.

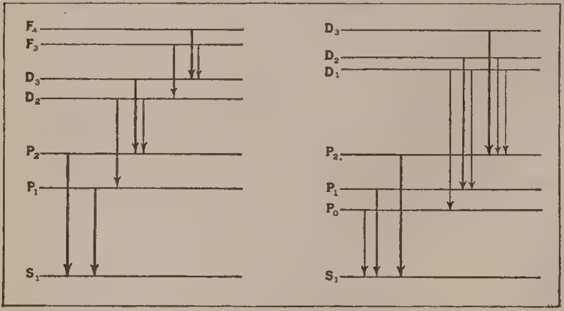


FIG. 16.—DOUBLET AND TRIPLET COMBINATIONS

A further complication must now be described. The terms of many spectra may be divided into two S, P, D, . . . groups, within each of which the combination rules just enunciated are obeyed. Combinations, however, may take place between terms of one group and those of the other. In such cases the rules are the same as before, with the exception of the one relating to the azimuthal quantum number, *k*, which becomes:—the difference of the *k* values must be 0 or ±2. To distinguish the groups from one another, the term symbols for one of them are often followed by a dash at the top right hand corner; thus—S′, P′, etc. We may, therefore, have such combinations as PP′, DD′, SD′. . . but not SP′, PD′. . . . It is immaterial which of the groups is denoted by the dash, for there is, in fact, no difference between their properties except that indicated by the rules of combination.

Identification of Multiplets.—Well-developed series are usually found only in systems of low multiplicity, although the rule is not invariable. Singlet, doublet and triplet series have long been known, but it was not until 1922, through the work of Miguel A. Catalán, that the existence of systems of higher multiplicity was discovered. In spectra containing such systems it appears that the energy radiated is mainly distributed among the numerous lines of the earlier members of the series (*i.e.*, those corresponding to the smaller values of *n*), the later members being absent or relatively inconspicuous.

Although for descriptive purposes it has been thought desirable to deduce the structure of a complex spectrum from the multiplicity of its terms, the practical problem is, of course, the reverse; namely, to deduce and classify the terms from the regularities observed among the lines. In systems of low multiplicity, with well-developed series, this can often be done by careful inspection after some experience has been obtained, the numerical values of the terms being determined by the calculation of a Hicks or Ritz formula. With higher multiplicities, however, one looks for groups of lines belonging to particular combinations, such as the quartet PD combination referred to above. These are detected by the recurrence of certain wave-number differences between the lines in a group, and to a lesser extent by the relative intensities of the lines.

The true numerical values of the terms in these systems of high multiplicity cannot be determined unless sufficient members of a series are found to permit the calculation of a formula. Relatively accurate values, however, can always be found from the observations. Thus, in the above example, if the value of $^4S_2$ be known or assumed, all the other terms participating in the group can be at once evaluated by subtraction.

A good example of one of the many multiplets occurring in the arc spectrum of iron is illustrated in Plate I. No. 7, this representing the combination of a septet D and a septet F term, giving 15 lines.

Zeeman Effects.—The analysis of a spectrum is often facilitated by a study of the Zeeman effect, *i.e.*, the splitting of the lines into components when the source of light is placed in a strong magnetic field. (*See* ZEEMAN EFFECT.) The group, or pattern, into which each line is dissected depends, in general, on the quantum numbers, *r, k, j,* of its component terms, and, largely through the work of A. Landé, an algebraical expression involving *r, k, j,* has been found which in many spectra represents with extreme accuracy the number and relative separations of the components of a term. The pattern characteristic of each possible combination—*e.g.*, a $^3P_1\ ^1S_0$ combination—can thus be constructed, and by comparison with observation the lines can be classified. The pattern is not unique in every case—for example, all lines of a singlet system show the same pattern—but it is nevertheless a very valuable aid in analysis, and may be a crucial factor in deciding between alternative possibilities.

SPECTRA AND THE PERIODIC TABLE

General Relationships.—The spectra of a large number of elements have now been at least partially analysed, and it is possible to draw some general conclusions with regard to the relations between spectra and the periodic table. That some relations exist was indeed evident many years ago, when it was discovered that the spectra of elements in certain chemical families showed marked resemblances to one another. Thus the spectra of the alkali metals all show well-developed series of doublets; those of the alkaline earths show similar series of singlets and triplets, and so on. These now appear to be special cases of a general rule that elements of the same chemical family yield spectra with the same multiplicities. Furthermore, in progressing across the table from left to right, the multiplicities encountered are alternately even and odd, as may be seen by the following example taken from the third row of the table:—

Term Systems in Arc Spectra, K-Ni

Group	I.	II.	III.	IV.	V.	VI.	VII.	VIII.		
Element	19. K	20. Ca	21. Sc	22. Ti	23. V	24. Cr	25. Mn	26. Fe	27. Co	28. Ni
Multiplicities		1		1						1
	2		2		2				2	
		3		3		3		3		3
			4		4		4		4	
				5		5		5		5
					6		6		6	
						7		7		
							8			

The figures preceding the chemical symbols of the elements are the atomic numbers. Within a chemical family there is, in general, an increase in separation of component terms, roughly proportional to the squares of the atomic numbers, and at the same time a movement of corresponding lines towards the region of greater wave-lengths. It will be noticed that the low multiplicities occur mainly among the elements at the left of the table, and it was among these elements that series were first detected. The existence of complicated multiplets was first discovered by Catalán in the spectrum of manganese, which is derived from quartet, sextet and octet terms.

Enhanced Spectra.—It has already been mentioned that each element possesses a number of spectra, which are produced successively by gradually increasing the exciting stimulus. They are denoted, in the case of a typical element, Z, by the symbols, ZI, ZII, ZIII, etc. The type of structure which has been described appertains to any of these spectra, but we meet with an important modification of the series formula in passing from one of them to the next, viz.—the value of the Rydberg constant, which is approximately $R = 109678$ for ZI, becomes approximately $4R$ for ZII, $9R$ for ZIII, and in general, n^2R for the nth spectrum. Since the other constants in the expression for the terms have the same general order of magnitude for all the spectra, it follows that the term values increase rapidly from one spectrum to the next.

There are strong reasons for believing that the number of such spectra which an element yields is equal to its atomic number. Thus, no increase of stimulus can produce a successor to the red spectrum of hydrogen (HI), or more than two spectra of helium, three spectra of lithium, etc. Owing to practical difficulties, it is only for the lightest two elements—hydrogen (H), and helium (He)—that lines of all the possible spectra have been observed, but the results in these cases illustrate a very important rule which from theoretical considerations, is believed to be quite general, namely: if n be the atomic number of an element, then its nth spectrum is as simple as the first spectrum of hydrogen, consisting only of terms of the form n^2R'/m^2, where R' is almost, but not quite, equal to R for hydrogen, and is very slightly different for each element. The lines of HeII were observed before this rule was known—first in the spectra of heavenly bodies and afterwards in the laboratory by A. Fowler—and, from the simplicity of the terms, were mistakenly attributed to hydrogen. It was not until the foundations of the theory of spectra were laid by Niels Bohr in 1913 that the true origin of the lines was indicated. Their connection with helium was afterwards confirmed by experiment.

Displacement Law.—There are certain significant relationships between the successive spectra of the same and neighbouring elements which must now be considered. Passing along the sequence, ZI, ZII . . . , we meet with an alternation of multiplicities similar to that already noted in the spectra of elements forming a row of the periodic table. The resemblance is not accidental, but is implied in what is known as the *displacement law* of A. Kossel and A. Sommerfeld, which in its generalized form states that the spectrum ZII will have the same multiplicity and general character as the first spectrum, YI, of the element preceding Z in the table; and further, that ZIII will resemble YII and XI—the first spectrum of the element preceding Y; and so on. The correspondence between these similar spectra is very close as regards multiplicities and the types of the most prominent terms, but it does not extend to the numerical values of the terms, which increase rapidly with the stimulus required to produce the spectrum.

As a particular example, consider the successive elements—sodium (Na), magnesium (Mg), aluminium (Al) and silicon (Si), details of which have been investigated by A. Fowler and F. Paschen. Here the spectra, NaI, MgII, AlIII and SiIV are strikingly similar to one another, and may profitably be compared with the sequence of spectra of the alkali metals, NaI, KI, RbI, CsI. These two sequences have the spectrum NaI in common. They both consist of doublets, the separations between the components of which increase rapidly with advancing position in the sequence. But whereas, in the spectra of the alkali metals, corresponding lines move towards the red with increasing atomic number, the drift in the other sequence is towards the violet. Moreover, both the increase in separation of component terms, and the changes of position in the spectrum, are more regular in the NaI, MgII . . . sequence, as may readily be seen from fig. 17, in which the 3^2S–3^2P doublets are shown on a scale of wave-number. It appears as though the atomic systems which are responsible for the spectra NaI, MgII, etc., are more regularly related to one another than the atoms of elements of the same chemical family.

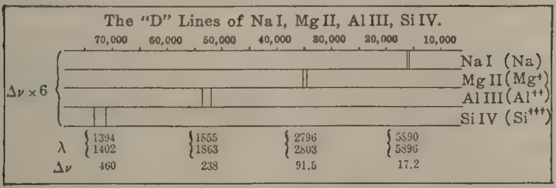


FIG. 17

3. THEORY OF SPECTRA

THE HYDROGEN SPECTRUM

The Nucleus Atom.—From the earliest days of spectroscopy the question of the origin of spectra has engaged the attention of theoretical physicists, but it was not until 1913 that the line of investigation which has since proved so fruitful was inaugurated by Bohr. The earlier work can be summed up very briefly. The fact that a spectrum was characteristic of the emitting substance showed that it was an atomic or molecular phenomenon, and a theory of spectra therefore involved at least a partial theory of atomic and molecular structure. The fact that both sound and light were conceived as trains of waves naturally suggested that the latter, like the former, might originate in periodic vibrations of material bodies, and the atoms of luminous substances were consequently looked upon as vibrating systems. But in those days there was no evidence of structure in the atom, and the character of the vibrations could be little more than guessed at. Furthermore, as already stated, the frequencies of the radiations in even the simplest known spectrum—that of hydrogen—bore no relation to one another which could be reconciled with the harmonic ratios known in acoustics. It is not surprising, therefore, that no progress was made.

But by the year 1913 the developments of general physics had created a much more favourable situation for the solution of the problem. In the first place, a definite model of the atom, proposed by Sir Ernest Rutherford, was available, which consisted of a central nucleus positively charged with electricity, surrounded by a number of revolving electrons whose total (negative) charge balanced the charge of the nucleus. One element differed from another in the nuclear charge, and consequently in the number of revolving electrons, this number being equal to the atomic number of the element. Thus, hydrogen had one revolving electron, helium, two, and so on. Secondly, other physical phenomena seemed to point to the conclusion that atoms could radiate energy only in definite unit quantities, known as *quanta*, the amount of which depended on the frequency of the radiation and was, in fact, equal to the product of the frequency and a constant quantity, h (Planck's constant). The application of this idea to the Rutherford atomic model enabled Bohr to give a quantitative explanation of the hydrogen spectrum and lay the foundations of the whole modern theory of spectra.

Bohr's Theory.—The physical conceptions of the Bohr theory will be described here only in so far as is necessary to interpret the facts of spectroscopy. Their wider aspects are dealt with elsewhere. (*See* ATOM, QUANTUM THEORY.) In order to explain the hydrogen spectrum, Bohr assumed that the single electron of hydrogen could revolve round the nucleus according to the ordinary mechanical laws, but only in any one of a series of discrete orbits, determined by the condition that the angular momentum must be an integral multiple of $h/2\pi$. The atom was, therefore, capable of existing in a number of states, known as *stationary states*, corresponding to the different possible orbits of the electron. The energy of the atom depended on the orbit of the electron, and was regarded as proportional to a term of the spectrum, each orbit thus being associated with a particular spectrum term. In the ordinary, non-radiating state of the gas, the electrons were in their innermost orbits, where their energy was less than that required for revolution in any other orbit, but on being stimulated to radiate, the atoms absorbed energy from the exciting source in just the amounts necessary to remove the electrons to outer orbits. An atom so excited, however, returned to its normal state at the earliest opportunity, either by a single jump or by successive transitions to intermediate permissible orbits. At each transition it radiated the difference of energy corresponding to revolution in the two orbits concerned as a spectrum line of frequency ν, where hν was the energy radiated. An inward passage between each pair of orbits thus resulted in the radiation of a particular line in the spectrum, whose wave-number was equal to the difference of the corresponding terms, and the whole spectrum consisted of the sum of the radiations of all the atoms in the radiating source.

Treating these conceptions mathematically, Bohr was able to deduce the Balmer and other formulae for the hydrogen series, and further, to show that the Rydberg constant, R, was given by

$$R = \frac{2\pi^2 e^2 E^2}{ch^3} \cdot \frac{mM}{m+M}$$

where e, m are respectively the charge and mass of an electron, E, M, are the corresponding quantities for the nucleus, and c is the velocity of light. For hydrogen, with only one electron, $e=E$, but M is nearly 2,000 times m. The spectroscopic determination of R, in fact, now appears to be one of the most accurate methods of determining the ratio of M to m, and gives a value, 1,845.

OTHER SPECTRA

The Series Constant.—The mathematical difficulties of a complete solution of the motion of electrons in atoms with more than one electron have proved insuperable, but a physical idea of the process of radiation by such atoms can be formed. It is supposed, as a first approximation, that passages from orbit to orbit are performed mainly by a single electron, the others meanwhile revolving unchanged in their normal orbits. In such a case, if the dimensions of the orbits of the roving electron are large compared with the dimensions of the rest of the atom (the *core*, as it is called), the latter may be regarded as a single positive charge, E (equal and opposite to the charge, e, of an electron), round which the roving electron moves. The calculation made for hydrogen is then approximately applicable, and gives a formula in which the Rydberg constant, R, recurs. The deviation from exactitude results in the change of m (the denominator in the expression for the hydrogen terms) from an integer to a mixed number. Its new value—(m+ μ) in the Rydberg formula—is known as the *effective quantum number*.

Ionised Atoms.—The universal occurrence of the constant R is thus explained, and a natural extension of the theory provides a simple explanation of the fact that for the successive spectra of each element, it must be multiplied by 2^2, 3^2, etc. For, consider an atom subjected to a gradually increasing stimulus. Its travelling electron will be able to move out to more and more distant orbits until a point is reached when it absorbs enough energy to leave the atom altogether. The atom is then said to be *ionised*. The remainder of the atom, being still subjected to the exciting stimulus, will be able to absorb energy only by the removal of a second electron to outer orbits, and the new transitions of this electron will generate a spectrum different from that given by the un-ionised atom. For in this case the positive charge, E, of the core is 2e—*i.e.*, twice the charge of an electron—and the expression for R becomes $4 \cdot \frac{2\pi^2 e^4}{ch^3} \cdot \frac{mM}{m+M}$ —approximately four times the value of R for hydrogen. In a similar way, a still greater stimulus will remove a second electron from the atom, which is then said to be doubly ionised, and the spectrum generated by the movements of a third electron will give a spectrum involving a constant approximately 9R, and so on.

It should be observed that the values of the constant for the corresponding spectra of different elements are not exactly the same because of the factor $Mm/(M+m)$. Here M is the mass of the core, which is practically equal to the atomic weight of the element, and it is easily seen that the variation of M brings about a slight, but only a slight, variation of $Mm/(M+m)$. The effect of this variation, however, is of some importance in the case of atomic systems containing only one electron. Thus, the line $R/2^2–R/3^2$ of the Balmer series, of hydrogen, for example, would clearly be identical in position with the line $4R'/4^2–4R'/6^2$ of HeII if R were exactly equal to R'. Actually, however, the lines are separated by about 2½A. It was on account of this and similar separations, predicted by the Bohr theory, that it was first realized that the lines of HeII were not due to hydrogen.

Absorption.—The explanation of absorption on the Bohr theory is fairly obvious. If emission corresponds to an inward transition of an electron, absorption will naturally correspond to an outward transition. Since the energy values of the orbits are constant, it follows that the frequencies absorbed will be the same as those capable of being emitted, and the relation between the absorption and emission spectra of an element is thus explained. It is clear, however, that absorption by a non-luminous vapour should on this view produce only the lines in which the innermost orbit (or the largest spectrum term) is involved, for in the initial state, all the atoms will have their travelling electrons in this orbit. This agrees with observation, as for example in the case of potassium vapour (Plate I., B. 2) which, when not radiating, absorbs only the principal series, 1S–mP. The innermost orbit corresponds to the term 1S, which, as we have seen, can under the selection rule combine only with P terms.

In ordinary absorption the electron is ejected outwards by light of the proper frequency in the incident beam. A similar ejection can be brought about by electron bombardment, as in the experiments of Franck and Hertz and others. (*See* art., RESONANCE POTENTIAL.) In these and similar experiments the energy is usually imparted to the bombarding electron by an electric field, and the potential difference through which the electron has to fall to acquire sufficient energy to excite the atom from its normal state to the next possible state is known as the *resonance potential* of the atom (*q.v.*). Similarly, the potential difference necessary to enable the bombarding electron to ionise the atom is known as the *ionisation potential* of the atom. Clearly the ionisation potential is a measure of the energy of the atom in its normal state, and is, therefore, proportional to the largest term in the spectrum. It is given in volts by dividing the largest term, expressed in wave-number units, by 8,102.

Interpretation of Terms.—In applying the ideas of the Bohr theory to the facts concerning the spectra of the elements already described, the outstanding problem is to interpret the four numbers which specify a spectroscopic term, namely, $n^r k_j$. The conception that each of these numbers may be identified with a definite characteristic of an electron orbit is clearly incomplete, inasmuch as the movements of a point charge, such as an electron is conceived to be, can be completely defined by three quantities, whereas observation shows that four are to be accounted for. This difficulty has been partly overcome by assuming that an electron can rotate about an axis, thus giving it an additional "degree of freedom," but the more advanced developments of the theory seem to indicate that even this amplification is insufficient to interpret all the facts of observation, and the whole conception of electron orbits may have to be regarded as merely a symbolical one. For that reason the phrase "energy of an orbit" is often discarded in favour of the more general one, "energy level of the atom." The simple conception of spinning electrons in orbital motion, however, gives a fairly clear picture of what is happening when a spectrum is emitted.

In the earlier days of the theory, it was supposed that the spectrum was generated by the transitions of a single electron between different orbits, and that the k value of a term (1 for S, 2 for P . . .) was always simply related to the corresponding orbit; so that, for example, if the term were 3P the orbit was considered to be specified by 3_2. The principal quantum number n was then regarded as an index of the major axis of the orbit (supposed in the general case to be an ellipse), and k was considered to represent the minor axis, n_k thus indicating the size and shape of the orbit associated with a particular term. The interpretation of r and j, however, remained somewhat vague and incomplete. An important indication of the need for further development of the theory was also subsequently given by the analysis of the more complex spectra, it being then found that the term representing the normal state of an atom was sometimes of a type which was very unlikely to represent the orbit of the most loosely bound electron in the unexcited atom.

In identifying the quantum numbers of the terms with the elements of a single electron orbit, it is implied that when an atom is excited, only a single electron is disturbed; but it is obviously conceivable that the exciting agency might disturb two or more electrons simultaneously, with the result that the energy level of the atom might be altered in a way inexpressible in terms of the movements of a single electron. Evidence that this actually occurs was first brought to light by Henry Norris Russell and F. A. Saunders in a study of the spectrum of calcium. They showed in effect that terms existed in the spectrum larger than the term corresponding to the ionisation potential of the element. This meant that the atom contained more than enough energy to ionise it if all the energy were given to one electron, and it naturally followed, since the atom was not ionised, that the energy was shared between two or more electrons.

A more general problem than that so far considered was thus opened up. A spectrum term could no longer be regarded as necessarily characterized by the elements of a single orbit; it had to be conceived as measuring, in the most general case, the sum of the energies of all the electrons in the atom, each of which might be changed when the atom was excited to a new state. Fortunately it appears that, with the ordinary methods of exciting spectra at least, only a few of the electrons are disturbed, and remarkable progress has been made in correlating the distribution of electron orbits with the spectrum terms. It is now possible to state what terms correspond to any given configuration of electrons, and so to predict the possible terms in the spectrum of an element when the probable orbits of its electrons are known.

Two distinct problems are involved. First, the specification of the orbits of all the electrons in an atom in the normal state and in the states which are most probable when the atom is excited. Secondly, the determination of the spectroscopic terms corresponding to these various states. The former problem has been solved mainly through the labours of Bohr, Main Smith and Stoner; the results so far as the normal state are concerned will be found elsewhere. (*See* ATOM, MAGNETISM, QUANTUM THEORY.) The same results for the arrangement of electrons in the normal atoms of the elements also follow from Pauli's exclusion principle, which asserts that not more than one electron can have the same four quantum numbers which are now necessary to define its motions completely. Thus, proceeding outwards from the nucleus, the so-called K shell, or group, cannot contain more than two electrons, the L shell eight, and so on. In excited states the outermost, or valence, electrons are most easily disturbed and experience has shown that their movements usually account for the most prominent terms occurring in spectra.

The solution of the second problem is largely due to the work of Heisenberg and Hund, the whole theory being based on the supposition that the angular momenta of all the rotary motions within the atom can only be changed by unit steps. These rotary motions, for each individual electron, require four quantum numbers for their complete specification. Besides n and k, which determine the size and shape of the orbit, there are also two so-called "magnetic quantum numbers," one of them involving the orientation of the orbit and the other the direction of spin, each electron being assigned half a unit of angular momentum. The problem of predicting the spectroscopic terms for different arrangements of the electrons is, fortunately, greatly simplified by the fact that electrons which are in completely filled n_k groups can be disregarded, as it follows from Pauli's principle that the resultant angular momentum for such groups is zero. The general outcome of the extended theory is that the quantum numbers which define the spectroscopic terms are now to be regarded as resultants of those which define the characteristics of the outer or valence electrons. The process by which the terms are deduced from the atomic states, however, is too complex to be described here, and, in fact can scarcely be indicated completely in terms of the orbital model of the atom.

The theoretical prediction of the spectroscopic terms to be expected for given configurations of the electrons, however, has already been of immense service in the disentanglement of many complicated spectra, and there is every reason to believe that the elucidation of the structures of all line spectra, and their correlation with atomic structures, is not far distant.

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SPECTROSCOPY, X-RAY. It is now a generally accepted fact that X-rays form a branch of ordinary optics. Proceeding from the visible light (8,000–4,000 Ångström units) to the electromagnetic waves of shorter wave-lengths we are able by recent spectroscopic methods to pass without any break through the ultra-violet region (the Schuman-Lyman-Millikan regions) to the realm of wave-lengths characterizing X-rays (extending from some hundredths to about one tenth of an Ångström unit). On the short wave-length side of the X-ray region we pass into those wave-lengths known as the radioactive gamma-radiation and the still shorter wave-lengths of the "cosmic" rays.

Historical Remarks.—That the X-rays produced in an ordinary X-ray tube are complex and differ in quality when the vacuum of the tube, or primarily the tension on the tube, is varied was noted by Röntgen himself in his first papers dealing with the new radiation. It was shown early that the X-radiations became more penetrative as the tension of the tube was raised. The degree of penetration (usually measured in terms of the thickness of aluminium necessary to reduce their intensity by half) was used as a means of characterizing the quality of the radiation.

It was by this means also that C. G. Barkla was able to show that the different elements when excited so as to give off X-rays all have their own "characteristic" radiations. For instance for an element such as silver Barkla showed the existence of two "characteristic" radiations called the K- and L-radiation having very different penetrating power.

The K-radiation from this element is reduced to half its intensity after passing through a sheet of aluminium about 1 mm. thick whereas the L-radiation is diminished in the same degree after it has passed through only 0·004 mm. of aluminium.

These two characteristic radiations, the K-series and the L-series, were experimentally verified for a great number of elements. The measurements of their penetration in aluminium showed that their "hardness" increases regularly for both series when the atomic weight of the emitting element increases.

Corresponding to the emission of the characteristic fluorescent radiation of a certain element, Barkla and his collaborators, especially Sadler, showed the existence of a remarkable abnormality in the absorption of the X-rays. This was the first indication of what is now called the absorption-spectra in the field of X-rays, and which have been shown to be intimately connected with the emission spectra or characteristic radiation of the elements.

Basis of the X-ray Spectroscopy.—The knowledge which had so far been obtained regarding the characteristic X-radiation and absorption was extended to quite a new branch of spectroscopy after the fundamental discovery of Laue (1912). By this discovery experimental science obtained the tool that was necessary for exploring the fascinating subject, which X-ray spectra of the elements turned out to be.

The diffraction patterns which Friedrich and Knipping obtained on allowing a fine beam of X-rays to pass through a crystal as suggested by Laue induced W. H. and W. L. Bragg to perform experiments, which formed the first step of the development of the X-ray spectroscopy. As the Braggs showed, a monochromatic X-ray beam is reflected by a cleavage face (or any other atomic plane) of a crystal according to the ordinary laws of optical reflection, *i.e.,* the incident and the reflected beams are in the same plane and this plane is perpendicular to the reflecting face, and further the angles between these two beams and the reflecting face are equal. In addition to these laws the following condition must be fulfilled if reflection is to occur, namely:

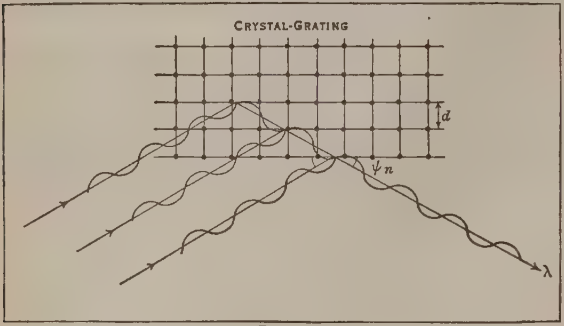


FIG. 1

$$n\lambda = 2d\sin\psi \qquad (1)$$

where λ is the wave-length of the monochromatic radiation, d is the distance between two adjacent atomic layers parallel to the reflecting plane, ψ the angle between the beam and the plane and n indicates the "order" of the reflection. (Fig. 1.)

This equation, generally known as *Bragg's law,* forms the basis for measuring the wave-lengths of X-rays. It may be mentioned that this law needs a small correction, due to the fact that the wave-length is slightly different in a vacuum (or air) and in the crystal.

Spectrometric Methods.—The arrangement for the spectroscopic analysis of an X-ray beam is shown diagrammatically in fig. 2. The different monochromatic rays which constitute the beam coming from the X-ray source (or slit) are reflected by the crystal at different angles and directions according to the Bragg law (1) as the angles may vary from ψ_1 to ψ_2 only such rays are reflected whose wave-lengths have values between λ_1 and λ_2 where

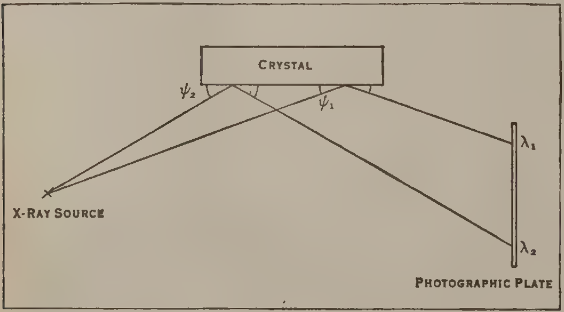


FIG. 2

$$n\lambda_1 = 2d\sin\psi_1$$
$$n\lambda_2 = 2d\sin\psi_2.$$

On the photographic plate therefore there is found, after exposure and developing, a spectrum ranging from λ_1 to λ_2. The region of wave-lengths can be varied by turning the crystal.

From the position of a certain spectral-line on the photographic plate its wave-length is computed by equation (1). A number of different methods have been used for determining the angle ψ which forms the main problem of the X-ray spectrometry.

Exciting of X-ray Spectra.—To excite the X-ray spectrum of a substance a small piece of it is placed on the anticathode (3a, 3b) of an X-ray tube. After the tube has been exhausted to a suitable vacuum a high potential (10 to 150 kilovolts) is applied to the electrodes of the tube. By this means the anticathode is bombarded by the electrons forming the cathode rays. The kinetic energy of the electrons imparted to the bombarded atoms is partially transformed into heat, light, etc., and partially to X-rays. We will here deal exclusively with the last mentioned rays and more especially with the question as to how this radiation varies with the material on the anticathode.

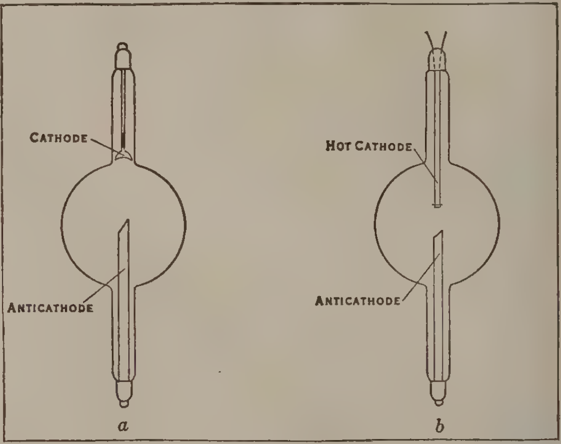


FIG. 3.—X-RAY TUBES

As to the X-ray tube and its working there are two main ways of producing the cathode rays used for bombardment. In the first type (3a) the tube has a vacuum of 0·01 to 0·001 mm. Hg. The high tension in this case gives rise to ionization of gas remaining in the tube and the positive ions formed are thrown against the cathode (of aluminium) and on their collision set free a number of electrons. The electrons travel in the opposite direction—from the cathode to the anticathode—and bombardment of the anticathode gives rise to X-rays characteristic of the substance of the anticathode. In the second type (3b Coolidge-tube) the vacuum of the tube is much lower, so that no current passes through the tube when the high-potential is applied to the tube. In this case the electrons for the cathode rays are supplied by heating to a high temperature a filament (mostly of tungsten) which is placed in the centre of the cathode.

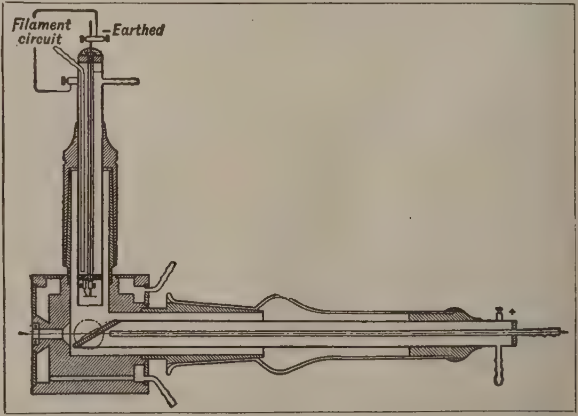


FIG. 4.—METAL X-RAY TUBE WITH HOT CATHODE FOR SPECTROSCOPIC USE

For analysing purposes it is often necessary to change the substance on the anticathode and the tube must be built in such a way that the anticathode is easily detachable. This can be accomplished by mounting the anticathode in a special joint. A tube especially designed for spectroscopic purposes which permits rapid change of both cathode and anticathode is shown in fig. 4. The tube itself is built of metal with water cooling to permit a very high output of energy. Further a small window of aluminium or goldbeater's skin makes it possible to study the radiation of longer wave-lengths which are absorbed by the glass walls of an ordinary tube.

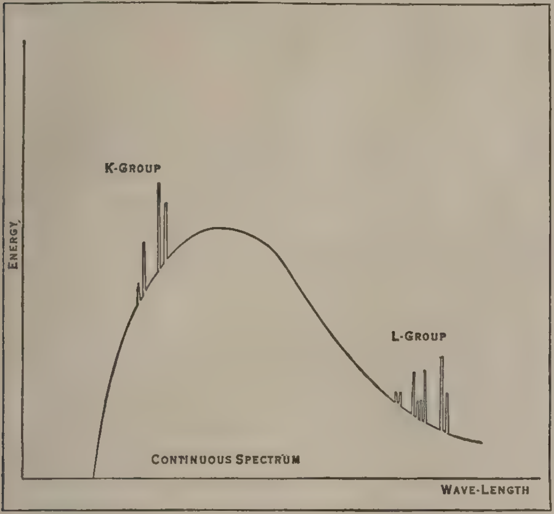
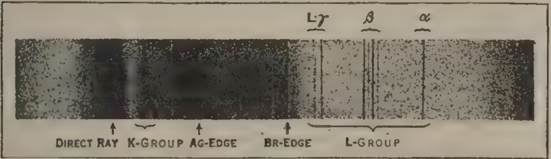


FIG. 5

Another way of exciting X-ray spectra is to irradiate the substance with an intense beam of X-rays. In this case the substance emits "secondary" rays which, with a few exceptions, are identical with the X-radiation sent out by the same substance used as an anticathode in an X-ray tube. This method does not however give the same intensity as the former.

Different Kinds of X-ray-spectra.—The X-ray spectrum emitted from an arbitrary substance is built up of two kinds of radiation, one of which shows a continuous distribution over a wide range of wave-lengths, the other consisting of a few monochromatic rays overlapping the former (*see* fig. 5). The first mentioned radiation corresponds to the "white" light of ordinary optics, whereas the second is analogous to the line-spectra. The continuous spectrum contains the greater part of the energy of radiation and is therefore the most important part for medical and many other applications of the X-rays. This part of the X-ray spectrum shows qualitatively no dependence on the radiating substance, the intensity only being different from various anticathodes.



FROM SIEGBAHN, "SPEKTROSKOPIE DER RÖNTGENSTRAHLEN" (SPRINGER)

FIG. 6.—SPECTRUM FROM A COOLIDGE TUBE WITH TUNGSTEN ANTICATHODE

The line-spectra on the other hand are characteristic of the emitting substance. They correspond to the K- and L-radiation of Barkla, but analysis has shown that each of these radiations consists of a group of monochromatic spectral-lines.

In addition to the emission-spectrum of X-rays there is also an absorption-spectrum analogous to the absorption-spectra of ordinary optics. Such spectra are obtained when a sheet of thin foil of some substance is placed between the X-ray source and the photographic plate. Instead of a continuous blackening from the white X-radiation the plate shows one or more sharp edges where there is a rapid change in the blackening; these edges are called "absorption-edges." The wave-lengths of these absorption-edges show an intimate relation to the characteristic line-spectrum of the substance used as absorbing screen. Such absorption-spectra were first obtained by Duc Maurice de Broglie and given right interpretation by Sir William Bragg and M. Siegbahn. Fig. 6 is a reproduction of a spectral-plate showing these three kinds of spectra.

The Continuous Spectrum.—As already mentioned the "white" or continuous radiation from an X-ray tube covers a rather wide region of wave-lengths. The diagrams of fig. 7 give an idea of the distribution of the energy of the different wave-lengths at voltages from 20 to 50 kilovolts. The curves of distribution always start at a definite minimum wave-length ($\lambda_{\min}$). The value of this wave-length decreases with increasing voltage.

It has been found empirically and verified by many investigators that this wave-length ($\lambda_{\min}$) or its corresponding frequency $\left(\nu_{\max}=\frac{1}{\lambda_{\min}}\right)$ obeys the Einstein law

$$\nu_{\max}=\frac{eV}{h} \qquad (2)$$

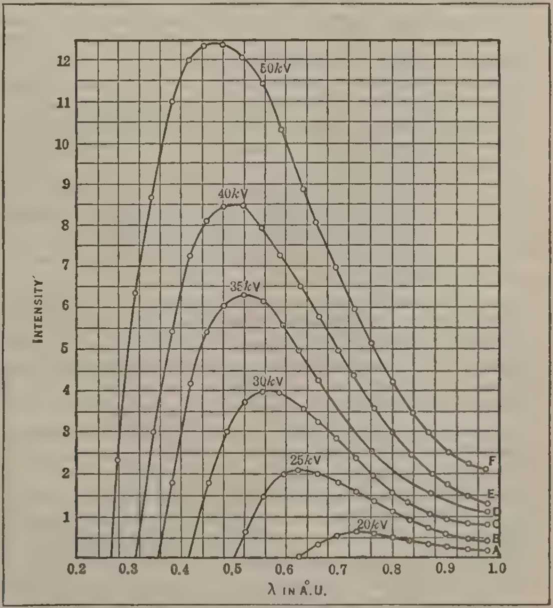
where e is the charge of the electron, V the tension on the tube, and h = Planck's constant. If the numerical figures of e and h are introduced the equation may be written

$$\lambda_{\min}=\frac{12\cdot3}{V} \qquad (3)$$

where the wave-length is expressed in Å.U. (10^{-8} cm.) and V in kilovolts.

The physical interpretation of the equation (2,3) is given by the quantum theory as follows. When the potential is applied between the cathode and the anticathode an electron on passing from the former to the latter acquires the energy: eV. If the electron is suddenly brought to rest at the anticathode this energy is given off as an electromagnetic wave with the frequency ν and containing the energy $h\nu$, which gives

$$h\nu=eV$$



FROM SIEGBAHN, "SPEKTROSKOPIE DER RÖNTGENSTRAHLEN" (SPRINGER)

FIG. 7.—INTENSITY DISTRIBUTION OF THE CONTINUOUS RADIATION FROM A TUNGSTEN ANTICATHODE AT VARIOUS VOLTAGES

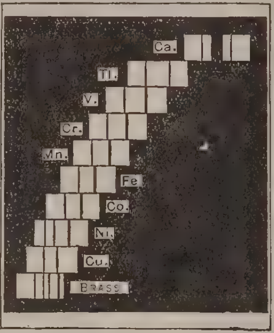
which corresponds to the above equation (2) for the maximum frequency. Generally the electron before being completely stopped will suffer several collisions and will send out smaller amounts of energy or waves of smaller frequencies.

The *total amount of energy,* that is, the integral energy included by the distribution-curves in fig. 7, has also been measured by many investigators. As the result of these researches it can be stated that *the total energy is proportional to the square of the voltage on the tube.*

Secondly it has been found (by G. W. C. Kaye and others) that for different elements used as anticathode the *total radiation is proportional to the atomic number of the element.*

Already in the early days of X-ray technique it was found advantageous to use heavy elements as anticathodic materials for the medical X-ray tubes, an observation which is in agreement with the last general law.

The Line-spectra.—In 1913 and 1914 the young English physicist H. G. J. Moseley published two very remarkable papers in the Philosophical Magazine entitled *"The High-frequency spectra of the elements."* The two papers contain the first announcement of the birth of a new branch of optics. Moseley showed in these publications that there existed in the realm of X-rays line-spectra of the same type as was known in ordinary optics and at the same time that these new spectra were built up in a much more simple and regular way than is generally the case in the spectra which had previously been studied.



FROM PHILOSOPHICAL MAG. 1913, SER. 6, VOL. 26, PL XXIII (TAYLOR AND FRANCIS, LONDON)

FIG. 8.—THE K-SERIES OF THE ELEMENTS Ca TO Cu, AND OF BRASS (Cu, Zn)

Two groups of spectral-lines were found. One of these groups was identified with the K-series of Barkla; the other, of longer wave-length and of more complex structure, corresponds to the L-series. Fig. 8 is a reproduction from Moseley's paper of spectra of successive elements from Ca (atomic number 20) to Zn (30). It shows in the most beautiful way how regularly the spectra—in this case the K-group—repeat themselves from one element to the next. With increasing atomic number (here from 20 to 30) of the emitting element the line-group is displaced in regular steps towards the shorter wave-length. This rule is not confined only to these elements and this group, but is universally confirmed by all X-ray spectra.

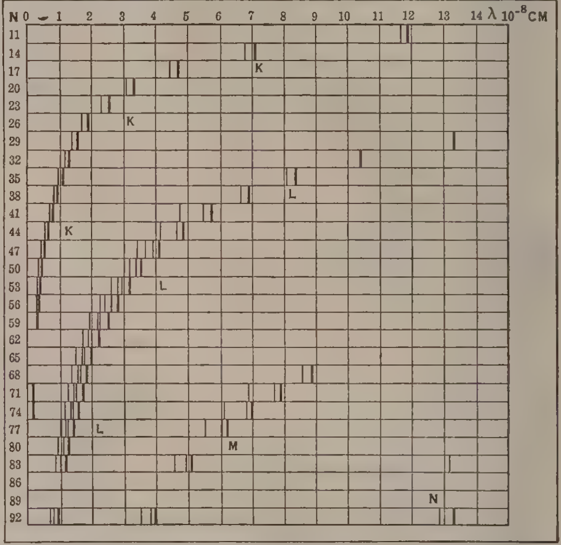
In 1916 M. Siegbahn discovered a new series of still greater wave-lengths called the M-series. The existence of series outside the K- and L-group had already been suspected earlier by reasons of analogy. In the later development of X-ray spectroscopy some indications of still other series, N, O, etc., have been traced, but further experimental work is needed to prove its existence.

A general scheme of the X-ray spectra is given in the diagram fig. 9 which contains the strongest lines of the three groups K, L and M at every third element from Na (11) to U (92). The diagram shows how all three series are regularly displaced to longer wave-lengths as one proceeds from the heavier elements to the lighter. If the spectrum of some special element, say Tungsten, a material commonly used for the anticathode, is considered, it will be seen that there are big gaps between the three groups where no lines are to be found. This fact is of predominant importance in interpreting the spectra in their relation to the structure of the atom.

As to the structure of the different groups it may be mentioned that the K-group generally consists of 4 lines ($\alpha_1\alpha_2\beta_1\beta_2$) the L-group of more than 20 lines (the strongest lines designated by $\alpha_1\alpha_2$, $\beta_1\beta_2\beta_3 \cdots$, $\gamma_1\gamma_2 \cdots$) and finally the M-group of about 20 lines.

Most of the X-ray spectra consists of a very easily absorbed radiation so that in using an ordinary X-ray tube they will not reach outside the glass-walls. In the diagram in fig. 9, only the small portion between the vertical lines 0 and 1 Å.U. includes the radiation given off by the technical X-ray tube. Hence for the study of X-ray spectra, one is confined to the use of tubes with thin foils as windows and spectrometers built for vacuum.

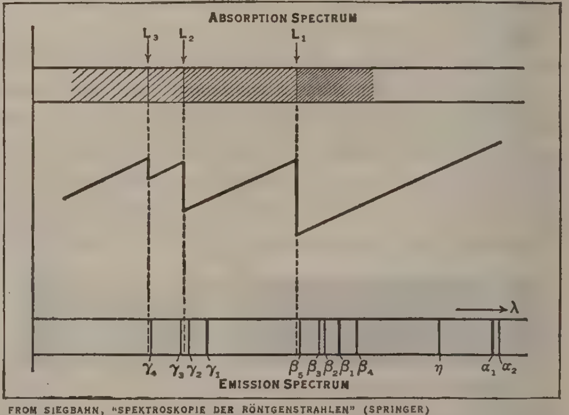
The Absorption Spectra.—As already mentioned the absorption spectra, obtained by putting a screen of the substance between the X-ray source and the spectral plate, usually have the appearance of a sudden, sharp drop in the blackening of the plate.



FROM SIEGBAHN, "SPEKTROSKOPIE DER RÖNTGENSTRAHLEN" (SPRINGER)

FIG. 9.—DIAGRAM SHOWING THE STRONGEST LINES OF THE SEVERAL X-RAY SERIES FOR EVERY THIRD ELEMENT

The study of these spectra has shown that there is always *one* absorption-edge in the region of wave-lengths where the K-group of the same element is located. In the region of the L-group there are *three* absorption-edges and finally in the domain of the M-group experiments have revealed *five* edges.


ABSORPTION SPECTRUM
L_3
L_2
L_1
λ
γ_4 γ_3 γ_2 γ_1 β_5 β_3 β_2 β_1 β_4 η α_1 α_2
EMISSION SPECTRUM

FROM SIEGBAHN, "SPEKTROSKOPIE DER RÖNTGENSTRAHLEN" (SPRINGER)

FIG. 10.—DIAGRAM OF THE ABSORPTION AND THE EMISSION SPECTRUM SHOWING THE RELATIVE POSITIONS OF DISCONTINUITIES AND LINES

As to the K-absorption-edges the measurements of their wave-lengths show that they have, if not exactly, very nearly, the same values as those of the line with the shortest wave-lengths within the K-group.

How the three absorption-edges of the L-group are located relative to the L-emission-lines is shown in figure 10. As seen from this diagram, here also the edge with the shortest wave-length agrees with the shortest emission-line. It is reasonable to suppose that the L-group may be divided in three sub-groups of lines of which every one is related to one of the three edges as is the case in the K-group. A numerical analysis of the material strongly supports this view as will be stated later.

Analogous results concerning the five edges within the M-group indicate the existence of five sub-groups in this series.

Connection Between Emission- and Absorption-spectra.—As soon as reliable measurements of the two kinds of X-ray spectra, line- and absorption-spectra, had been performed it was immediately clear that there existed a very intimate relation between them. If the frequencies of the absorption-edges are indicated by

K for the one absorption-edge within the K-group
$L_I\ L_{II}\ L_{III}$ for the three absorption-edges within the L-group
$M_I\ M_{II}\ M_{III}\ M_{IV}\ M_V$ for the five absorption-edges within the M-group

it is found that the differences between some of these values give exactly the frequencies of some of the emission-lines. For instance the differences $K-L_{II}$ and $K-L_{III}$ give the values of the frequencies of the two strongest lines of the K-group namely $K\alpha_1$ and $K\alpha_2$. On calculating the difference between some of the above M-values and the K-value other lines belonging to the K-group are obtained.

In the same way a difference between L_I, L_{II} and L_{III} with some of the values of the higher absorption-edges ($M_I\ M_{II}\cdots$) gives emission-lines of the L-group. Now these connections between the absorption and emission-spectra allow an extension which seems highly probable. The frequencies obtained by calculating the difference between the three L-values and the M-values include only part of the L-emission-lines, but supposing the existence of higher absorption-frequencies $N_I\ N_{II}\ N_{III}\cdots O_I\cdots$ of suitable frequencies the remaining L-lines may be accounted for as differences between absorption-frequencies. The existence of these higher absorption edges has not as yet been directly experimentally proved but they are strongly supported by the fact that also lines of the M-group may be calculated from them in the same way as were the L-lines.

If this hypothesis is right we should expect that there are for the heaviest elements *seven* absorption-edges, *five* O and probably three P-edges.

Now it may be added that not all the numerical differences between two arbitrary absorption-values correspond to emission-lines. Some of these "calculated" lines for some reason or other do not exist; they belong to what are called "forbidden" transitions.

Physical Interpretation of the X-ray Line-spectra and the Structure of the Atom.—According to the Bohr-Rutherford hypothesis the atoms are built up of a positive nucleus of comparatively small dimensions which is surrounded by a number of electrons. If this general picture of the atom is accepted the X-ray spectra furnishes us with a lot of valuable information regarding the feature of the electronic part of the atom. Then plausible calculations show that the X-ray series of highest frequencies, the K-series, must be ascribed to those electrons which form the innermost part of the electronic atmosphere of the atom. The higher series consequently correspond to successive electronic transitions outwards to the surface-layers of the atom, where we meet the region of the ordinary optical spectra.

In the X-ray absorption-spectra according to this view we find the different energy-levels pictured, which correspond to the energy-output necessary to remove one or other of the electrons of the atom. In consequence we speak of the K-level, the L-levels, etc. of the atom. Or if we wish to indicate the parts of the electronic atmosphere, the K-shell, the L-shell, etc., each of these shells may of course include more than one electron. For instance it is probable that the K-shell contains two electrons, the L-shells eight electrons, the M-shell eighteen electrons and so on.

After one electron has—by absorption of energy—been thrown out from its place within the atom its place will soon be filled up by an electron which through the attraction of the positive nucleus falls from some of the outer shells into the empty place. This means a diminishing of the energy of the atom, the superfluous energy being sent out as an X-ray wave. In this way we understand the emission of, for instance, the K-line in the following manner. One of the electrons belonging to the K-shell has by absorption of energy been removed, its place is taken up by an electron from the L-shell, accompanied by emission of the K-α-line. As after this process there is an empty place in the L-shell this may again be filled say by an M-electron with emission of an L-line and so on.

It is immediately seen that this picture of the absorption and emission-process is in conformity with the connection between the two kinds of spectra discussed in the preceding paragraph.

As to the structure of the electronic shells of the atoms some general conclusion may be drawn from the empirical knowledge of the X-ray spectra, which, as just mentioned, may be interpreted as coming from the different layers of the electronic atmosphere of the atom.

First the fact that the X-ray spectra of all the elements show a very big resemblance to each other and change from element to element mainly by moving toward higher frequencies must mean that the general structure of the electronic layers within the atom is the same for all elements. The increasing of the frequencies is readily understood by the increasing positive charge of the nucleus and the accompanying strengthening of the attractive forces acting on the electrons.

Secondly the appearance of the distinct and widely separated groups: K, L, M . . . indicates that the electronic atmosphere of the atom consists of distinct layers or shells with decreasing energy-contents beginning with the innermost shell, the K-shell followed by the L-shell, the M-shell and so on.

Thirdly all these shells or groups of electrons (except the K-group) are divided into sub-groups as indicated by the existence of more than one absorption-edge or energy-level within every main group.

Further information regarding the structure of the atom is obtained by considering the completeness or rather lack of completeness of the X-ray spectra of the different elements. If one starts with the heaviest element, uranium (with atomic number 92) and proceeds towards the lightest elements it is found that successively and systematically a number of spectral lines (and consequently also absorption-edges) vanish. That means the successive peeling off of electronic shells whereby the number of possible transitions between the groups is reduced. The remaining lines and edges of every atom consequently show directly the number of layers and furnish us with a means of mapping out the electronic structure of the different elements. If we confine ourselves to the inert gases the empirical study of the X-ray spectra suggests the existence of the following shells filled with a number of electrons as given in the table on p. 200.

X-ray Spectra and Chemical Constitution.—The most striking difference between the ordinary optical spectra and the X-ray spectra is the fact that the former show a marked resemblance between elements with same chemical character and change considerably from one group of chemically analogous elements to another whereas in the X-ray spectra no indication of the chemical nature of the elements is to be found. This is readily understood by the picture of the atom and its relation to the spectra which has just been given. From this interpretation the optical spectra arise from the surface of the atom which is also the seat of the chemical bounds, while the X-ray spectra are given off from the inner parts of the electronic atmosphere of the atom. But of course it is to be expected that a small influence may be seen if an atom emitting an X-ray is acted upon by neighbouring atoms. This is a question of the sensitivity or accuracy in the methods of studying the X-ray spectra. By increasing the precision of the measurements it has been possible to detect a number of such effects as just mentioned; for instance it has been shown by Bergengren and Lindh that the K-absorption-edges are a little displaced when the atom (Phosphorus, Sulphur and Chlorine especially have been studied) enters in different chemical combinations. The valency of the atom seems to be one of the main factors in this respect so that by investigations of the kind valuable information regarding the valencies may be obtained.

TABLE I.

	K	LI.	LII. LIII.	MI.	MII. MIII.	MIV. MV.	NI.	NII. NIII.	NIV. NV.	NVI. NVII.	OI.	OII. OIII.	OIV. OV.	PI.	PII. PIII.
2. Helium .	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
10. Neon .	2	2	6	..	..	..	..	..	..	..	..	..	..	..	..
18. Argon .	2	2	6	2	6	..	..	..	..	..	..	..	..	..	..
36. Krypton .	2	2	6	2	6	10	2	6	..	..	..	..	..	..	..
54. Xenon .	2	2	6	2	6	10	2	6	10	..	2	6	..	..	..
86. Radon .	2	2	6	2	6	10	2	6	10	14	2	6	10	2	6

But the line-spectra are also in a certain degree influenced by the chemical bonds as shown by Lundquist, Bäcklin, Ray, etc.

Finally we may in this connection point out the service that the X-ray spectroscopy has rendered as a method of chemical analysis and for the detection of new elements. On the suggestion of Bohr that the element with atomic number 72 may be sought in minerals containing its homologue Zirkon, Coster and Hevesy succeeded in identifying this new element by its X-ray spectrum. Berg, Noddack and Tacke gave convincing evidence of the unknown elements 75 and 43 by X-ray methods. (M. SIE.)

SPEE, MAXIMILIAN, COUNT VON (1861–1914), German sailor, was born in Copenhagen on June 22, 1861. He entered the German navy in 1878 and from 1887 to 1888 was Hafenkommandant (commander of the port) in German Cameroon. In 1908 he was made chief of staff of the German North sea command, and at the end of 1912 took over the Far Eastern Squadron. On Nov. 1, 1914, he was engaged by Admiral Cradock off Coronel, on the Chilean coast, and succeeded in defeating the British squadron. On Dec. 8, 1914, however, he was attacked by Admiral Sturdee's cruiser squadron. The Germans were heavily defeated in the battle that took place. This is usually known as the battle of the Falkland islands, and in it Spee himself went down with his flagship, the "Scharnhorst." (*See* CORONEL; FALKLAND ISLANDS.)

SPEED, JOHN (1552–1629), English historian and cartographer, was the son of a London tailor, and followed his father's trade, being admitted member of the Merchant Taylors Company in 1580. He settled in Moorfields, where he built himself a house. He was enabled to devote himself to antiquarian pursuits through the kindness of Sir Fulke Greville, whom Speed calls the "procurer of my present estate," and through his patron's interest he also received a "waiter's room in the custom-house." His important works are: *Theatre of the Empire of Great Britaine* (1611), a series of fifty-four maps (with descriptive matter) of different parts of England, which had already appeared separately, and in which he was helped by Christopher Saxton, John Norden and William White; and *History of Great Britaine under the Conquests of the Romans . . . to . . . King James* (1611). Speed brought some historical skill to bear on the arrangement of his history; in preparing it he received help from Sir Robert Cotton, William Smith, Henry Barkham and Sir Henry Spelman. Speed brought some historical skill to bear on the arrangement of his work, and although he repeated many of the errors of older chroniclers he added on the whole a substantial contribution of valuable material for the history of his country. He died in London on July 28, 1629.

Other maps of his, beside those in the *Theatre,* are in the British Museum. Another edition of the *Theatre* is *Theatrum Magnae Britanniae latine,* redditum a P. Holland (London, folio, 1616). He wrote *Genealogies Recorded in Sacred Scriptures* (1611), and a similar work, *A Cloud of Witnesses* (1616). These passed through numerous editions, and were frequently prefixed to copies of the Bible. An account of Speed's descendants is to be found in Rev. J. S. Davies's *History of Southampton* (1883), which was founded on ms. material left by John Speed (1703–1781).

SPEEDOMETERS, instruments for measuring linear speeds—more particularly the speeds of road vehicles—and graduated in miles (or kilometres) per hour. They are driven either from one of the road wheels, or from the transmission, through a flexible shaft and a gear mechanism. Account is taken of the diameter of the road wheel and of the gear ratio between the wheel and the speedometer shaft. Speedometers carry a so-called odometer, which indicates distance.

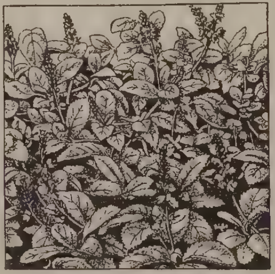
Main Principles.—The oldest speedometers depend on centrifugal force. A pair of weights is carried on a revolving shaft, in such a manner that they may move out from the axis as in the Watt conical pendulum governor, being restrained by a spring. The faster the shaft revolves, the farther the weights will move out from the axis of rotation. An indicator records the speed.

A second principle very extensively used is that of magnetic drag. A cup of sheet aluminium is mounted on a spindle and held in the "zero" position by a spiral spring. A permanent magnet whose lines of force pass through the wall of the cup is rotated inside the latter at a speed proportional to that to be measured. The rotation of the magnet induces currents in the aluminium cup and the reaction between these currents and the magnetism of the magnet produces a drag on the cup, which causes it to turn around its axis against the resistance of the spring, and in proportion to the speed of the magnet. A scale printed on the outside of the cup shows through an opening in the face of the instrument, and the scale reading in line with a mark on the face indicates the speed.

A third principle made use of is based on the fact that speed is the quotient of distance by time. Instruments based on this principle comprise an odometer and a clockwork, measuring distance and time respectively, and they effect the operation of division mechanically.

A further principle is that of the magneto and voltmeter. A magneto generator has the characteristic that the voltage generated by it varies with the speed at which its armature is driven. Therefore, if a magneto is placed in driving connection with a road wheel and its terminals are connected to a voltmeter whose scale, instead of in volts, is graduated in miles per hour, the combination will serve as a speedometer. This type is particularly adapted for use where it is desirable to take readings at a long distance from the road wheel as the only connection is by wires. (P. M. H.)

SPEEDWELL, in botany the name applied to the 17 British species of the genus *Veronica* (family *Scrophulariaceae*); the British forms are herbs with bright blue flowers. The genus *Veronica* contains about 250 species, temperate, alpine and arctic, many of which are shrubs or trees with handsome spikes of flowers, and are often cultivated The woody forms are especially characteristic of the mountains of New Zealand. Some 15 species occur in North America, including several that have been naturalized from the Old World. The culver-root (*Veronica virginica*), found across the continent, was formerly much used in medicine.



BY COURTESY OF THE WILD FLOWER PRESERVATION SOCIETY

THE COMMON SPEEDWELL (VERONICA OFFICINALIS), WHICH BEARS SMALL PINK, BLUE OR WHITE FLOWERS

SPEENHAMLAND SYSTEM, a system of poor relief adopted by the Berkshire magistrates in 1795, by which the wages of labourers were supplemented from the poor-rates up to a certain level, an additional dole being permitted for each child. At a critical moment the Berkshire justices were forced to adopt a desperate remedy, but it was a pernicious plan, for it unfairly transferred the burden of wages from the employer to the rate-payer, it encouraged the farmers to pay inadequate wages, and degraded the labourer to the position of a pauper. The system lasted until the new Poor Law of 1834; it was never in force in Scotland or the north of England.

SPEKE, HUGH (1656–*c.* 1724), English writer and agitator, was a son of George Speke (d. 1690) of White Lackington, Somerset. Educated at St. John's College, Oxford, Hugh Speke joined the Green Ribbon Club, and in 1683 he was put in prison for asserting that Arthur Capell, earl of Essex, had been murdered by the friends of the duke of York. In prison Speke kept a printing-press, and from this he issued the *Address to all the English Protestants in the Present Army,* a manifesto written by the Whig divine Samuel Johnson (1649–1703), urging the soldiers to mutiny. In 1687 he was released, and in 1688 he served James II. as a spy in the camp of William of Orange. In December of this year a document, calling upon the Protestants to disarm their Roman Catholic neighbours was freely circulated, and much damage was done to property in London before it was found that it was a forgery. Speke asserted his authorship in his *Memoirs* (1709), revised as *The Secret History of the Happy Revolution in 1688* (1715). Speke died in obscurity before 1725.

SPEKE, JOHN HANNING (1827–1864), English explorer, discoverer of the source of the Nile, was born on May 4, 1827, at Jordans, Somersetshire. He entered the Indian Army in 1844. He served under Sir Colin Campbell's division in the Punjab. When on furlough Captain Speke explored the Himalayas, and crossed into Tibet. In 1854 he joined Richard Burton in Somaliland, as narrated in *What led to the Discovery of the Source of the Nile* (London, 1864). In April 1854 Speke was wounded by Somalis. Invalided home, he volunteered for the Crimea and served with a regiment of Turks.

In 1856 Speke joined Burton in exploration of the African lakes, especially Nyassa. The route to Nyassa was closed by the Arabs, and the travellers left Zanzibar in June 1857 by a more northerly route. They learnt from an Arab trader that further inland were three great lakes—and Speke assumed that the most northerly would be the source of the Nile. In January 1858 the travellers reached Lake Tanganyika. By June they were back at Kazé, and here Speke induced his chief, who was ill, to allow him to attempt to reach the northern lake. Marching north for 25 days, on July 30 Speke reached a creek, along which he travelled till, on Aug. 3, he saw it open up into the waters of a lake extending northward to the horizon. He no longer doubted that this lake—the Victoria Nyanza—was the source of the Nile. Returning to Kazé (Aug. 25) he made known his discovery to Burton, who did not believe Speke's theories.

Speke had the support of Sir Roderick Murchison, president of the Royal Geographical Society, under whose direction a new expedition was fitted out. Of this expedition Speke had the command, his only European companion being Captain (afterwards Colonel) J. A. Grant (*q.v.*). The expedition, over 200 men all told, started from Zanzibar in Oct. 1860 and reached Kazé on Jan. 24, 1861. The Victoria Nyanza was again reached, at its south-west corner, in Oct. 1861. Following the western shores of the lake Speke crossed the Kagera Jan. 16, 1862, and arrived at the capital of Uganda on Feb. 19 following. Here he was detained by the king Mtesa, for some months, but at last prevailed on the chief to furnish him with guides, and on July 28 Speke stood where the Nile issued from the lake. The travellers were not permitted to visit another large lake (the Albert Nyanza) of whose existence and connection with the Nile they learned. As far as possible Speke and Grant followed the course of the Nile, and on Dec. 3 came in touch with the outside world once more. On Feb. 15, 1863, they arrived at Gondokoro. At Gondokoro they met Sir Samuel (then Mr.) Baker, generously giving him the information which enabled him to discover the Albert Nyanza.

In the same year (1863) Speke published his *Journal of the Discovery of the Source of the Nile,* a work written in a frank, attractive style. His conclusions were disputed by Burton and McQueen in *The Nile Basin* (1864), it being argued in this work that Tanganyika was the true Nile source. Speke was to discuss the question with Burton at the geographical section of the British Association at Bath on Sept. 16, but he accidentally shot himself while out after partridge on Sept. 15.

See, besides the works mentioned, Sir R. F. Burton, *The Lake Regions of Central Africa* (1860); J. A. Grant, *A Walk across Africa* (1864); T. D. Murray and A. S. White, *Sir Samuel Baker: a Memoir* (1895); *The Times* (Sept. 17 and 19, 1864); Sir H. H. Johnston, *The Nile Quest* (n.d. [1903]).

SPELL, a word of Teutonic origin meaning something "spoken." In general terms, the belief underlying the use of spells is that the wish that they embody will be fulfilled, regardless of its goodness or badness, so long as the formula has been correctly pronounced. Broadly speaking, then, spell and prayer, like magic and religion to which they severally belong, can be distinguished by the nature of the intended purpose.

Ritual is to be seen in relation to its moral context as a whole. For instance, the judicial oath may have lost some of its special significance as a religious act of binding force, but, taken in connection with the solemn endeavour, of which it forms a part, to administer justice in the light of the truth, its validity can hardly be said to have been affected. Or, again, charges of formalism as regards the details of religious worship are recklessly bandied about, when the spirit and not the letter of the observance should alone be regarded as relevant to the issue. Next, as regards the criterion of intelligibility, we must make sure in using it that we are not making our own ignorance the measure of the intrinsic value of the rite alleged to be without meaning. Just as any foreign tongue is gibberish to the unlearned, so we may be deaf to the most eloquent symbolism if we have not a key to the sense.

To take an example from Australia, if members of the witchetty grub totem desire to secure a harvest of these grubs for the benefit of the community, they repair in procession to certain stones that remind them by their shape of witchetty grubs and rub their stomachs with these stones, thus indicating the precise destination to which the symbolized delicacies are meant to find their way. Moreover, this pantomime is reinforced by oral means in the solemn declaration, "We have eaten much food"; where, let the perfect tense be noted, as if for the man of faith the thing were as good as done.

The chief deity of the Masai goes by the name that simply means "The Rain"; and the simplest of their rites consists in crying out "Rain! Rain!" in chorus (*see* PRAYER). Here the question whether this is prayer or spell ought not to turn on the degree of personality attaching to the god, and still less on a grammatical point such as the possible use of the imperative mood. Surely the religious character of the whole proceeding is sufficiently established by the fact that "The Rain" is for the Masai, the reputed giver of all good things.

In primitive rite the verbal formula tends to be accessory to the dramatic part of the procedure. Sometimes it is but descriptive of the action, "We are doing so and so," though sometimes the purpose is added, "We are doing so and so, that so and so may happen." Thus the efficacy of the rite, words and all, is apt to seem self-contained. The rite has *mana* (*q.v.*), which is almost to say "It works, I know not why" in one pregnant word. Correspondingly, it becomes a perilous instrument for the ordinary man to handle, and its use is reserved for the man with *mana*—the expert who is strong enough to wrestle with mysteries. Now to be vested with esoteric attributes in one's own eyes no less than in the eyes of the rest bears hard on the weakness of the flesh. True, the wonder-worker may be ready to admit that his *mana* possesses him rather than he it. An Australian medicine-man, for instance, who had given way to European strong drink, became convinced that his healing power had left him and in a spirit of befitting humility retired from practice. Or, again, we have the Malay wizard whose spell explicitly announces that some power greater than himself is working through him: "It is not I that am burying him (in the form of a waxen image), it is Gabriel who is burying him."

In Melanesia and elsewhere a man owns a ritual and charms so completely that he can bequeath them to a son. Nay, he can even sell them in the open market, and in such a case we expressly learn that the oral part of the rite—the muttered spell—is what the money is paid for, since it is what the owner can most easily hide and so keep to himself. At this point the spell has clearly become a non-moral thing, a mere trade secret. It will degenerate still further into *abracadabra*. The folklorist is constantly coming across oral survivals in the mouths of peasants that once were medical recipes or even prayers couched in Latin. Afterwards, when reduced to mere rigmarole, these have been treasured by the unlettered for the sake of the sheer mystery lurking in the unfamiliar sounds. (R. R. M.)

BIBLIOGRAPHY.—W. Hertmüller, *Im Namen Jesu* (1903); R. R. Marett, "From Spell to Prayer" in *The Threshold of Religion* (1914); W. W. Skeat, *Malay Magic*. *See* also MANA; PRAYER; RITUAL.

SPELLO (*Hispellum, q.v.*), a town of Umbria, 1,030 ft. above sea-level. Pop. (1921), 2,849 (town); 6,161 (commune). S. Maria Maggiore contains some of Pinturicchio's finest frescoes (1501), "The Annunciation," "The Adoration" and "Christ in the Temple."

SPELMAN, SIR HENRY (*c.* 1564–1641), English antiquary, was the eldest son of Henry Spelman, of Congham, Norfolk, and the grandson of Sir John Spelman (*c.* 1495–1544), judge of the king's bench. He was educated at Walsingham School, and Trinity college, Cambridge. With Sir Robert Cotton and William Camden, he belonged to the Society of Antiquaries, which declined, and Spelman's efforts to revive it in 1614 were frustrated by James I. A judgment given against him by Bacon in a case over the crown lease of two abbeys led to his pamphlet *De non temerandis ecclesiis* (1613–16), which induced many lay owners of ecclesiastical spoils to make restitution, and Spelman himself acted accordingly. Spelman proposed to write a work on the foundations of English law, based on early charters and records; as a preliminary to this task he began to compile a glossary, the first volume of which, *Archaeologus in modum glossarii*, was published at his own expense in 1626. He continued to work at the subject until 1638. A second volume, *Glossarium archaiologicum* (1664), appeared after his death. His *Codex legum veterum statutorum regni Angliae, quae ab ingressu Gulielmi I usque ad annum nonum Henry III. edita sunt* was published by David Wilkins in his *Leges anglo-saxonicae* (1721). Spelman's most important work, *Concilia, decreta, leges, constitutiones in re ecclesiarum orbis britannici* (2 vols., 1636–64), is an attempt to place English church history on a basis of genuine documents. Spelman entered parliament as member for Castle Rising in 1597, and took a prominent part in public business until his death (Oct. 1641). He was buried in Westminster Abbey.

Edmund Gibson, bishop of London, published in 1723 *The English Works of Sir Henry Spelman, Kt., Published in his Lifetime; together with his Posthumous works relating to the Laws and Antiquities of England*. The first section contained *De non Temerandis Ecclesiis*, already mentioned; *The Larger Treatise concerning Tythes*, first published in 1646; *De sepultura;* and *Villare anglicum, or a View, of the Towns of England;* while the second included *The Original Growth, Propagation and Condition of Feuds and Tenures by Knightservice in England*, written in 1639; *Two Discourses: i. Of the Ancient Government of England, ii. Of Parliaments; The Original of the Four Terms of the Year*, written in 1614 and first printed in 1684; *Icenia:* a Latin description of Norfolk, and some other treatises. This was a revised edition of an earlier collection (1698), and contained a life of the author, based chiefly on the autobiographical matter prefixed to the Glossary of 1626, and two additional papers, *Of the Admiral Jurisdiction, and the Officers thereof*, and *Of Antient Deeds and Charters*. Wilkin's edition of his *Concilia* was edited by A. W. Haddan and W. Stubbs in 1869–73.

SPENCE, THOMAS (1750–1814), inventor of a system of land nationalization, was born at Newcastle-on-Tyne on June 21, 1750, the son of a Scottish netmaker and shoemaker. He proposed the establishment of self-contained parochial communities, in which rent paid to the corporation, in which the absolute ownership of the land was vested, should be the only tax of any kind. His pamphlet, *The Meridian Sun of Liberty*, which was first hawked in Newcastle, appeared in London in 1793; it was reissued by Mr. H. M. Hyndman under the title *The Nationalization of the Land in 1775 and 1882*. Spence presently left Newcastle for London, where he kept a bookstall in High Holborn. In 1784 he spent six months in Newgate gaol for the publication of a pamphlet distasteful to the authorities, and in 1801 he was sentenced to twelve months' imprisonment for seditious libel in connection with his pamphlet entitled *The Restorer of Society to its Natural State*. He died in London on Sept. 8, 1814. His admirers formed a "Society of Spencean Philanthropists." (*See* Harriet Martineau's *England During the Thirty Years' Peace*.)

See also Davenport, *Life, Writings and Principles of Thomas Spence* (London, 1836); O. Rudkin, *Thomas Spence* (1926).

SPENCER, HERBERT (1820–1903), English philosopher, was born at Derby on April 27, 1820. His father, William George Spencer, was a schoolmaster, and his parents' religious convictions familiarized him with the doctrines of the Methodists and Quakers. He declined an offer from his uncle, the Rev. Thomas Spencer, to send him to Cambridge, and so was practically self-taught. During 1837–46 he was employed as an engineer on the London and Birmingham railway; in 1848–53 as sub-editor of the *Economist*. From about this time to 1860 he contributed numerous articles to the *Westminster Review*, which contain the first sketches of his philosophic doctrines. He also published two larger works, *Social Statics* in 1850, and *Principles of Psychology* in 1855. In 1860 he sent out the syllabus of his *Synthetic Philosophy* in ten volumes, which he completed in 1896 with the *Principles of Sociology*. He died on Dec. 8, 1903.

Spencer's significance in the history of English thought depends on his position as the philosopher of the great scientific movement of the second half of the 19th century, and on his friendship with men like Darwin, G. H. Lewes, and Huxley. He tries to express in a general formula the belief in progress which pervaded his age, and to erect it into the supreme law of the universe. But to the specialists in sciences which were advancing rapidly to results which often transformed their initial assumptions, Spencer has often appeared too much of a philosopher and defective in specialist knowledge; to the technical philosophers he has not seemed philosophic enough.

Spencer claims, with some reason, that he was always an evolutionist. But his notions of what "evolution" is developed gradually. At first he seems to have meant only the belief that progress is real, and that the existing order of nature is the result of a gradual process. In *Social Statics* (1850) he still regards the process teleologically, and argues after the fashion of Paley that "the greatest happiness is the purpose of creation" (ch. iii. § 1). In *The Development Hypothesis* (1852) he objects strongly to the incredibility of the special creation of the myriad forms of life, without, however, suggesting how development has been effected. In *Progress, its Law and Cause* (1857) he adopted Von Baer's law, that the development of the individual proceeds from the homogeneous to the heterogeneous. This is at once connected with the nebular hypothesis, and subsequently "deduced" from the ultimate law of the "persistence of force," and finally supplemented by a counter-process of dissolution, all of which appears to Spencer only as "the addition of Von Baer's law to a number of ideas that were in harmony with it." Spencer welcomed Darwin's *Origin of Species* (1859) and enriched its doctrines with the phrase "survival of the fittest"; but he did not give up the (Lamarckian) belief in the hereditary transmission of the modifications of organisms by the exercise of function.

Of his *First Principles* (1862) the first part shows that while ultimate metaphysical questions are insoluble they compel to a recognition of an inscrutable Power behind phenomena which is called the Unknowable; the second part is devoted to the formulation of the Law of Evolution. In the first part Spencer's argument rests on Mansel's *Limits of Religious Thought* and Hamilton's "philosophy of the conditioned" (and so ultimately on Kant), and tries to show that in scientific and religious thought the ultimate terms are "inconceivable" (not by him distinguished from "unimaginable"). In science, the more we know the more extensive "the contact with surrounding nescience." In religion the vital and constant element is the sense of mystery. This is illustrated by the difficulties inherent in the conception of Cause, Space, Time, Matter, Motion, the Infinite, and the Absolute, and by the "relativity of knowledge," which precludes knowledge of the Unknowable, since "all thinking is relationing." Yet of the Unknowable we may have an "indefinite knowledge," positive, though vague. Hence both science and religion must recognize as the "most certain of all facts that the Power which the Universe manifests to us is utterly inscrutable." In the edition of his *First Principles,* published in 1900, he adds a "postscript" which shows some consciousness of the contradiction involved in his knowledge of the Unknowable, and finally contends that his account of the Knowable in part ii. will stand even if part i. be rejected. But, in reality, a really inscrutable Unknowable would destroy all confidence in the order of nature and render all knowledge precarious.

In part ii. Spencer recognizes successively likenesses and unlikenesses among phenomena (the effects of the Unknowable), which are segregated into manifestations, vivid (object, non-ego) or faint (subject, ego), and then into space and time, matter and motion and force, of which the last is symbolized by our experience of resistance, and is that out of which our ideas of matter and motion are built. Hence the Persistence of Force is the ultimate basis of knowledge. From it Spencer deduces the indestructibility of matter and energy, the equivalence and transformation of forces, the necessity of a rhythm, of Evolution (*i.e.,* integration of matter with concomitant dissipation of motion) and Dissolution, and finally the statement of the Law of Evolution as "an integration of matter and concomitant dissipation of motion, during which the matter passes from an indefinite incoherent homogeneity to a definite coherent heterogeneity, and during which the retained motion undergoes a parallel transformation." This process of evolution is due to "the instability of the homogeneous," the "multiplication of effects" and their "segregation," continuing until it ceases in complete "equilibration." Sooner or later, however, the reverse process of Dissolution, with its absorption of motion and disintegration of matter must prevail, and these oscillations of the cosmic process will continue without end. It appears, therefore, that Spencer ultimately describes the Knowable in terms of the mechanical conceptions of matter and motion, and this gives a materialistic colouring to his philosophy.

In the *Principles of Biology* (1864) the chief points are the definition of life as the continuous adjustment of internal to external relations, and the consequent emphasis on the need of adapting the organism to its environment. This does not sufficiently recognize that the higher organisms largely adjust external to internal relations and adapt their environment to their needs. His universal process of Evolution seems to give Spencer a criterion of "higher" and "lower" "progression" and "degeneration," independent of the accidents of actual history. The higher (at least in times of "evolution") is the more complex, whether it invariably survives or not. On the other hand, he advances too easily from the maxim that function is prior to structure to the conclusion that the results of use and disuse are immediately incarnate in structural adaptations capable of hereditary transmission, an inference that has involved him in controversy with Weismann's school.

In his *Principles of Psychology* (1870–72) Spencer advocates the genetic explanation of the phenomena of the adult human mind by reference to its infant and animal ancestry. On the fundamental question, however, of the psychophysical connection and the derivation of mind from matter, his utterances are neither clear nor consistent. On the one hand, his whole formulation of Evolution in mechanical terms urges him to compose the mind out of homogeneous units of consciousness (or "feeling") "similar in nature to those which we know as nervous shocks; each of which is the correlative of a rhythmical motion of a material unit or group of such units" (§ 62); on the other hand, he is ready to amend *nervous* into *psychical* shocks, which is no doubt what he ought to have meant but could not say without ruining the illusory bridge between the psychical and the physiological which is suggested in the phrase "nervous shock." And he admits (§ 63) that if we were compelled to choose between translating mental phenomena into physical and its converse, the latter would be preferable. But he finally leaves the relation between the unknowable "substance of Mind" and the unknowable "substance of Matter" to the Unknowable. To the theory of knowledge Spencer contributes a "transfigured realism," to mediate between realism and idealism, and the doctrine that "necessary truths," acquired in experience and congenitally transmitted, are *a priori* to the individual, though *a posteriori* to the race, to mediate between empiricism and apriorism.

In the *Principles of Sociology* (1877–96) Spencer's most influential ideas have been that of the social organism, of the origination of religion out of the worship of ancestral ghosts, of the natural antagonism between nutrition and reproduction, industrialism and warfare. Politically, Spencer was an individualist of an extreme *laissez faire* type, and it is in his political attitude that the consequences of his pre-Darwinian conception of Evolution are most manifest. But for this, he would hardly have established so absolute an antithesis between industrial and military competition, and would have been readier to see that the law of the struggle for existence, just because it is universal and equally (though differently) operative in every form of society, cannot be appealed to for guidance in deciding between the merits of an industrial or military and of an individualist or socialist society.

In the *Principles of Ethics* Spencer, though relying on the intrinsic consequences of actions for the guidance of conduct, conceives the ethical end in a manner intermediate between the hedonist and the evolutionist. The transition from the evolutionist criterion of survival to the criterion of happiness is effected by means of the psychological argument that pleasure promotes function and that living beings must, upon pain of extinction, take pleasure in actions conducive to their survival. Conduct being the adjustment of acts to ends, and good conduct that which is conducive to the preservation of a pleasurable life in a society so adjusted that each attains his happiness without impeding that of others, life is valuable only if it conduces to happiness. On the other hand, life must in the long run so conduce because a constant process of adjustment is going on which is bound to lead to a complete adjustment which will be perfect happiness. Spencer concludes that the sense of duty must diminish as moralization increases. In this reasoning Spencer overlooks the possibility of an expansion of the ethical environment. If this is as rapid as the rate of adaptation, there will be no actual growth of adaptation and so no moral progress. Complete adaptation to an infinitely receding ideal is impossible, but Spencer considers that he can both anticipate such a state, and lay down the rules obtaining in it, which will constitute the code of "Absolute Ethics." He conceives it as a state of social harmony so complete that even the antagonism between altruism and egoism will have been overcome; everyone will derive egoistic pleasure from doing such altruistic acts as may still be needed. Originally the socially salutary action was in the main that which was enjoined on the individual by his political and religious superiors and by social sentiment; it was also in the main that to which his higher, more complex and re-representative feelings prompted. Hence the fear with which the political, religious and social controls were regarded came to be associated also with the specifically moral control of lower by higher feelings, and engendered by coercive element in the feeling of obligation. Its authoritativeness depends on the intrinsic salutariness of self-control, and must cease with the resistance of the lower feelings. Hence Spencer concludes that the sense of duty must diminish as moralization increases. In the preface to the last part of his *Ethics* (1893) Spencer regrets that "the Doctrine of Evolution has not furnished guidance to the extent he had hoped," but his contributions to ethics are not unlikely to be the most permanently valuable part of his philosophy.

After completing his system (1896) Spencer continued to revise it, and brought out new editions of the *Biology* (1898–99) and *First Principles* (1900). The dates of his chief works are as follows: 1842, Letters to the *Nonconformist, "The Proper Sphere of Government";* 1850, *Social Statics;* 1852, *The Theory of Population* (*cf.* part vi. of *Biology*); "The Development Hypothesis" (in *Essays,* vol. i.) 1853; *The Universal Postulate* (cf. *Psychology,* part vii.); 1854, "the Genesis of Science" (in *Essays,* vol. ii.); 1855, *Principles of Psychology* (1 vol.); 1857, *Progress, its Law and Cause* (*Essays,* vol. i.) 1858, *Essays* (containing most of his contributions to the *Westminster Review;* 1863, vol. ii.; 1885, vol. iii.); 1861, *Education: Intellectual, Moral, Physical;* 1862, *First Principles* (2nd ed., 1867; 6th, 1900); 1864–67, *Principles of Biology* (2 vols.); 1872, *Principles of Psychology* (2nd ed., in 2 vols.); 1873, *The Study of Sociology;* 1876, vol. i., *The Principles of Sociology;* vol. ii., *Ceremonial Institutions,* 1879, *Political Institutions,* 1882; vol. iii., *Ecclesiastical Institutions,* 1885, completed 1896; 1879, *The Data of*

Ethics (part i of *Principles of Ethics* in 2 vols.; part iv., *Justice,* 1891; parts ii. and iii., *Inductions of Ethics* and *Ethics of Individual Life,* 1892; parts v. and vi., *Negative and Positive Beneficence,* 1893). 1884, *Man versus the State.* 1886, *Factors of Organic Evolution.* 1893, *Inadequacy of Natural Selection.* 1894, *A Rejoinder to Professor Weismann* and *Weismannism once more.* 1897, *Fragments.* 1902, *Facts and Comments.* An *Autobiography* in 2 vols. appeared posthumously in 1904. For a useful summary of his chief doctrines by Spencer himself *see* his preface to Collins's *Epitome of the Synthetic Philosophy; see* also: J. A. Thompson, *H. Spencer* (1906); W. H. Hudson, *H. Spencer* (1908).

SPENCER, JOHN CHARLES SPENCER, 3RD EARL (1782–1845), English statesman, better known by the courtesy title of Lord Althorp, which he bore during his father's lifetime, was the son of George John, 2nd Earl (1758–1834), who served in the ministries of Pitt, Fox and Grenville, and was first lord of the admiralty from 1794–1801. John Charles was born at Spencer House, London, on May 30, 1782, and was educated at Trinity college, Cambridge. He represented Okehampton (1804), St. Albans (1806) and Northamptonshire (1806). When Lord Grey's administration was formed at the close of 1830 the chancellorship of the exchequer combined with the leadership of the House of Commons was entrusted to Lord Althorp. The budget was a failure, but this misfortune was soon forgotten in the struggles over the Reform bill, in the preparation and success of which Lord Althorp played an important part.

The death of the 2nd Earl Spencer in Nov. 1834, called his son to the upper house and was the occasion of Melbourne's dismissal by King William IV. He was the first president of the Royal Agricultural Society (founded 1838), and a notable cattle-breeder. He died at Wiseton on Oct. 1, 1845.

See Sir Denis Le Marchant, *Memoir* (1876); W. Bagehot, *Biographical Studies* (1881); E. J. Myers, *Lord Althorp* (1890).

SPENCER, JOHN POYNTZ SPENCER, 5th EARL (1835–1910), English statesman, was the son of the 4th Earl and his first wife. Born on Oct. 27, 1835, and educated at Harrow and Trinity college, Cambridge, he was a member of parliament for a few months before he succeeded to the earldom in Dec. 1857. His long career as a Liberal politician dates from his acceptance of the office of lord-lieutenant of Ireland under Gladstone in 1868, a post which he retained until 1874. When the Liberals returned to power in 1880 he was appointed lord president of the council, but in 1882 he entered upon a second term of office as lord-lieutenant of Ireland. In the Liberal administration of 1886 he was lord-president of the council, and from 1892 to 1895 he was first lord of the admiralty. From 1902 to 1905 he was the Liberal leader in the House of Lords, and early in 1905, was discussed as a possible Liberal prime minister. He died on Aug. 13, 1910. The fine library, collected at Althorp by the 2nd earl, was sold by him for £250,000 to Mrs. Rylands, the widow of a Manchester merchant, who presented it to that city.

SPENCER, a town of Worcester county, Massachusetts, U.S.A. Pop. (1920) 5,930. Spencer was settled in 1721 and incorporated in 1753. One of its houses was the birthplace of three inventors: William Howe, Tyler Howe and Elias Howe, Jr., who invented respectively the "Howe truss" bridge, the spring bed and the sewing machine.

SPENDER, JOHN ALFRED (1862–), British journalist, was born at Bath, the son of a doctor, and educated at Bath College, and at Balliol College, Oxford. Adopting the career of a journalist, he was editor of *The Eastern Morning News* from 1886 to 1890 and then on the staff of *The Pall Mall Gazette* in London. When the *Westminster Gazette* was established in 1893, he became an assistant editor and from 1896 to 1922 was its editor, leaving just after it became a morning paper. As editor of the *Westminster* Spender won general respect, not only as a brilliant writer but as the possessor of an exceptionally fair and balanced mind. He held a high place in the councils of the Liberal party and his services to the state included membership of the royal commission on divorce and of the Milner Mission to Egypt. A slight volume, *The Comments of Bagshot* (1914), reveals Mr. Spender at his best. He has also written *The Indian Scene* (1912); *The Foundations of British Policy* (1917); and *The Life of Sir H. Campbell-Bannerman* (1923). His memoirs appeared in 1926, *Life, Journalism, and Politics* (2 vols.).

SPENER, PHILIPP JAKOB (1635–1705), German theologian, was born on Jan. 13, 1635, at Rappoltsweiler in Upper Alsace. He won his degree of master at Strasbourg (1653) by a disputation against the philosophy of Hobbes. In 1666, he was chief pastor in the Lutheran Church at Frankfort-on-Main. Here he published his two chief works, *Pia desideria* (1675) and *Allgemeine Gottesgelehrtheit* (1680), and began that form of pastoral work which resulted in the movement called *Pietism.* In 1686 he accepted the invitation to the first court chaplaincy at Dresden. But the elector John George III. was offended by his chaplain's candour. Spener refused to resign his post, and the Saxon government hesitated to dismiss him. The difficulty was solved by his promotion (1691) to the rectorship of St. Nicholas in Berlin with the title of "Konsistorialrat." The university of Halle was founded under his influence in 1694. Spener was exposed to the abuse of orthodox Lutheran theologians. In 1695 the theological faculty of Wittenberg formally laid to his charge 264 errors. He died on Feb. 5, 1705. His last important work was *Theologische Bedenken* (4 vols., 1700–02), to which was added after his death *Letzte theologische Bedenken,* with a biography of Spener by C. H. von Canstein (1711). Though "the father of Pietism," the extravagances of the movement cannot be ascribed to him personally.

Spener was a voluminous writer. The list of his published works comprises 7 vols. folio, 63 quarto, 7 octavo, 46 duodecimo; a new edition of his chief writings was published by P. Grünberg in 1889. *See* W. Hossbach, *Philipp Jakob Spener und seine Zeit* (1828, 3rd ed., 1861); A. Ritschl, *Geschichte des Pietismus,* ii. (1884); E. Sachsse, *Ursprung und Wesen des Pietismus* (1884); P. Grünberg, *P. J. Spener* (3 vols., 1893–1906).

SPENGLER, OSWALD (1880–), German philosopher, was born at Blankenburg in the Harz on May 29, 1880. He studied mathematics and natural history, with history and art. This rare combination is the foundation of the peculiar character of Spengler's work, in which unexpected parallels between scientific truths of physics and mathematics and the artistic and other cultural achievements of an epoch of history are drawn. He completed in 1914 the first version of *Der Untergang des Abendlandes* (1918, rev. ed. 1922; Eng. trans. *The Decline of the West,* by C. F. Atkinson).

Other works of Spengler, chiefly concerned with contemporary political problems are: *Preussentum und Sozialismus* (1920); *Pessimismus* (1921); *Politische Pflichten der deutschen Jugend* (1924); *Neubau des deutschen Reiches* (1924).

See M. Schroeter, *Der Streit um Spengler, etc.* (1922).

SPENSER, EDMUND (?1552–1599), "the prince of poets in his time," was born in London—Oldys says, in East Smithfield—probably in 1552, possibly in 1549. (The date depends on whether Sonnet 60, written when Spenser was 41, belongs to 1593 or to 1590: *v. infra.*) His mother's name, he tells us, was Elizabeth: his father has been conjecturally identified with John Spenser, a journeyman cloth-maker. Later, the poet claimed kindred with the Spencers of Althorpe in Northamptonshire, and had his claim allowed; but the poverty of his home is shown by the grants made to him out of the Nowell bequest as a poor scholar of Merchant Taylors' school. There, under the great Mulcaster, he laid the foundations of his wide, if inexact, scholarship; best of all, he learned from Mulcaster to "worship the English," and to believe it as capable of great poetry as any language. He was still at school when, in 1569, he supplied some verse translations from Marot and du Bellay to Van der Noodt's *Theatre of Worldlings.* Van der Noodt, it is true, took the credit of these verses to himself: but they were included, with some alterations, in the *Complaints* volume of 1591 (*v. infra*), and we need not doubt that they are Spenser's. The rhymed stanzas after Marot at least bear his mark: the blank-verse renderings from du Bellay are inferior, and were considerably altered and tagged with rhymes for the re-issue of 1591.

In this same year he entered Pembroke hall, Cambridge, as a sizar, matriculating on May 20. He remained at Cambridge for seven years, as was then not unusual, proceeding B.A. in 1572 and commencing M.A. in 1576. His health was poor; but he read widely, especially in philosophy and rhetoric, studying Italian as well as Latin, Greek and French, and training himself for poetry. His studies profited from the friendship of Gabriel Harvey, a fellow of his college, a conceited pedant, but a real scholar, and sincerely attached to Spenser, though his friendship may not always have been quite disinterested nor his literary advice wise. Literature, however, stirred the mind of Cambridge less than theology. In the ecclesiastical controversy with which the university had seethed ever since Cartwright's brief tenure of the chair of divinity (1569–70), Spenser took the Puritan side. But he was neither sectary nor ascetic. He had a hatred of popery (inflamed by the Bartholomew massacre) and contempt for the hirelings who "for their bellies' sake" had climbed into the Anglican fold.

What he did on leaving Cambridge is still a mystery. He had missed his fellowship, and must look about him for a profession or a patron. The view that he went to live with relatives in Lancashire, though buttressed by appeals to family tradition and to the language and scenery of the *Calender,* rests at bottom on no ascertained fact.

But in the "North-parts" (Drayton brings Rosalind to the Cotswolds; Aubrey says that she was related to Sir Erasmus Darwin's lady, who was a Wilkes of Hodnell in Warwickshire), Spenser fell in love with the Rosalind of the *Shepheardes Calender,* of whom again we can say only that she was a lady of higher rank than his, who enjoyed, but did not reward, her young poet's devotion. In 1577 we seem to get a glimpse of Spenser in an unexpected quarter. In the *View of the Present State of Ireland* Irenaeus tells how he witnessed the execution of Murrogh O'Brien, which took place at Limerick in July, 1577. In the rest of that dialogue Irenaeus represents Spenser himself, and it is natural though not inevitable to conclude that he does so in this place also. But no other evidence has been found for this visit; Phillips's statement that Spenser was secretary to Sir Henry Sidney may be discounted, since he has probably confused Sidney with Grey. Yet Irenaeus's account of this hideous incident reads like the words of an eye-witness, and the visit, if it occurred, would point to a connection with the Sidney-Leicester circle earlier than 1579.

After this we are on firmer ground. We know that in 1578 Spenser was secretary to John Young, bishop of Rochester, who had been master of Pembroke hall while Spenser was a student. The bishop of Rochester (*Episcopus Roffensis*) is the Roffyn of the *Shepheardes Calender:* the fable of Roffyn's dog and the wolf may glance at the old Roman Catholic bishop, Thomas Watson, who was committed to Young's custody in Feb. 1579. Much of the *Shepheardes Calender* was apparently written at Rochester, where also Spenser first conceived the idea of the wedding of Thames and Medway. If Spenser at this time thought of entering the Church, he changed his mind on a nearer view of its condition, for by Easter 1579 he was in Westminster, sharing rooms with Harvey and holding "long conference" with him. There was a third party to their discussions, one "E.K.," to be identified probably with Edward Kirke, once a fellow-sizar of Spenser's at Pembroke. The notion that E.K. is a mask for Spenser himself has been disproved by Dr. Herford. It is not unlikely, indeed, that the "Mistress Kerke" in Westminster, who took charge of letters for Spenser in October of this year, was E.K.'s mother, and that all three were living in her house. Among other things they discussed Spenser's *début* as an author. He had several pieces ready or nearly ready—*Dreams, Legends, Court of Cupid, Pageants, The English Poet* (in prose), and the *Shepheardes Calender.* It was decided to bring out the last, and to bring it out in classical style with introduction, notes and glossary by E.K., even as Muretus edited the first book of Ronsard's *Amours.* E.K. wrote the introduction forthwith—it is dated from London, April 10, 1579—and got to work on the notes.

Harvey's Letter-book gives us an amusing picture of Spenser that summer. He is reading some law, evidently with an eye to diplomatic or administrative work; he has blossomed into a courtier and a gallant, bearded and moustachioed, Italianate, Frenchified. At what date, and in what sense, he entered Leicester's service we do not know precisely. At all events on Oct. 5 he writes from Leicester house to tell Harvey that he expects to go abroad in a week, "most what" at Leicester's charges—the "most what" shows that he was not entirely dependent on Leicester's bounty—and that "gentle Mr. Sidney" has proposed that they two should correspond. The tour apparently never took place, for his next letter of ten days later says no word about it, but is all concerned with quantitative verse and with doubts about the publication of his *Slumbers.* He has been to Court and expects to go again; Sidney and Dyer have him "in some use of familiarity." The *Shepheardes Calender* was licensed on Dec. 5, and published anonymously; the dedication to Sidney is by "Immerito."

The Shepheardes Calender.—The *Calender* consists of 12 pastoral eclogues in the artificial style of Virgil, Mantuan, Sanazzaro and Marot, which admits real persons and current events in a pastoral guise. From all these precursors Spenser borrowed ostentatiously, above all from Marot, whom E. K. nevertheless belittles, perhaps because the Pléiade had eclipsed him. Derivative and conventional as it is, the *Calender* made an epoch in English literary history, not so much by naturalising pastoralism as by showing (under cover of the pastoral convention) what English could do in many kinds and metres. The couplets of the satires and fables are intentionally rude, and the rhymeless sestina is mere virtuosity; but the elegiac stanzas of the complaints recaptured the metrical secret of Chaucer, and the lyric staves of the paean and the dirge extended the range of English song. In all these measures he made free use of alliteration, dear to English ears, though abused by his contemporaries and frowned on by the classicists. For his reform of poetic diction Spenser had before him the example and precepts of the Pléiade. Like them, he sought to embellish the beggarly vocabulary of contemporary verse, partly by foreign loan-words, but mainly by drawing on native sources, by archaisms, pseudo-archaisms and dialect words. He was in search of a vocabulary fit for the heroical poem that he already contemplated. But the new poet had to care not only for words but for the order of his words and the structure and juncture of his sentences. Here Spenser scored his greatest success, eschewing obscurity and looseness, and giving his syntax a movement, too copious perhaps, but admirably fluent, in lucid, easy yet well-knit sentences. Syntactically, Spenser is one of the simplest of poets.

The *Shepheardes Calender* may not have fulfilled all Spenser's hopes, but it went into a second edition in 1581. Sidney praised it judiciously, or judicially, but durst not approve its rustic diction. However, Spenser had many other arrows in his quiver. In April 1580 he is full of projects for the immediate publication of his *Dying Pelican* and *Dreams;* his Latin *Stemmata Dudleiana* will need "more advisement" before it can be "sent abroade," but the quantitative *Epithalamion Thamesis* shall be "shortly set forth." Under the influence of Sidney, Dyer and Drant, he had come for the moment to take quantitative verse more seriously. But he is more eager to proceed with the *Faerie Queene,* of which he sent Harvey specimens. Harvey thought little of them, preferring the (lost) *Nine Comedies* in the manner of Ariosto. Moreover, the poet is in love again, this time with better hopes. Harvey's compliments to *Mea Domina Immerito, Mea Bellissima Collina Clouta,* taken with an obscure passage in *Daphnaida* (11. 64–66), which reads like consolation tendered by one widower to another, have led some scholars to believe that Spenser married this "second Rosalind." But there is no other evidence for the marriage, nor is the lady ever heard of again. These letters of April 1580 give no hint of any friction with Leicester. But now Spenser seems to have made a false step. The queen had dallied for years with the project of marrying the duke of Alençon. In Jan. 1579 his agent Simier came to England and Alençon himself paid a flying visit in August to press his suit in person. He was ugly, dwarfish and half her age, but the queen smiled on him, called him her "grenouille" and Simier her "petit singe." The Puritans took alarm. Sidney remonstrated in such plain terms that the queen forbade him the Court. He retired to Wilton to write his *Arcadia,* and Spenser probably never saw him again. This was in Jan. 1580.

It was at this juncture apparently that Spenser drew his pen. He had begun a *fabliau* of an ape and a fox, satirising the Parson

Trullibers and other humbugs of the day. Now, catching at Elizabeth's trick of animal nick-names, he brought his ape and fox to a court of beasts. The ape becomes Alençon-Simier, the fox is Burghley, who was believed to favour the marriage. Their misrule when they have stolen the lion's skin foreshadows the fate of England under a French king-consort. But Spenser misjudged the situation. Leicester had concluded that the wind stood fair for France, and trimmed his sails accordingly. Spenser was snubbed, and the satire, which was circulating in manuscript as *Mother Hubberds Tale,* was called in, but not before it had come to Burghley's ears. The tale of Spenser's discomfiture is told in *Virgils Gnat,* killed by the man whose life it had saved. Such is the most plausible explanation of this obscure episode. At all events, abandoning all his projects of publication, Spenser accepted a secretaryship to Lord Grey of Wilton, the newly appointed Lord Deputy of Ireland.

In Ireland.—Grey landed in Dublin in Aug. 1580 and set himself at once to the task of suppressing Desmond's rebellion. He was a stern Puritan, to whom the pope was Anti-christ and the Papist rebels were traitors at once to God and their queen. Spenser soon had proof of his quality. A band of Spanish and Italian filibusters had landed in Kerry to support the Munster rebels and occupied a fort near Smerwick. Grey marched against them, forced them to surrender unconditionally, held the officers to ransom, and put the men to the sword. Then he ravaged Munster, leaving famine to complete the work. On campaigns Spenser saw "such wretchednesse as that any stonye harte would have rued the same." With Grey's recall in 1582 Spenser lost his secretaryship; but in the previous year he had acquired a clerkship for the faculties (*i.e.,* licences and dispensations) in the Dublin chancery; and he had begun to obtain leases of forfeited houses and lands at modest rents which he did not always pay. At one of these houses, New Abbey in Co. Kildare, he seems to have resided occasionally in 1583 and 1584. But his headquarters were still in Dublin. We get a pleasant glimpse of him there in Ludovick Bryskett's *Discourse of Civil Life.* Bryskett tells us how a distinguished company, including the primate of Armagh, and soldiers like Norreys and St. Leger, met at his cottage near Dublin. Spenser suggested that their host should read them his translation of Giraldi da Cinthio's *Discourse of Civill Life;* which Bryskett accordingly did. The reading lasted for three days, being interspersed with discussions. On the third day Spenser interposed again, urging (to our astonishment) Aristotelian objections to the immortality of the soul. But Bryskett is simply putting into his mouth the arguments given by Giraldi to Torquato. It is doubtful, indeed, if this famous discussion ever took place at all, for Bryskett imitates Giraldi not only in the substance of his dialogue but in its setting. But if it never actually occurred it must be such as might have occurred.

In 1585 the centre of Spenser's interests began to shift to Munster. In that year he is found acting as deputy to Ludovick Bryskett in the clerkship of the council of Munster. In 1586 he held the prebend of Effin in Co. Limerick; and in that same year, under the Government's scheme for the plantation of Munster, he obtained a perpetual lease of Kilcolman Castle in Co. Cork with 3,028 acres of land. His resignation of his clerkship for the faculties in 1588 probably means that he then began to live at Kilcolman, where tradition says that his sister Sarah kept house for him. Here in 1589 he received a momentous visit from Raleigh. He had been engaged on the *Faerie Queene* intermittently for nearly ten years, receiving a fresh stimulus from Tasso's *Gerusalemme Liberata,* which reached him probably about the time of Lord Grey's recall. By 1589 three books were completed. Raleigh at once perceived their superlative merits and carried Spenser off to England to lay his poem at the queen's feet. It was licensed on Dec. 1, 1589 and published in 1590 with a dedication to the queen. Its reception can only be described as reverential. The great English epic so long awaited had appeared.

Spenser remained in England for more than a year, enjoying his fame, making friends with brother-poets, entertained at country houses, and acknowledged by his kinswomen of Althorpe, Lady Carey, Lady Strange, and Lady Compton and Mountegle. But Burghley had not forgiven him; the substantial preferment for which he hoped was whittled down to a pension of £50 a year, and in 1591 he returned to Ireland a disappointed man. Before leaving, he arranged for the publication of some of his minor poems, which appeared in 1591 as *Complaints.*

Complaints.—Of the *Complaints,* the *Visions of Petrarch* and *Visions of Bellay* are refurbishings of his schoolboy translations. *The Ruines of Rome,* a rendering of du Bellay's *Antiquitez de Rome,* is clearly a juvenile production also. In the same kind, but much superior, is the original *Visions of the Worlds Vanitie,* in which, from Harvey's remarks, we may fairly recognize a fragment of the *Dreams* of 1580. The *Teares of the Muses,* mentioned in *A Midsummer Night's Dream,* V. i. 52, where Theseus dismisses it as "some satire, keen and critical," is an unconvincing complaint of the neglect of poetry, more excusable in 1580 than in 1590. The *Ruines of Time* laments various members of the Dudley family, including Sidney and Leicester, who had died in the previous decade: its present form belongs to 1590; but it probably incorporates some material collected for the Latin *Stemmata Dudleiana;* and the "Pageants" at the end may be another fragment of the *Dreams. Mother Hubberds Tale* was strengthened by the addition of a brilliant and bitter denunciation of the wretchedness of the suitor's state; and Spenser bated no jot of his satire on Burghley. *Virgils Gnat,* a free rendering of the *Culex,* has already been described. The one entirely new poem in the volume is *Muiopotmos,* which clearly belongs to 1590. Its theme recalls Sonnet 71, and may have been suggested simply by the sight of Lady Carey at her drawn-work. In spite of the grim ending the tone is so light-hearted that it seems perverse to read an inner meaning into this "airy trifle," with Burghley as the spider. Yet no reader would have suspected an inner meaning in *Virgils Gnat* but for the dedication to Leicester.

On reaching home, or so he would have us believe, Spenser wrote *Colin Clouts Come Home Againe,* dedicating it to Raleigh "from my house of Kilcolman the 27. of December 1591."[1] It was not published, however, till 1595, when it appeared in one volume with *Astrophel.*

Colin Clout; Astrophel.—*Colin Clouts Come Home Againe* is the most charming of Spenser's poems. He is again in Arcady, telling his fellow-shepherds of his voyage with the Shepherd of the Ocean, his reception by the mighty Cynthia, her court, her ladies and brave poets. Then the note changes to the old complaint of courtly falsity and praise of the shepherd's life. The whole poem is exquisitely written, in "an easy running verse with tender feet." There is nothing more attractive in Spenser than Colin's chivalrous defence of Rosalind.

Astrophel is the prelude to a set of pastoral elegies on Sidney by several hands. The second "number," the *Lay of Clorinda,* though credited to Sidney's sister, is demonstrably from Spenser's pen. If *Astrophel* seems conventional and frigid we must remember that Spenser had already lamented Sidney in the *Ruines of Time,* and that the Sidney whom he now laments is not the hero of Zutphen but the author of the *Arcadia.*

Colin's praise of the shepherd's life prepares us to find that Spenser, though disappointed of preferment in England, and harassed by law-suits with his Irish neighbour Lord Roche, had begun to love his Munster home and to weave its legends and scenery into his verse. Towards the close of 1592, on the orthodox view of the *Amoretti,* he fell in love with Elizabeth Boyle and married her on June 11, 1594. He celebrated his wooing in the *Amoretti* and his wedding in the *Epithalamion,* which were entered together at Stationers' Hall in November 1594, and published together in 1595. It is highly probable that some of the *Amoretti* had already done service to express an *amour courtois* for Lady Carey during his English visit. It is probable that Elizabeth Boyle was the orphan daughter of Stephen Boyle, of Bradden in Northamptonshire, who had accompanied her brother

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[1] Yet the dedication of *Daphnaida* is dated "London this first of Januairie, 1591" (*i.e.,* 1592 n.s.). No convincing explanation of this discrepancy has been offered. On the whole it is easiest to believe that Spenser, writing on New Year's Day, used the new style, *i.e.,* that his 1591 means our 1591.

Alexander when he went to Ireland to seek his fortune under the protection of their kinsman Richard Boyle, afterwards earl of Cork. The view that she was a widow, having been married to one Tristram Peace in 1588 or 1589, at present lacks documentary confirmation, and is hard to reconcile with Burke's statement that she bore seven children to her third—on this view her fourth—husband, Sir Robert Tynte, after 1612 or 1613.

Amoretti; Epithalamion.—The *Amoretti* are love-sonnets, all but one in a form which Spenser made his own, consisting of three *linked* quatrains and a couplet. It had already been used in Scots, but Spenser may have got it direct from Marot. Though it lacks the pyramidal strength of the Petrarchan form, and the freedom of the Shakespearean, its "linked sweetness" suits Spenser's style. Many of these sonnets are imitated from French or Italian, especially from Desportes and Tasso: for one a Spanish original has been found. They are all graceful, but only the famous sonnet on Easter can be called great. The *Epithalamion,* on the other hand, is by common consent the greatest of all wedding-songs; rich in poetic allusions and in echoes from his own earlier poems, as if Spenser had gathered up all the fruits of his study and all the flowers of his fancy to present them to his bride. Here for once his whole nature speaks, flesh and spirit reconciled in the sacrament of marriage. The stanza, suggested by the Italian canzone, is magnificent far beyond anything previously heard in English. The structure of the whole poem is as perfect as that of its parts.

Towards the end of 1595 Spenser, having finished three more books of the *Faerie Queene,* came to London to publish them. During this year he also published his *Prothalamion* and *Fowre Hymnes,* and composed or revised his *Veue of the Present State of Ireland,* which, though entered at Stationers' Hall in 1598, was not allowed to be printed without further authority, and, in fact, did not see the light till 1633.

Prothalamion; Hymnes; Veue of the Present State of Ireland.—The *Prothalamion* graced the wedding of two of the Earl of Bridgewater's daughters, who were married together from Essex house. Though it lacks the glow and sweep of the *Epithalamion,* it is, if possible, even more perfect in metre and diction.

The hymns of *Heavenlie Love* and *Heavenly Beauty* were written in 1596 to propitiate two pious noblewomen and counteract the hymns in *Honour of Love* and in *Honour of Beautie* written in his youth. So Spenser avers; but to print the earlier hymns was scarcely the way to ensure their oblivion.

In the *Veue of the Present State of Ireland* Irenaeus expounds to Eudoxus the causes of the Irish troubles and propounds a cure. Irish laws, customs and religion must all be reformed on the English model. But subjugation must precede reform. Vacillation has been the curse of the Government. Let them now bring over 10,000 foot and 1,000 horse, plant these in six convenient garrisons, give the rebels 20 days in which to surrender, and then hunt down relentlessly all who stand out. Two winter campaigns will break their spirit. Let a fresh offer of pardon then be made, and rebellion will be at an end. There follows a detailed scheme, supported by statistics, for the administration of the pacified areas, ending with a proposal for the appointment of a lieutenant-general, Essex being clearly indicated. Political antagonism and racial antipathy combined with religious hatred to blind Spenser to the Irish cause.

During this second visit to England Spenser's hopes of preferment were centred in the Earl of Essex, but again he sued in vain. He returned to Kilcolman, probably in 1597, and resumed the *Faerie Queene.* In Sept. 1598 he was recommended for the sheriffdom of Cork. But preferment came too late: in October Tyrone's rebellion had broken out, the Munster Irish rose, Kilcolman Castle was burned and Spenser fled with his family to Cork. From Cork he was sent to London with a dispatch which bears date Dec. 9, 1598. Along with it he brought a brief note of his own in which he reiterated the policy of the *View.* On Jan. 16, 1599 he died. He was buried in Westminster Abbey close to Chaucer; many nobles attended his funeral, and his fellow-poets brought elegies which they threw into his grave with the pens that had written them. Spenser's tragic reversal of fortune and sudden death gave rise to a crop of legends. Ben Jonson told Drummond that one of Spenser's children perished in the flames of Kilcolman Castle and that he himself died "for lack of bread." It is only too likely, after all he had gone through, that Spenser collapsed on reaching London, and was a dying man before his friends could learn of his condition and come to his aid. Two more cantos of the *Faerie Queene* with two stanzas of a third were published in 1609; if more was written, as is probable, after 1596, it is irrecoverably lost.

The Faerie Queene.—Spenser's place among the great poets depends on the *Faerie Queene,* a fragment of a great poem which was to have been "disposed," as the title informs us, "into XII. bookes fashioning XII. morall vertues," each virtue embodied in a knight, and the whole designed "to fashion a gentleman or noble person in vertuous and gentle discipline"—at once a chivalric romance and a handbook of morals and manners; nay more—for Spenser would emulate Virgil as well as Ariosto—a national epic to the glory of England's Elizabeth. Such a threefold cord is not easily twined. Yet the task seemed feasible to Spenser, because to him the eternal war of good and evil, which was his essential theme, was embodied in the struggle of Protestant England against her Catholic foes. Book I. indeed may be read not inconsistently either as a mere romance, or as the spiritual experience of an elect Christian, or as a history of the English Church in the sixteenth century. But in Book II. the story stands still for nearly two whole cantos; the tale of Hellenore in Book III. is told with a gusto ill calculated to fashion a gentleman in virtuous discipline; in Book IV. the poet grows so careless of his characters that he lets the long-parted lovers come together without recognizing one another; the recent history of Book V. has little allegorical or romantic interest; and Book VI. ends in a burst of sheer pastoralism in which the poet forgets his allegory as completely as the hero forgets his quest. Only Spenser's contemporaries could fully appreciate the historical element, and some of it even to them can only have had the interest of a *roman à clef;* yet it strengthens the texture of the poem, and gives figures like Arthegall and Satyrane some firmness of outline.

The allegory was treated with respect for two centuries; Milton thought "our sage and serious poet" a better teacher than Scotus or Aquinas; modern criticism has too often followed Hazlitt in commending the poem to readers with the assurance that the allegory won't bite them. But to ignore the allegory is to ignore the informing purpose of the whole, without which the story would be a mere series of ill-joined episodes, and much of the imagery meaningless, some of it grotesque or even repulsive. The ethical, as distinct from the structural, value of the allegory must depend on the worth of the ideas it embodies, as its poetical value depends on the imaginative force of their embodiment. Spenser was not an original nor a systematic thinker. His philosophy is a blend of Platonism refracted through Ficino, Aristotelianism of the scholastic tradition, and Christianity with a Calvinistic bias. And the elements do not perfectly combine. Thus the doctrine of love and beauty, by which Ficino thought to reconcile the love of woman with the love of God, this doctrine, brilliantly expounded in the first two Hymns, is fundamentally irreconcilable with the scheme of salvation through the atoning sacrifice of Christ which is expounded in the third Hymn. The poet was a sincere and militant Christian, but also a man sensitive to the allurements of the world and the flesh; he knew self-distrust, and weariness, and regret for evanescent youth, and is never so moving as when he writes out of such experiences or turns from this unstable life in longing for the eternal rest.

Of the romance itself, with its wealth of imagery and melody, there has never been but one opinion. Like all Spenser's work, it is highly imitative. He rifled romantic literature for incidents and situations. The descriptions in which he excels constantly recall works of art—picture, tapestry, pageant or masque. But he owed much also to real life; he was recommended for his sheriffdom as "not unskilful or without experience in the wars"; and his journeys through the wild woods of Munster and his intercourse with soldiers like Grey and Norreys yielded many a hint for the background and characters of the *F.Q.* Its diction, archaic but not rustic, and rich in strange coinages and terms of chivalry, is in keeping with its remote and old-world air. Not less appropriate is the stanza which he invented, *not* by "extending" the ottava rima or the rhyme royal, but by adding to the linked quatrains which he had used in the *S.C.* an Alexandrine such as Ferrars had employed to tip his sestets. The elements are not new; the miracle lies in their combination. It is not a perfect stanza for narrative, nor indeed is Spenser a perfect story-teller; but its amplitude fits the slow *tempo* of his thought, as he unrolls his leisurely pageants or ponders on time and change. Its power must not be judged by single stanzas, but by the cumulative effect as stanza after stanza rolls in, each ninth wave breaking higher than the rest.

Spenser has not Chaucer's genial breadth, nor Milton's art, nor Wordsworth's vision; but in the purely poetic gifts he is inferior to Shakespeare alone. The "school of Spenser" was small and short-lived, quite eclipsed in the next generation by Jonson and Donne; but in a wider sense all later English poets have been his scholars.

Beeston described Spenser to Aubrey as a little man, with short hair, little band and little cuffs—a description that fits the Pembroke College portrait better than the beruffled exquisite of the Dupplin portrait. These two portraits, whether genuine or not, do aptly illustrate the two sides of Spenser, scholar and Puritan on the one hand, courtier and man of affairs on the other; fundamentally a poet, sensitive and fastidious, yet responsive to the claim of affection or of honour. "Entire affection hateth nicer hands"; "No service loathesome to a gentle kind"; "The noblest mind the best contentment has"—in such lines we hear his authentic voice.

BIBLIOGRAPHY.—Dates of first issues are given above. Folios in 1609 (*F.Q.* only), 1611–13, 1617, 1670 (said to have been "overseen" by Dryden). Editions by J. Hughes (1715), H. J. Todd (1805), F. J. Child (1855), J. P. Collier (1862), R. Morris and J. W. Hales (1869), A. B. Grosart (1882–84), R. E. N. Dodge (1908), J. C. Smith and E. de Sélincourt (1909–10). *F.Q.* only by R. Church (1758), J. Upton (1758), K. M. Warren (1897–1900). *S.C.* by C. H. Herford (1895). *Fowre Hymnes* by L. Winstanley (1907). Commentaries and criticisms by J. Jortin (1714), T. Warton (1752), G. L. Craik (1845), R. W. Church (1879), J. J. Higginson (*S.C.* only) (1912), E. Legouis (1923), W. L. Renwick (1925). Much of the recent work on Spenser has been done by American scholars: F. I. Carpenter, E. A. Greenlaw, J. Erskine, J. B. Fletcher, P. W. Long, C. G. Osgood, F. M. Padelford, C. H. Whitman, etc. Most of it is available only in periodicals. Carpenter's *Reference Guide* (1923), Osgood's *Concordance* (1915), and Whitman's *Subject Index* (1918) are indispensable for detailed study. (J. C. SM.)

SPENSERIAN STANZA, a verse-form so called from its invention by Edmund Spenser for his *Faerie Queene* (1590). Its origin is disputed; Schipper derives it from the Old French ballade (*q.v.*), others from the Italian *ottava rima.* Probably, however, it is Chaucer's eight-line *Monk's Tale* stanza, with a ninth line (an alexandrine) added, a feature which gives the stanza its beauty. The rhyme-scheme is a b a b b c b c c + (the + denoting the extra foot in the last line). Spenser's sonnet-scheme is somewhat similar. The stanza was hardly used in the 17th century, though Giles and Phineas Fletcher made for themselves adaptations of it. About 1740 it was revived, by Akenside (*Virtuoso,* 1737), Shenstone (*Schoolmistress,* 1742) Thomson (*Castle of Indolence,* 1748); followed by Beattie (*Minstrel,* 1771) and Mrs. Tighe (*Psyche,* 1805). Since 1850 it has been rarely employed. It is a purely English form.

SPERANSKI, COUNT MIKHAIL MIKHAILOVICH (1772–1839), Russian statesman, the son of a village priest, spent his early days at the ecclesiastical seminary in St. Petersburg (Leningrad), where he rose to be professor of mathematics and physics. His brilliant intellectual qualities attracted the attention of the government, and he became secretary to Prince Kurakin. In 1806, the emperor Alexander I. took him to the conference of Erfurt and put him into direct communication with Napoleon, who described him as "the only clear head in Russia." They discussed Russian reforms.

From 1809 to 1812 Speranski was all-powerful; he replaced the earlier favourites, becoming practically sole minister. In 1810 and the first half of 1811 Speranski was still in high favour, and was the confidant of the emperor in that secret diplomacy which preceded the breach of Russia with Napoleon.

On the eve of the struggle with Napoleon, Alexander, conscious of his unpopularity, conceived the idea of making Speranski his scape-goat, and so mobilising Old Russian sentiment against revolutionary France. The grand-duchess Catherine, Karamzin, Rostopchin and the Swedish general Baron Armfield, intrigued to involve him in a charge of treason. Alexander did not credit the charge, but on March 29, 1812 he dismissed him from office. Reinstated in the public service in 1816, he was appointed governor-general of Siberia, for which he drew up a new scheme of government, and in 1821 entered the council of state. He died on Feb. 11, 1839, at St. Petersburg.

See the biography (in Russian) by M. Korff (St. Petersburg, 1861). On his public life and constitutional reforms *see* Theodor Schiemann, *Geschichte Russlands unter Kaiser Nikolaus I.,* Bd. i. *Kaiser Alexander I.* p. 75 *seq.* (Berlin, 1904); Pierre Chasles, *Le Parlement russe,* p. 19 *seq.* (Paris, 1910), and the works of V. Vagin (St. Petersburg, 1872 and Moscow, 1905). Count Nesselrode's letters to Speranski and many references are published in vol. iii. of the *Lettres et papiers du comte de Nesselrode.*

SPERMACETI, a wax found in the head cavities and blubber of the sperm-whale (*Physeter macrocephalus*), where it is dissolved in the sperm oil while the creature is living (from Lat. *sperma,* seed, and *cetus,* a whale). It also occurs in other Cetacea (*see* WHALE OILS). It is mainly cetin or cetyl palmitate, $C_{15}H_{31}CO_2C_{16}H_{33}$. The substance is used in making candles, in the dressing of fabrics, in medicine and surgery, and in cosmetic preparations. (*See* OILS AND FATS.)

SPERMOPHYTA, the name often used in botany to denote the seed-plants, including the true flowering plants, or angiosperms (*q.v.*), and the conifers and their allies or gymnosperms (*q.v.*). It is sometimes written "Spermatophyta."

SPERM-WHALE (*Physeter macrocephalus*), the largest of the toothed whales, called also cachalot, its size being about equal to those of the Arctic right-whale. The head is about one-third of the length of the body, massive, high, and truncated in front. It owes its size and form to the accumulation of a peculiar form of fatty tissue in the large hollow on the upper surface of the skull. The oil contained in cells in this cavity, when refined, yields spermaceti, and the sperm-oil of commerce is produced principally by the thick covering of blubber, which everywhere envelops the body. Ambergris, used in perfumery, is a concretion formed in the intestine, and found floating on the sea. (*See* CETACEA; SPERMACETI.)

SPERRY, ELMER AMBROSE (1860–), American inventor, was born at Cortland, N.Y., on Oct. 12, 1860. He began early to experiment with electric arc lights and in 1879 established a factory in Chicago to manufacture an improved model which was highly successful. He then turned his attention to the development of electric mining machinery, invented the electric rotary and the chain undercutting machines, devised and built his own electric mining generator and other mining apparatus and established another factory to manufacture this machinery. He next designed an electric locomotive for industrial work, and developed motor and transmission machinery for street cars, which resulted in the founding of the Sperry Electric Railway Co. of Cleveland. About 1900 he established a research laboratory in electro-chemistry at Washington, D.C., where he invented the chlorine detinning process and also the electrolytic process for producing white lead from impure by-product lead. In 1915 he announced his high-intensity arc searchlight, built upon an entirely new principle, allowing a brilliancy as high as 900 candle-power per square millemetre, whereas 160 was the highest obtainable previously. The electrical and mechanical means of operating, as well as the mechanism to control the high temperatures of the arc, represented a difficult engineering achievement. These searchlights have become the standard for the principal armies and navies of the world and are in use for aircraft and coast beacons, the largest giving a white light of 1,500,000,000 candle-power which can be seen for upwards of 150 miles.

Sperry's most important inventions were based upon the application of the gyroscope in which he was always greatly interested.

Chief of these is the gyro-compass (*q.v.*), first installed on the battleship Delaware in 1911. This compass, unaffected as it is by iron and steel, has entirely superseded the magnetic compass on submarines and battleships and is rapidly being placed on merchant ships. Upon it the whole complicated system of modern naval gunnery has been developed. (*See* GUNNERY, NAVAL.) Sperry also designed and manufactured electrically sustained gyros for torpedoes which enabled them to complete long trajectories with a high degree of accuracy. During the World War he also developed aerial torpedoes with automatic gyro-control which proved effective at a range of 35 miles. Quantity manufacture had begun when the war ended. Further experiments yielded the gyro-pilot for the steering of ships, the automatic gyro-pilot for stabilizing aeroplanes, the gyroscopic roll and pitch recorder for the testing of ships, and, finally, a gyroscopic ship stabilizer, which has been installed on a number of ships in the United States, British, Italian and Japanese navies and promises to find a wider application. The motion of a ship in the waves is almost completely neutralized by automatic counter movements of the gyroscopes. He has served since 1915 as a member of the naval consulting board, has published numerous scientific papers, and has been the recipient of many honours.

See "The Engineering and Scientific Achievements of Elmer A. Sperry," in *Mechanical Engineering*, vol. xlix. (1927).

SPES, properly *bona spes* ("good expectation," *i.e.*, hope), a goddess worshipped in Rome from an uncertain but doubtless early date (temple in the Forum Holitorium, or vegetable market, vowed during the first Punic War, *cf.* Tibullus, i. 1, 9, *cf.* ii. 6, 21). Possibly she was originally an agricultural deity, not the personification of hope in general.

See Wissowa, *Religion und Kultus*, 2nd ed., p. 329.

SPESSART, a highland forest district belonging mainly to the Bavarian province of Lower Franconia, but in the north to the Prussian province of Hesse Cassel.

SPEUSIPPUS (4th century B.C.), Greek philosopher, son of Eurymedon and Potone, sister of Plato, is supposed to have been born *c.* 407 B.C. He was bred in the school of Isocrates, but when Plato returned to Athens *c.* 387, Speusippus became a member of the Academy. In 361, when Plato undertook his third and last journey to Sicily, Speusippus accompanied him. In 347 the dying philosopher nominated his nephew to succeed him as scholarch, and the choice was ratified by the school. Speusippus held the office until his death in 339.

Of Speusippus's many philosophical writings nothing survives except a fragment of a treatise *On Pythagorean Numbers*. We gather (A) In regard to his theory of being: (1) whereas Plato postulated as the basis of his system a cause which should be at once Unity, Good, and Mind, Speusippus distinguished Unity, the origin of things, from Good, their end, and both Unity and Good from controlling Mind or Reason; (2) whereas Plato recognized three kinds of numbers—firstly, ideal numbers, *i.e.*, the "determinants" or ideas; secondly, mathematical numbers, the abstractions of mathematics; and thirdly, sensible numbers, numbers embodied in things—Speusippus rejected the ideal numbers, and consequently the ideas; (3) Speusippus traced number, magnitude and soul each to a distinct principle of its own. (B) In regard to his theory of knowledge: (4) he held that a thing cannot be known apart from the knowledge of other things; for, that we may know what a thing is, we must know how it differs from other things, which other things must therefore be known; (5) accordingly, in the ten books of a work called Ὅμοια, he attempted a classification of plants and animals; (6) the results thus obtained he distinguished at once from "knowledge" and from "sensation" holding that "scientific observation" though it cannot attain to truth, may, nevertheless, in virtue of a certain acquired tact, frame "definitions." (C) In regard to his theory of ethics: (7) he denied that pleasure was a good, but seemingly was not prepared to account it an evil.

Speusippus and his contemporaries exercised a far-reaching influence upon Academic doctrine. When they rejected their master's ontology and proposed to themselves as ends mere classificatory sciences which with him had been means, they bartered their hope of philosophic certainty for the tentative results of scientific experience.

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SPEY, river in the highlands of Scotland, rising in Mt. Clach-a-Cheannaiche in Lochaber, in Inverness-shire. A mile from its source it forms the small Loch Spey, and 31 m. lower down the larger Loch Inch. It falls by several mouths into the Moray Firth at Kingston. It is about 110 m. long. It is a very rapid river, famous for salmon-fishing, and is nowhere navigable.

SPEYER (Spires), a town and episcopal see of Germany, capital of the Bavarian palatinate, situated on the left bank of the Rhine, at the mouth of the Speyerbach, 16 m. S. of Mannheim by rail. Pop. (1925) 25,609. Speyer, known to the Romans as *Augusta Nemetum* or *Nemetae*, and to the Gauls as *Noviomagus*, appears under the form of Spira, about the 7th century. Captured by Julius Caesar in 47 B.C., it was repeatedly destroyed by the barbarian hordes in the first few centuries of the Christian era. The town had become an episcopal seat in the 4th century; but heathenism supervened, and the present bishopric dates from 610. In 830 Speyer became part of the Frankish empire. The contentions between the bishops and the citizens were as severe as in any other city of Germany. The situation of the town opposite the mouths of several roads through the Rhine valley early fostered its trade; in 1294 it rose to be a free imperial city. It enjoyed great renown as the seat of the imperial supreme court from 1527 till 1689. Numerous imperial diets assembled here. From 1801 till 1814 it was the capital of a department of France; but it was restored to Bavaria in 1814.

A basilica of sandstone, the cathedral has a peculiar importance in the history of architecture as probably the earliest Romanesque basilica in which the nave as well as the side arcades was vaulted from the first. Built in 1030–1061 by Conrad II. and his successor, this church has had a chequered history, its disasters culminating in 1689, when the soldiers of Louis XIV. burned it to the bare walls, and scattered the ashes of eight German emperors. Restored in 1772–1784 and provided with a vestibule and façade, it was again desecrated by the French in 1794; but in 1846–1853 it was once more thoroughly restored and adorned in the interior with gorgeous frescoes. Speyer, although rebuilt in 1697, has never recovered from the injuries inflicted by the French in 1689. Its manufactures include paper, tobacco and cigars, sugar, machines, lead, vinegar, beer and musical instruments.

SPEZIA, a city of Liguria, Italy, 49 ft. above sea-level. Pop. (1926) 94,347 (commune). It is the chief naval harbour of Italy, having been adopted as such in 1861 though Napoleon I. had entertained the idea. The Bay of Spezia (anc. *Portus Lunae*) is sheltered from all except southerly winds, and on its western shore are numerous openings, which afford perfectly safe anchorage in all weathers. The entrance is protected by forts, while a submarine embankment, 2 m. long, renders it secure. Its important arsenal dates from 1870. The establishment of San Vito is devoted entirely to the production of artillery; that of San Bartolomeo is exclusively used for electrical works and the manufacture of submarine weapons, especially torpedoes. It is the headquarters of the northern naval command (*see* ITALY). The museum contains a unique collection of menhirs from the neighbourhood cut into the form of human figures. Spezia probably arose after the destruction of Luna. It was sold by the Fieschi in 1276 to Genoa. The town was fortified by its new possessors and made the seat of a governor of some importance. It became a city in the 16th century.

SPHENE or **TITANITE,** a mineral consisting of calcium titano-silicate, $CaTiSiO_5$, crystallizing in the monoclinic system. The crystals vary considerably in habit, but are generally thin and wedge-shaped; hence the name sphene (Gr. σφήν, a wedge). The colour is green, yellow, brown or black, and the lustre resinous to adamantine; crystals are transparent to opaque. The hardness is

5·5, specific gravity 3·5. Sphene is cut as a gem-stone, though it is rather too soft to stand much wear; owing to its high dispersive power it gives brilliant flashes of prismatic colours. As small crystals, it is found in igneous rocks (granite, syenite, trachyte, phonolite, etc.), and also in gneiss, schist and crystalline limestone.

SPHENISCIDAE: *see* PENGUIN.

SPHENODON: *see* REPTILES.

SPHERE, in Greek geometry, the solid generated by the revolution of a semicircle about its diameter as an axis. In modern elementary geometry it is more generally considered as the spherical surface so generated, or as the locus of points at a constant distance from a fixed point called the *centre.* The constant distance is called a *radius,* and any line segment through the centre and limited at both ends by the sphere is called a *diameter.* In the geometry of surfaces it is defined as the quadric surface passing through the circle at infinity. Any section made by a plane cutting a sphere is a circle, being a *great circle* if the plane passes through the centre, and otherwise a *small circle.* The solid cut off by the plane of a great circle, is a *hemisphere;* that cut off by the plane of a small circle, a *segment.* In analytical geometery, the equation of a sphere in rectangular Cartesian co-ordinates is $x^2+y^2+z^2=a^2$, and in polar co-ordinates it is $r=a$. If the centre is (α, β, γ), the Cartesian equation becomes

$$(x-\alpha)^2+(y-\beta)^2+(z-\gamma)^2=a^2.$$

The surface of a sphere is found by the formula $S=4\pi r^2$, the area being four times that of a great circle. The volume is $\frac{4}{3}\pi r^3$. Analogous to the propositions of plane geometry and trigonometry is a series of propositions relating to the sphere. (*See* GEODESY, ASTRONOMY, SURFACES, ANALYTIC GEOMETRY, PROJECTIVE GEOMETRY, SOLIDS [Geometric], TRIGONOMETRY.)

SPHERES OF INFLUENCE. "Spheres of influence," "spheres of action, "spheres of interest," "zones of influence," "field of operations," "Machtsphäre," "Interessensphäre," are regions as to which nations have agreed that one or more of them shall have exclusive liberty of action. These phrases became common after 1882, when the "scramble for Africa" began.

Among treaties defining such spheres are the following:

Great Britain and Portugal as to Africa, Aug. 20, 1890, Nov. 14, 1890 and June 11, 1891. Great Britain and France as to Upper Niger, Jan. 20, 1891; Nov. 15, 1893, as to Lake Chad. Great Britain and France as to Siam, Jan. 15, 1896. The two Governments engage to one another "that neither of them will, without the consent of the other in any case or under any pretext, advance their armed forces into the regions, etc." They also engage not to acquire within this region any special privilege or advantage which shall not be enjoyed in common, or equally open to Great Britain and France or their nationals and dependants. Great Britain and Italy as to Africa, April 15, 1891; May 5, 1894, as to region of the Gulf of Aden. Congo and Portugal, May 25, 1891, as to "sphères de souveraineté et d'influence" in the region of Lunda. Great Britain, Belgium and Congo, May 12, 1894, as to the sphere of influence of the independent Congo State. Great Britain and Germany, July 1, 1890 and Nov. 15, 1893, as to East and Central Africa. Great Britain and Russia as to the spheres of influence to the east of Lake Victoria in the Pamir region, March 11, 1895.

Being the result of treaties, arrangements as to spheres of influence bind only the parties thereto. As Olney, in his correspondence with Lord Salisbury in regard to Venezuela, remarked: "Arrangements as to spheres of influence are new departures, which certain great European Powers have found necessary and convenient in the course of their division among themselves of great tracts of the continent of Africa, and which find their sanction solely in their reciprocal obligations" (United States No. 2, 1896, p. 27). Some treaties declare that the arrangement shall not affect the rights of other powers (Stoerck, *Recueil,* xvi. p. 932).

Hinterland.—Claims somewhat similar to these embrace hinterland. Sometimes it is called the "doctrine of contiguity," or "droit de vicinité, de priorité, de préemption ou d'enclave." The occupation of the mouth of a river is constructive occupation of all its basin and tributaries.

A State, having actually occupied the coast, may claim to reserve to itself the right of occupying from time to time territory lying inland (hinterland). In the discussions as to the western boundary of Louisiana between the commissions of the United States and Spain, as to Oregon, as to the claims of the Portuguese in East Africa, and as to the boundaries of Venezuela, the question of the extent of the rights of the discoverer and occupier came up. Lord Salisbury referred to "the modern doctrine of hinterland with its inevitable contradictions" (United States, No. 2, 1896, p. 12). Certainly it is inconsistent with the doctrine, more and more received in recent times, that effective possession is necessary to found a title to sovereignty or control. The doctrine of the hinterland is likely to become less important, now that Africa has been parcelled out. *See* MANDATE, PROTECTORATE, SOVEREIGNTY.

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SPHERICAL HARMONICS are certain functions which occur in the theories of gravitation, electricity, hydrodynamics, and many other branches of mathematical physics.

If a number of particles of masses $M_1, M_2, \cdots, M_m$, attracting according to the inverse-square law, are placed at points $A_1, A_2, \cdots, A_m$, the *potential* of these masses at any point P, *i.e.,* the work done by the gravitational attractions in bringing a unit mass from an infinite distance to P, is

$$\frac{M_1}{A_1 P}+\frac{M_2}{A_2 P}+\cdots+\frac{M_m}{A_m P}.$$

If now the points $A_1, A_2, \cdots, A_m$, P are referred to a set of rectangular co-ordinate axes, and the co-ordinates of the points are (a_1, b_1, c_1), (a_2, b_2, c_2), $\cdots$, (a_m, b_m, c_m), (x, y, z) so that

$$A_1 P = \sqrt{\{(x-a_1)^2+(y-b_1)^2+(z-c_1)^2\}}$$

with similar expressions for $A_2P, A_3P, \cdots, A_mP$, and if V denotes the potential, it may be verified by partial differentiations that

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=0.$$

This equation does not involve the masses or the points at which they are placed, and so it is satisfied by the potential produced at a point (x, y, z), in free space, by any gravitating system; it is known as *Laplace's equation,* and it is frequently written in the form

$$\nabla^2 V=0,$$

∇^2 denoting the differential operator $\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}$ for brevity.

Laplace's equation occurs in problems of Gravitation, Electrostatics and Hydrodynamics; the related equation $\nabla^2 V=k\partial V/\partial t$ occurs in problems of conduction of heat, V being then a function of the co-ordinates x, y, z, and the time t, and k being a constant; and the equation $c^2\nabla^2 V=\partial^2 V/\partial t^2$ occurs in problems of Vibrations of air and aether, c being the velocity of sound or of light, according to the problem considered.

In order to discuss generally problems concerning the potential, it is found more effective to examine solutions of Laplace's equation than to regard the potential as the sum of a number of terms of the type M/AP, each term representing the potential produced by an attracting particle. If $V_1, V_2, V_3, \cdots$ are a number of solutions of Laplace's equation, and if

$$V = V_1+V_2+V_3+\cdots,$$

it is easily verified that

$$\nabla^2 V = \nabla^2 V_1+\nabla^2 V_2+\nabla^2 V_3+\cdots = 0,$$

and so the sum of any number of solutions of Laplace's equation is itself a solution of the equation. It is thus possible to build up a solution of Laplace's equation by adding together simpler solutions.

Now let V be any potential function, and suppose that it can be expanded by Taylor's theorem as a series of positive integral powers of x, y, z, thus

$$V = a_0+a_1x+b_1y+c_1z+a_2x^2+b_2y^2 \\ +c_2z^2+d_2yz+e_2zx+f_2xy+a_3x^3+\cdots.$$

Group together all terms which are of the same degree in x, y, z, and denote the groups of terms which are of degrees $0, 1, 2, \cdots, n, \cdots$ in the expansion by

$$Y_0(x, y, z),\quad Y_1(x, y, z),\quad Y_2(x, y, z), \cdots,\quad Y_n(x, y, z), \cdots,$$

or, for brevity, by $Y_0, Y_1, Y_2, \cdots, Y_n, \cdots$, so that

$$V = Y_0+Y_1+Y_2+\cdots+Y_n+\cdots.$$

The expression $Y_n(x, y, z)$ is called *a spherical harmonic of degree n*. It may be verified that

$$\nabla^2Y_2+\nabla^2Y_3+\cdots+\nabla^2Y_n+\cdots = \nabla^2V = 0$$

so that the expression on the left vanishes identically; and since the terms written down are of different degrees, $0, 1, \cdots, n-2\cdots$, each must vanish separately, so that spherical harmonics are themselves solutions of Laplace's equation.

If the polar co-ordinates of (x, y, z) are (r, θ, ϕ), so that

$$x = r\sin\theta\cos\phi,\quad y = r\sin\theta\sin\phi,\quad z = r\cos\theta,$$

then $Y_n(x, y, z)$ may be written in the form $r^nf_n(\theta, \phi)$, where $f_n(\theta, \phi)$ is independent of r; and $f_n(\theta, \phi)$ is called a *surface harmonic*.

It can be proved that $Y_n(x, y, z)/r^{2n+1}$ is also a solution of Laplace's equation, and it is called a spherical harmonic of degree $-(n+1)$; this function and $Y_n(x, y, z)$ are called *solid* harmonics.

The term spherical harmonics (German, *Kugelfunktionen;* French, *Fonctions sphériques*) is due to Lord Kelvin.

When referred to polar co-ordinates, Laplace's equation becomes

$$\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right)+\frac{1}{\sin\theta}\,\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial V}{\partial\theta}\right)+\frac{1}{\sin^2\theta}\,\frac{\partial^2V}{\partial\phi^2} = 0;$$

this was the form of the equation originally given by P. S. de Laplace in 1784, in a memoir on Saturn's rings.

Determination of Harmonics of Given Degree.—Let $a_{r,s,t}\,x^ry^sz^t$ be an arbitrary expression of positive integral degree n in x, y, z where r, s, t are positive integers (zero included) such that $r+s+t=n$, and the summation extends over all possible sets of values of r, s, t. It is required to find conditions that this expression may be a harmonic.

It is readily proved that the number of terms in the expression is $\frac{1}{2}(n+2)(n+1)$; if the expression is operated on by Laplace's operator, the result is an expression of degree $n-2$ in x, y, z, in which the $\frac{1}{2}n(n-1)$ coefficients are linear combinations of the $a_{r,s,t}$. If the last expression is equated to zero, $\frac{1}{2}n(n-1)$ equations connecting the $a_{r,s,t}$ are obtained, which have to be satisfied if the former expression is to be a harmonic. It follows that the number of independent coefficients $a_{r,s,t}$ is

$$\tfrac{1}{2}(n+2)\ (n+1)-\tfrac{1}{2}n(n-1),$$

i.e., $2n+1$, and the remaining coefficients are expressible linearly in terms of them.

Consequently there are $2n+1$ independent harmonics of degree n, and any other harmonic of degree n is expressible as a linear combination of these harmonics.

Take $n=2$ as an illustration; the expression

$$a_2x^2+b_2y^2+c_2z^2+2d_2yz+2e_2zx+2f_2xy$$

is a harmonic if $a_2+b_2+c_2=0$, and 5 independent harmonics of degree 2, in terms of which any harmonic of degree 2 may be expressed, may be taken to be

$$yz,\quad zx,\quad xy,\quad 2z^2-x^2-y^2,\quad x^2-y^2.$$

The next step is to construct $2n+1$ harmonics of degree n. This may be effected by considering the condition that

$$(ax+by+cz)^n$$

may be a harmonic, where a, b, c, are constants, and deducing the harmonics from it. By actual differentiation it follows that the condition that $(ax+by+cz)^n$ is a harmonic is

$$a^2+b^2+c^2 = 0;$$

and this condition is satisfied by taking

$$a = i\cos u,\quad b = i\sin u,\quad c = 1,$$

where u is any angle and i stands for $\sqrt{(-1)}$; and so

$$(z+ix\cos u+iy\sin u)^n$$

is always a harmonic.

Now suppose this expression to be expanded by the multinomial theorem, and replace $\cos u$ and $\sin u$ by their exponential values $(e^{iu}+e^{-iu})/2$ and $(e^{iu}-e^{-iu})/(2i)$; when the products of powers of $\cos u$ and $\sin u$ are multiplied out in this way, replace expressions such as e^{miu}, e^{-miu} by $\cos mu\pm\sin mu$.

It is thus possible to express $(z+ix\cos u+iy\sin u)^n$ in the form

$$(z+ix\cos u+iy\sin u)^n = \tfrac{1}{2}g_0(x, y, z) \\ +\sum_{m=1}^{n}[g_m(x, y, z)\cos mu+h_m(x, y, z)\sin mu],$$

where $g_m(x,y,z)$ and $h_m(x,y,z)$ are polynomials of degree n in x,y,z, and are independent of u; and since

$$\tfrac{1}{2}\nabla^2g_0(x,y,z)+\sum_{m=1}^{n}[\nabla^2g_m(x,y,z)\cos mu+\nabla^2h_m(x,y,z)\sin mu]\equiv 0,$$

for all values of u, it is evident that $g_m(x,y,z)$ and $h_m(x,y,z)$ must be harmonics. As an illustration,

$$(z+ix\cos u+iy\sin u)^2 = z^2-\tfrac{1}{2}x^2-\tfrac{1}{2}y^2+2ixz\cos u \\ +2iyz\sin u+\tfrac{1}{2}(y^2-x^2)\cos 2u-xy\sin 2u.$$

To obtain $g_m(x,y,z)$ and $h_m(x,y,z)$ explicitly, use Fourier's rule for determining the coefficients in a trigonometrical series, *i.e.*, multiply the expansion of $(z+ix\cos u+iy\sin u)^n$ by $\cos mu$ and by $\sin mu$, and integrate with respect to u from $-\pi$ to π. It follows that

$$\pi g_m(x,y,z) = \int_{-\pi}^{\pi}(z+ix\cos u+iy\sin u)^n\cos mu\ du, \\ (m=0, 1, 2, \cdots, n),$$

$$h_m(x,y,z) = \int_{-\pi}^{\pi}(z+ix\cos u+iy\sin u)^n\sin mu\ du \\ (m=1, 2, 3, \cdots, n).$$

It will be proved later that these functions $g_m(x,y,z)$ and $h_m(x,y,z)$ are linearly independent, and so they form a set of $2n+1$ independent harmonics.

The General Solution of Laplace's Equation.—It has just been seen that any harmonic of degree n may be expressed in the form

$$\sum_{m=0}^{n}a_mg_m(x,y,z)+\sum_{m=1}^{n}b_mh_m(x,y,z),$$

where a_m and b_m are constants. If now, for brevity,

$$\sum_{m=0}^{n}a_m\cos mu+\sum_{m=1}^{n}b_m\sin mu$$

be called $\pi f_n(u)$, it follows that *any* harmonic of degree n is expressible in the form

$$\int_{-\pi}^{\pi}(z+ix\cos u+iy\sin u)^nf_n(u)du,$$

where $f_n(u)$ is a function of u; and, conversely, if $f_n(u)$ is an *arbitrary* function of u, it may be verified by substituting the expression in Laplace's equation that it is a harmonic of degree n.

Next take *any* solution V of Laplace's equation and suppose it to be expansible in a convergent series of positive integral powers of x,y,z; group together all the terms of the same degree and replace each group of terms of the same degree n by an expression of the form

$$\int_{-\pi}^{\pi}(z+ix\cos u+iy\sin u)^n f_n(u)du;$$

it follows that

$$V=\sum_{n=0}^{\infty}\int_{-\pi}^{\pi}(z+ix\cos u+iy\sin u)^n f_n(u)\,du;$$

and this value of V is expressible in the form

$$V=\int_{-\pi}^{\pi}f(z+ix\cos u+iy\sin u,\ u)du,$$

where f denotes a function of the two arguments $z+ix\cos u+iy\sin u$ and u; and conversely if f denotes an arbitrary function of its two arguments, the expression on the right may be shown to satisfy Laplace's equation.

It is possible to remove the restriction concerning the possibility of expanding V as a series of positive integral powers of x,y,z; and hence *the general solution of Laplace's equation may be written in the form*

$$V=\int_{-\pi}^{\pi}f(z+ix\cos u+iy\sin u,\ u)du.$$

This solution was obtained by E. T. Whittaker in 1902; it may be compared with the solution of the equation

$$\frac{\partial^2 W}{\partial x^2}+\frac{\partial^2 W}{\partial y^2}=0,$$

(known as Laplace's two-dimensional equation) namely

$$W=f(x+iy)+g(x-iy)$$

where f and g denote arbitrary functions.

Zonal, Tesseral and Sectorial Harmonics.—The $2n+1$ harmonics of degree n which have been constructed take more simple forms when referred to polar co-ordinates; it is, in fact, possible to establish the expansion:

$$(z+ix\cos u+iy\sin u)^n = r^nP_n(\cos\theta)+2\sum_{m=1}^{n}\frac{n!\,i^m}{(n+m)!}r^nP_n^m(\cos\theta)$$

$(\cos m\phi\cos mu+\sin m\phi\sin mu)$ where $P_n(\cos\theta)$ depends on θ, but not on ϕ, and $P_n^m(\cos\theta)=\sin^m\theta\dfrac{d^mP_n(\cos\theta)}{d(\cos\theta)^m}$.

From the form of the above expansion, it is evident that $r^nP_n(\cos\theta)$ is identical with $\frac{1}{2}g_0(x,y,z)$ so that

$$P_n(\cos\theta)=\frac{1}{2\pi}\int_{-\pi}^{\pi}\{\cos\theta+i\sin\theta\cos(\phi-u)\}^n du,$$

it follows from the statement that $P_n(\cos\theta)$ is independent of ϕ that it is permissible to put $\phi=0$ in the last formula without affecting the result; and so

$$P_n(\cos\theta)=\frac{1}{2\pi}\int_{-\pi}^{\pi}(\cos\theta+i\sin\theta\cos u)^n du,$$

a formula known as *Laplace's integral*.

From the result stated, it follows that $2n+1$ harmonics of degree n are

$$r^nP_n(\cos\theta), r^nP_n^m(\cos\theta)\cos m\phi,\ r^nP_n^m(\cos\theta)\sin m\phi,$$
$$(m=1,2,\cdots,n),$$

and, from the manner in which ϕ occurs in them, they are obviously linearly independent.

An alternative definition of $P_n(\cos\theta)$ is derived from the fact that the potential produced at (x,y,z) by a unit mass at $(0,0,a)$ is

$$1/\sqrt{\{x^2+y^2+(a-z)^2\}}=1/\sqrt{(a^2-2ar\mu+r^2)},$$

in polar co-ordinates, where μ denotes $\cos\theta$; when this potential function is expanded in ascending powers of r, the result is of the form

$$\frac{1}{a}+\frac{rP_1(\mu)}{a^2}+\cdots+\frac{r^nP_n(\mu)}{a^{n+1}}+\cdots,$$

where $P_n(\mu)$ depends on μ and n only; and it may be seen from the expression in Cartesian co-ordinates that $r^nP_n(\mu)$ is a harmonic of degree n; it is possible to identify $P_n(\mu)$, defined in this manner, with Laplace's integral; and it can be proved that

$$P_1(\mu)=\mu,\quad P_2(\mu)=\frac{3\mu^2-1}{2},\quad P_3(\mu)=\frac{5\mu^3-3\mu}{2},\cdots,$$

$$P_n(\mu)=\frac{(2n)!}{2^n\cdot(n!)^2}\Big[\mu^n-\frac{n(n-1)}{2(2n-1)}\mu^{n-2}+\frac{n(n-1)(n-2)(n-3)}{2\cdot4(2n-1)(2n-3)}\mu^{n-4}-\cdots\Big].$$

If a sphere is drawn with centre at the origin, the locus of points on the sphere at which $P_n(\cos\theta)$ vanishes consists of the n parallels of latitude on which the cosine of the co-latitude is a root of the equation $P_n(\mu)=0$; the locus thus divides the sphere into $n+1$ zones, and for this reason $r^nP_n(\cos\theta)$ is called a *zonal* harmonic.

In like manner when $n>m\geqq1$, $P_n^m(\cos\theta)$ vanishes on $n-m$ parallels of latitude, while $\cos m\phi$ vanishes on $2m$ meridians, and $\sin m\phi$ vanishes on $2m$ other meridians; the sphere is thus divided into $2m(n-m-1)$ rectangular regions, with $2m$ triangular regions round each pole, and for this reason $r^nP_n^m(\cos\theta)\cos m\phi$ and $r^nP_n^m(\cos\theta)\sin m\phi$ are called *tesseral* harmonics (τέσσερα = a square).

For similar reasons $r^nP_n^n(\cos\theta)\cos n\phi$ and $r^nP_n^n(\cos\theta)\sin n\phi$ are called *sectorial* harmonics.

The function $P_n(\cos\theta)$ is called a *Legendre coefficient*, or a *Legendre function*, while $P_n^m(\cos\theta)$ is called an *associated Legendre function*.

Normal Solutions of Laplace's Equation.—The zonal, tesseral and sectorial harmonics are of the form $R\cdot\Theta\cdot\Phi$ where R,Θ,Φ respectively involve the co-ordinates, r,θ,ϕ, only; a solution consisting of the product of three functions each involving only one co-ordinate is called a *normal solution*.

Thus, if $X\cdot Y\cdot Z$ is a normal solution of Laplace's equation in Cartesian co-ordinates, it follows, on substitution and division by XYZ, that

$$\frac{1}{X}\frac{\partial^2X}{\partial x^2}+\frac{1}{Y}\frac{\partial^2Y}{\partial y^2}+\frac{1}{Z}\frac{\partial^2Z}{\partial z^2}=0,$$

and so $\dfrac{1}{X}\dfrac{\partial^2X}{\partial x^2},\quad\dfrac{1}{Y}\dfrac{\partial^2Y}{\partial y^2},\quad\dfrac{1}{Z}\dfrac{\partial^2Z}{\partial z^2}$

must be respectively independent of x,y,z; hence they are constants. If these constants are called a^2, b^2, c^2, where $a^2+b^2+c^2=0$, we obtain the solutions

$$V=e^{\pm ax\pm by\pm cz}.$$

Similarly, if $R\Theta\Phi$ is a normal solution in polar co-ordinates,

$$\frac{1}{R}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right)+\frac{1}{\Theta\sin\theta}\frac{d}{d\theta}\left(\sin\theta\frac{d\Theta}{d\theta}\right)+\frac{1}{\Phi\sin^2\theta}\frac{d^2\Phi}{d\phi^2}=0,$$

and so $\dfrac{1}{R}\dfrac{d}{dr}\left(r^2\dfrac{dR}{dr}\right)$ and $\dfrac{1}{\Phi}\dfrac{d^2\Phi}{d\phi^2}$ must be constants, say $n(n+1)$ and $-m^2$; and so Θ satisfies the equation

$$\frac{1}{\sin\theta}\frac{d}{d\theta}\left(\sin\theta\frac{d\Theta}{d\theta}\right)+\left(n[n+1]-\frac{m^2}{\sin^2\theta}\right)\Theta=0,$$

while $\dfrac{d}{dr}\left(r^2\dfrac{dR}{dr}\right)-n(n+1)R=0,\quad\dfrac{d^2\Phi}{d\phi^2}+m^2\Phi=0.$

Possible values of R are r^n and r^{-n-1}; and possible values of Φ are $\cos m\phi$ and $\sin m\phi$. But now n and m are not necessarily integers, and so the question arises of defining $P_n^m(\cos\theta)$ in such circumstances.

This problem is dealt with by means of the hypergeometric function of Gauss defined by the equation

$$F(\alpha,\beta;\gamma;z)=1+\frac{\alpha\beta}{\gamma\cdot1}z+\frac{\alpha(\alpha+1)\beta(\beta+1)}{\gamma(\gamma+1)\cdot1\cdot2}z^2+\cdots.$$

A solution of the equation which it is convenient to adopt as the definition of $P_n^m(\cos\theta)$ is

$$P_n^m(\cos\theta) = \frac{1}{\Gamma(1-m)}\left(\frac{\mu+1}{\mu-1}\right)^{\frac{1}{2}m} F(-n, n+1; 1-m; \tfrac{1}{2}-\tfrac{1}{2}\mu),$$

where $\Gamma(1-m)$ denotes the gamma function of Euler which reduces to $(-m)!$ when m is a negative integer (when m is a positive integer, this function differs from the associated Legendre function, as previously defined, by a constant factor). The theory of generalized Legendre functions is consequently merged into the wider theory of hypergeometric functions.

Cylindrical and Ellipsoidal Harmonics.—The cylindrical co-ordinates (ρ,ϕ,z) of a point are defined by the equations

$$x=\rho\cos\phi, \quad y=\rho\sin\phi, \quad z=z.$$

When the solution $e^{k(z+ix\cos u+iy\sin u)}$ of Laplace's equation is expressed in terms of such co-ordinates it becomes:

$$e^{kz}e^{ik\rho\cos(\phi-u)}$$

and this can be expanded in the form

$$e^{kz}\left[J_0(k\rho)+2\sum_{m=1}^{\infty} i^m J_m(k\rho)(\cos m\phi\cos mu+\sin m\phi\sin mu)\right]$$

where $$J_m(k\rho) = \sum_{n=0}^{\infty}\frac{(-1)^n(\frac{1}{2}k\rho)^{m+2n}}{n!(m+n)!}$$

This leads to the consideration of the *cylindrical harmonics*

$$e^{kz}J_0(k\rho), \quad e^{kz}J_m(k\rho)\cos m\phi, \quad e^{kz}J_m(k\rho)\sin m\phi,$$

which may also be derived as normal solutions of Laplace's equation in cylindrical co-ordinates, viz.

$$\frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial V}{\partial\rho}\right)+\frac{1}{\rho^2}\frac{\partial^2 V}{\partial\phi^2}+\frac{\partial^2 V}{\partial z^2}=0.$$

The functions $J_m(k\rho)$ are known as *Bessel functions* (*q.v.*). They occur in numerous physical problems of diverse types including F. W. Bessel's investigations of planetary motion, Daniel Bernoulli's problem of a vibrating hanging chain and L. Euler's problem of a vibrating circular membrane.

The functions which occur in a similar manner when Laplace's equation is referred to a system of confocal conicoids as surfaces of reference are known as *Lamé's functions*; these are of a more complicated type than the functions described hitherto, because they cannot be expressed as series with simple coefficients. But when the confocal conicoids are spheroids, the substitution

$$x=(r^2-c^2)^{\frac{1}{2}}\sin\theta\cos\phi, \quad y=(r^2-c^2)^{\frac{1}{2}}\sin\theta\sin\phi, \quad z=r\cos\theta$$

gives a form of Laplace's equation with normal solutions of the type

$$P_n^m(r/c)P_n^m(\cos\theta)\begin{matrix}\cos\\ \sin\end{matrix} m\phi,$$

the spheroids being prolate; with oblate spheroids, c must be replaced by ic.

Recent Researches.—Some of the main lines along which progress has been made in recent years include methods of transforming the hypergeometric series; obtaining approximate expressions for $P_n^m(\cos\theta)$ when n or m (or both) is large; expanding arbitrary functions of two variables as series of surface harmonics; expanding arbitrary functions $f(\mu)$ in the form $\sum a_nP_n(\mu)$; obtaining approximate formulae for $J_n(z)$ when z or n (or both) is large; obtaining formulae by which the roots of the equation $J_n(z)=0$ may be calculated; expanding arbitrary functions as series of Bessel functions; obtaining integral equations satisfied by ellipsoidal harmonics, and by the harmonic functions associated with confocal elliptic cylinders. These investigations all arose in the first instance out of some problem of Mathematical Physics, though many of them require the most profound methods of Pure Mathematics for their solution.

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SPHEROID, literally a sphere-like body. In geometry the term is applied to figures generated by an ellipse (q.v.) revolving about either its minor axis (giving an *oblate spheroid*) or its major axis (giving a *prolate spheroid*). If the equation of the generating ellipse is $b^2x^2+a^2y^2=a^2b^2$, and the ellipse revolves about the major axis (the x axis), the volume is $\frac{4}{3}\times ab^2$; if about the minor axis, it is $\frac{4}{3}\pi a^2b$. The equation of the prolate spheroid is $b^2x^2+a^2(y^2+z^2)=a^2b^2$, and of the oblate spheroid it is $b^2(x^2+z^2)+a^2y^2=a^2b^2$. *See* ELLIPSOID.

SPHERULITES, in petrology, small rounded bodies which commonly occur in vitreous igneous rocks. They are often visible in specimens of obsidian, pitchstone and rhyolite as globules about the size of millet seed, with a duller lustre than the surrounding glassy base of the rock, and when they are examined with a lens they prove to have a radiate fibrous structure. Under the microscope the spherulites are of circular outline and composed of thin divergent fibres, which are crystalline and react on polarized light. Between crossed nicols a black cross appears in the spherulite; its axes are usually perpendicular to one another and parallel to the crossed wires; as the stage is rotated the cross remains steady; between the black arms there are four bright sectors. This shows that the spherulite consists of radiate doubly refracting fibres which have a straight extinction; the arms of the black cross correspond to those fibres which are extinguished. The aggregate is too fine grained for us to determine its minerals.

Spherulites are commonest in acid glassy rocks but occur also in basic glasses such as tachylyte. Sometimes they compose the whole mass; more usually they are surrounded by a glassy or felsitic base. When obsidians are devitrified the spherulites are often traceable, though they may be more or less completely recrystallized or silicified. In the centre of a spherulite there may be a crystal (*e.g.*, quartz or felspar) or sometimes a cavity. Occasionally spherulites have zones of different colours, and while most frequently spherical they may be polygonal, or irregular in outline. In some New Zealand rhyolites the spherulites send branching "cervicorn" processes (like stags' horns) outwards through the surrounding glass of the rock. Long, elliptical or band-like spherulites are called *axiolites*.

Spherulites may be ½in. or more in diameter. In composition they are a mixture of quartz and acid felspar.

Very large and cavernous spherulites have been called *lithophysae;* they are found in obsidians at Lipari, the Yellowstone Park, etc. The characteristic radiate fibrous structure is usually conspicuous, but the fibres are interrupted by cavities which are often so arranged as to give the spherulite a resemblance to a rosebud with folded petals separated by arching interspaces. Some of these lithophysae are 1in. or more in diameter. In the crystallization of a glass there must be contraction, and it is supposed that thus the concentric cavities arise. The steam and other vapours in the magma would fill these empty spaces and exert a powerful mineralizing action on the warm rock. Analogous structures may be produced in artificial glasses, salt solutions and melts of organic substances. (J. S. F.)

SPHINX, the Greek name for a compound creature with lion's body and human head (Gr. *σφίγγειν* to draw tight, squeeze). The Greek sphinx had wings and female bust, and the male sphinx of Egypt (wingless) is distinguished as "androsphinx" by Herodotus. The type perhaps originated in Egypt, where a defined type is usually recumbent. The most celebrated example is the Great Sphinx of Giza, 189ft. long, a rock carved into this shape, and from its situation likely to be the work of the IVth Dynasty.

According to inscriptions of the XVIIIth Dynasty in the shrine between the paws, it represented the sun god Harmachis. It has recently been completely excavated and its head restored. Sphinxes of granite, etc., occur of the XIIth Dynasty and later. (*See* EGYPT, *Art and Archaeology*.) The heads of the sphinxes are royal portraits, and apparently they are intended to represent the power of the reigning Pharaoh. The king as a sphinx, in certain religious scenes, makes offerings to deities; and elsewhere he tears his enemies in pieces. Sphinxes in pairs guarded the approach to a temple, and the Great Sphinx at Giza so guards the entrance of the Nile valley.

The great temple avenues at Thebes are lined with recumbent rams, true sphinxes (a few late instances), and with the so-called criosphinxes or ram-sphinxes, having lion bodies and heads of the sacred animal of Ammon. A falcon-headed sphinx was dedicated to Harmachis in the temple of Abu Simbel, and is occasionally found in sculptures representing the king as Horus, or Mont, the war-god. It is distinguishable from the gryphon only by the absence of wings.

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In Assyria the sphinx appears with a bearded male head on cylinders; the female sphinx, lying down and furnished with wings, is first found in the palace of Esar-haddon (7th cent. B.C.). Sphinxes have been found in Phoenicia, one at least being winged and another bearded. They are copies of the Egyptian, both in form and posture, wearing the pshent and the uraeus, but distinguished by having the Assyrian wings. The sphinx is common on Persian gems, and the representations are finely executed. On a Persian intaglio are two sphinxes face to face, each wearing a tiara and guarding a sacred plant which is seen between them; but the sphinx, whether of the Egyptian or the Assyrian type, is not found in Persian sculptures (Perrot and Chipiez, *History of Art in Persia*, Eng. trans., London, 1892). In Asia Minor the oldest examples are the "Hittite" sphinxes of Euyuk. They are Egyptian sphinxes treated in the Assyrian style. They are not recumbent, and the hair falling from the head is curled, not straight, as in the true Egyptian sphinx.

In the early art of Cyprus (the half-way house between Asia and Greece) sphinxes of Greek type are not uncommon. On the other hand, on a gem of Phoenician style found at Curium in Cyprus there appear two male (bearded) sphinxes, with the tree of life between them. With regard to Greece proper, in the third tomb on the acropolis of Mycenae (*c.* 1600 B.C.) were found six small golden sphinxes; they are beardless, but the sex is doubtful.

Moreover, the sphinx (generally sejant, in the Greek fashion) was well-known in Minoan art. It occurs in ivory (couchant) among the Mycenean antiquities from Enkomi in Cyprus, in the British Museum. In the ancient tomb discovered in 1877 at Spata near Athens (which represents a kindred but somewhat later art than the tombs at Mycenae) were found female winged sphinxes carved in ivory or bone. Sphinxes on glass plates have been found in graves at Camirus in Rhodes and on gold plates in Crimean graves. Sphinxes were represented on the throne of Apollo at Amyclae and on the metopes at Selinus; in the best period of Greek art a sphinx was sculptured on the helmet of the statue of Athena in the Parthenon at Athens; and sphinxes carrying off children were sculptured on the front feet of the throne of Zeus at Olympia. There have been found in Boeotia terra-cotta figures of wingless sphinxes. Roman sphinxes of a late period have sometimes a man's, sometimes a woman's head with an asp on the forehead.

In Greek mythology the most famous sphinx was that of Thebes in Boeotia, first mentioned by Hesiod (*Theog.* 326), who calls her the daughter of Orthus and Chimaera. According to Apollonius (iii. 5, 8), she was the daughter of Typhon and Echidna, and had the face of a woman, the feet and tail of a lion and the wings of a bird. She dwelt at the south-east corner of Lake Copais on a bald rocky mountain called Phicium (mod. Fagas), which was derived from Φιξ, the Aeolic form of σφιγξ. The Muses taught her a riddle and the Thebans had to guess it. Whenever they failed she carried one of them off and devoured him. The riddle was this: "What is that which is four-footed, three-footed and two-footed?" At last Oedipus guessed correctly that it was man; for the child crawls on hands and feet, the adult walks upright, and the old man supports his steps with a stick. Then the sphinx threw herself down from the mountain.

Among the remains of the Mayan culture in Yucatan are found examples of sphinxes, male and female, which are not unlike those of Egypt and Asia Minor.

See Milchhöfer, in *Mitth. d. deutsch. archäol. Instit. in Athen* (1879), p. 46 *seq.;* J. Ilberg, *Die Sphinx in der griechischen Sage und Kunst* (1895); Sir R. C. Jebb's ed. of Sophocles, *Oed. Tyrann.*, app., note 12. (J. M. M.; H. R. H.)

SPICE-BUSH (*Benzoin aestivale*), a North American shrub of the laurel family (Lauraceae), allied to the sassafras and Oregon myrtle (*qq.v.*), native to moist woods from Massachusetts to Ontario and Michigan south to North Carolina and Kansas. It grows from 4 to 20 ft. high, with smooth fragrant twigs and foliage, and bears bright yellow flowers, which unfold before the leaves, and scarlet fruit (drupe), maturing in late summer. The similar hairy spice-bush (*B. melissaefolium*) is found in swamps in the south-eastern States. The bark of *B. aestivale* was formerly of high repute in household medicine, being used as a febrifuge.

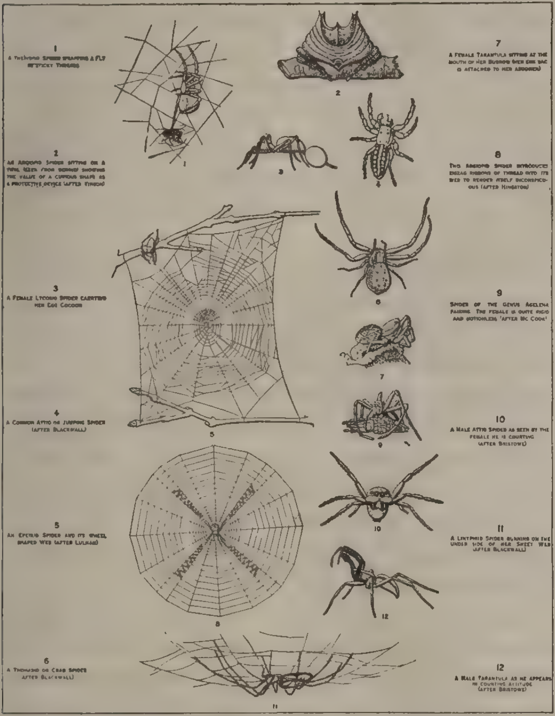
SPIDER-MONKEY, a group of tropical American monkeys known to zoologists as *Ateles*. They take their English name from the slimness of the body, the elongated limbs, and the long tail, the under surface of the prehensile extremity of which is naked. The thumb is rudimentary or wanting. The absence of woolly under-fur, and the broader partition between the nostrils distinguishes them from the woolly spider-monkeys (*Brachyteles*). The species are arboreal. (*See* PRIMATES.)

SPIDERS are a group of animals closely related to scorpions, mites and harvestmen belonging like them to the natural class Arachnida (*q.v.*) but being characterized within it by possessing silk-producing organs called spinnerets, which are attached to the underside of the abdomen. A good many other Articulata can produce silk, but none make such an extended and diversified use of it as spiders. They employ it not only for making cocoons to protect both the eggs and the spiders themselves, young and mature, from wet and cold, but they also weave it into snares as beautiful as they are diabolical in their ingenuity.

Besides their silk, spiders have another weapon of offence in poison, which they inject into their prey through the sharp sickle-shaped digital joints of their front jaws. Cases are known of spider-poison affecting vertebrate animals and being fatal to man, but it is far quicker in its action on the spiders' natural prey, the articulate animals, where it induces rapid paralysis.

Many spiders, although able to produce silk, spin no web, but rely on a fairly keen sense of sight for catching insects. Such are the *Salticidae* or jumping spiders, which stalk their prey stealthily and leap upon it when close enough. These have relatively large eyes and, as they are diurnal in their habits and love to run and jump in the sunshine, many of them are coloured in such a way as to render them inconspicuous among their surroundings, while a few closely resemble certain species of ants and thus escape the attention of many of their natural enemies. The *Thomisidae* are called "crab-spiders," since many run sideways. One Thomisid, *Misumena vatia* is light green or yellow and lurks in yellow or white flowers.

The *Lycosidae,* another family of wandering spiders, are not so long-sighted as the *Salticidae* and only attack when an insect comes close or touches them. Some of them have developed more sedentary habits, probably owing to the continual attacks of various solitary wasps which paralyse the spiders with their stings and store them living in their nests to be food for their larvae when they hatch out. The famous Tarantulas (*q.v.*) build silk-lined burrows in sandy soil; and often construct a little parapet or a trap-door at the opening. Here they sit waiting until an insect comes within striking distance. One little Lycosid, *Trochosa picta,* besides having a burrow for protection, is spotted with black, yellow, pink and white, so that while it is motionless on sandy soil it is often quite invisible. Burrowing habits are also found among the *Mygalomorphae,* a group differing widely from *Lycosidae,* and including the large "bird-eating" spiders. They are much more skilful builders, the trap doors which some of them make being beautiful close-fitting structures, decorated with *débris,* indistinguishable from their surroundings.


1
A Theridiid Spider wrapping a fly in sticky threads
2
An Argiopid Spider sitting on a twig, seen from behind showing the value of a curious shape as a protective device (after Vinson)
3
A Female Lycosid Spider carrying her Egg Cocoon
4
A Common Attid or Jumping Spider (after Blackwall)
5
An Epeirid Spider and its wheel shaped web (after Lulham)
6
A Thomisid or Crab Spider after Blackwall
7
A Female Tarantula sitting at the mouth of her burrow with egg sac attached to her abdomen
8
The Argiopid Spider introduces zigzag ribbons of thread into its web to render itself inconspicuous (after Hingston)
9
Spider of the genus Agelena pairing. The female is quite rigid and motionless (after Mc Cook)
10
A Male Attid Spider as seen by the female he is courting (after Bristowe)
11
A Linyphiid Spider running on the under side of her sheet web (after Blackwall)
12
A Male Tarantula as he appears in courting attitude (after Bristowe)
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TYPES OF SPIDERS, VENOMOUS AND NON-VENOMOUS

(1) Theridiid spider, wrapping a fly in sticky threads; (2) Argiopid spider, shown from behind (After Vinson); (3) Female Lycosid spider carrying egg cocoon; (4) Common Attid spider (After Blackwall); (5) Epeirid spider and web (After Lulham); (6) Thomasid spider (After Blackwall); (7) Female Tarantula with egg sac attached to abdomen; (8) Argiopid spider (After Hingston); (9) Grass spider (*Agalena*), pairing (After McCook); (10) Male Attid spider (After Bristowe); (11) Linyphid spider, on under side of her sheet web (After Blackwall); (12) Male Tarantula, in courting attitude (After Bristowe)

Some *Lycosidae* of the genus *Pirata* live by water, on which they can run perfectly. Moreover, they can submerge themselves when necessary by climbing down stems of water-plants, taking down as air supply a bubble, entangled in the hairs of the body, which will last for many hours. *Lycosa purbeckensis,* which lives on marshy ground among tussocks of grass and reeds by tidal estuaries, runs over the water to a plant stem as the tide comes in and deliberately crawls down, remaining submerged until the ebb. In a closely related family, the *Agalenidae,* is placed the water-spider, *Argyroneta aquatica,* which leads a truly aquatic life. It builds a little silken diving bell under the water and fills it with air carried down as bubbles between the abdomen and back legs. Its food consists of aquatic insects, and it even mates and produces its young in its nest under water. Other species of the genus *Desis* live in the sea and make nests in coral reefs below high water mark, coming out at low tide to prey on small crustaceans. Among other genera in the same family are land-dwellers with a much more highly developed web, on which the spiders depend for the capture of prey. The upper end of the silken tube, used as a retreat, opens out into a wide sheet of which the cobwebs built in the angles of walls by various species of *Tegenaria* are examples. When an insect falls on to the sheet the spider rushes out, seizes it in its jaws and rushes back to its retreat. The attack is very simple, the web serving to guide the spider to its prey.

The *Theridiidae* are an interesting family of spiders which are usually globular-bodied with relatively long legs and small jaws. They build somewhat formless snares consisting of single threads spun at random in a criss-cross manner. When a fly becomes entangled in the web, the spider runs out, turns round and covers its victim with sticky threads which it draws out of its spinnerets with its two back legs. Then approaching very carefully, it bites a projecting leg or wing, whereupon the insect's struggles slacken and soon cease owing to paralysis produced by the spider's poison. If the first bite is not effective another is administered after more silk has been thrown on. The silk has here a more complicated function. For whereas the *Agalena* or *Tegenaria* relies on the strength of her limbs and jaws and the *Linyphia* on the protection of her sheet, rushing straight at her prey, the *Theridion* with her feeble jaws must restrict her prey's violent struggles before she can safely approach.

Many species of the *Argiopidae* spin the most strikingly regular and beautiful wheel-shaped webs. The stages of the construction of these webs are always the same. A triangular or trapezoid framework attached to plants or near-by objects is first laid down. Then the radii of the wheel are made, all equidistant and converging to a silken hub or platform. Next a temporary spiral is woven to act as a bridge for the construction of the final spiral, which is made of sticky threads. The spiral is begun on the outer margin of the web, and, one round completed, the spider walks to the next radius and feels with the tip of its fore leg until it touches the filament of the spiral laid down in its previous circuit. When this is done the spinnerets are applied to the radius and the attachment made. Then spinning, it proceeds to the next radius, feels for the outer circuit, again attaches its thread, and so continues, with the result that each turn of the spiral is at a fixed distance from the turns on either side of it. If the spider's fore leg be amputated, the measuring is at once at fault and the snare when made is quite irregular.

When an insect becomes entangled in a wheel web, the spider runs towards it and bites it, then wraps it in silk and carries it to the platform or to its retreat to eat. A large and formidable insect, however, is made to revolve and serve as a bobbin, becoming enwrapped at once in a dense sheet, so that the spider can approach and bite it. Some of these spiders which sit in the middle of their webs are exposed to the attacks of birds, as well as of solitary wasps and ichneumons which lay their eggs on the living spiders. There is in Brazil a predaceous fly which attacks and eats the spiders as they sit in their webs. Many species, then, are protected by the most ingenious devices. Some are specially coloured. *Epeira cucurbitina,* which builds its web on leaves, is bright green. Others spin in their webs silk bands, zig-zags or crosses and take up such positions that they seem to form part of these devices. Sometimes insect débris is made with silk into pellets which closely resemble the spider, or sometimes cocoons have the same function.

A large group of spiders have an auxiliary spinning organ called a "cribellum," which produces a very fine flocculent silk which the spider draws out in tiny waves by means of a comb of stiff bristles (the calamistrum) attached to the hind legs. The spider bites either the body or the limb of its entangled prey, and then simply holds on. The poison is usually powerful.

Courtship and Mating.—The courtship and mating of spiders, which is often extremely curious, presents some very interesting problems. The male can be instantly recognized as such by dark swellings on the digital joints of the palpi. These are produced by organs which are used for conveying the sperms to the female. The testes lie in the abdomen, and the male before mating deposits a drop of sperm on to a sheet or strand of silk, then reabsorbs it into the palpal organs, which are applied to the female's epigynum (underneath the abdomen) during mating.

Courtship serves one or both of two functions, recognition and stimulation. The female spends her life capturing and eating in order to grow and provide substance for her eggs. Another spider, even of the same species is as good food as any other, and unless the male advertised his identity he might well be attacked and eaten before mating could take place. Males of the families *Salticidae* and *Lycosidae,* keen-sighted spiders, have often curious little tufts of coloured or dark hairs on their legs, palpi or the fore parts of their bodies. These epigamic characters they display in ludicrous dances before their prospective mates. Once the males have started dancing, they are comparatively safe, but they must continue, often for hours, until the females are so stimulated that they will submit to mating. In *Pisaura mirabilis,* of a closely related family, *Pisauridae,* the male has no epigamic characters, but approaches his mate with a fly, wrapped in silk, which she seizes and retains during mating.

The web-spinning spiders even if they see distinctly do not rely on sight to any appreciable extent. These males perform a tactile courtship through the medium of the web. As a rule the female recognizes the male's movements at once, and his courtship, a series of pluckings or jerks on the web, now serves to stimulate her and to entice her out from her retreat to a clear space where mating can take place.

As the season proceeds females of short-lived spiders usually lose much of their sexual impulse and are concerned solely with feeding and later with egg-laying. Males, their purpose served, are no longer recognized, and are often attacked and eaten.

Cocoons and Young.—All spiders make silken cocoons for their eggs, a fact which suggests that this was the first function of the silk. But in spite of the protection thus provided, the eggs are often infested with the larvae of parasitic Ichneumons and Diptera which eat them before they are hatched.

The *Lycosidae* carry their egg-cocoons attached with silk to their spinners and are very concerned if one tries to remove them, resisting furiously. But if they are given some other object of about the same size as the cocoon, such as a pith ball, they will accept it even though it be brightly coloured! Some tarantulas sit in the sun at the mouths of their burrows turning their cocoons slowly so that they receive light and warmth.

As soon as the young hatch, they scramble on to their mother's back and (as with all *Lycosidae*) cling on to her abdomen and are carried about for several weeks before they disperse.

Each minute spider climbs above its nest and then emits silk which is caught and drawn out by the wind. When the strand is long enough the spider seizes it with its legs and is borne away on the wind, often for a great distance. Such gossamer threads are a very beautiful sight on still days in autumn when they often cover whole fields.

In spite of their ingenuity shown in the construction of webs, burrows and nests of all kinds, spiders appear to have practically no intelligence. All their actions are instinctive. Even the construction of the beautiful wheel webs is quite automatic, the severing of one strand of the spiral producing a corresponding deformity in the next. The Lycosid will accept a pith ball instead of her egg-cocoon, and a Theridion will industriously enwrap a piece of paper agitated with a needle point. (For classification of spiders, *see* ARACHNIDA.) (G. H. L.)

SPIELHAGEN, FRIEDRICH VON (1829–1911), German novelist, was born at Magdeburg on Feb. 24, 1829. He was brought up at Stralsund, studying also at Berlin, Bonn and Greifswald. He became a master in a gymnasium at Leipzig, but upon his father's death in 1854 devoted himself entirely to writing. After publishing *Klara Vere* (1857) and *Auf der Düne* (1858), he obtained a striking success with *Problematische Naturen* (1860–1861). His powerful *Sturmflut* appeared in 1876. He died Feb. 25, 1911.

Spielhagen's *Sämtliche Werke* were published in 1871 in sixteen volumes, in 1878 in fourteen volumes; his *Sämtliche Romane* in 1898 (22 vols.), and these were followed by a new series in 1902. *See* his autobiography, *Finder und Erfinder* (2 vols., 1890).

SPIKENARD or **NARD,** a celebrated perfume which seems to have formed one of the most durable aromatic ingredients in the costly unguents used by the Romans and Eastern nations. The ointment prepared from it is mentioned in the New Testament (Mark xiv. 3–5; John xii. 3–5) as being "very costly," a pound of it being valued at more than 300 denarii (over £10). This appears to represent the prices then current for the best quality of nard, since Pliny (*H.N.* xii. 26) mentions that nard spikes reached as much as 100 denarii per lb. The source of the true or Indian nard is now identified as *Nardostachys jatamansi,* a plant of the family Valerianaceae, the fibrous root-stocks or "spikes" of which are still collected in Bhotan and Nepal.

The great spikenard of the United States is *Aralia racemosa,* and another species of the same genus, *A. nudicaulis,* or wild sarsaparilla, is known as "wild spikenard." In the West Indies *Hyptis suaveolens* is called "spikenard," and in Great Britain the name "ploughman's spikenard" is given to *Inula squarrosa* (*I. conyza*).

SPILITE, in petrology, a rock of basaltic character, but possessing in place of the normal labradorite, a felspar of the composition of albite. The ferromagnesian mineral is an augite of pale brown colour; spilites are, however, usually very completely decomposed, augite being represented by chlorite and calcite. They are commonly vesicular or variolitic and show wonderfuly preserved pillow structure, a feature in most cases indicative of a submarine origin of the lavas. The individual pillows are filled with concentric zones of vesicles filled with chlorite and calcite. The formation of pillow structure in volcanic rocks has been directly observed by Dr. Tempest Anderson in the case of the lava poured into the sea from the volcano Matavanu, in Samoa. On the surface of the lava, buds form and expand, giving rise to "pillows" with a glassy crust. The interspaces between the pillows are frequently filled with sediment representing the soft ooze of the sea floor. Not all pillow lavas are spilitic in character.

Some spilites showing pillow structure are not strictly lavas but shallow intrusions into unconsolidated submarine ooze. Excellent examples of such intrusive spilites are provided by the Devonian spilites of Nundle, New South Wales. Though the term spilite was first used by Brongniart for altered basic lavas free from phenocrysts and possessing well marked vesicular textures, a new significance was given to the term by Dewey and Flett, who urged that a special group of rocks—the spilitic suite—should be recognized. According to these authors, a large suite of igneous rocks is genetically associated with the spilites. Their composition varies widely, but they all have some characters in common. They possess a high percentage of soda and are usually extensively altered. These rocks are albite-dolerites, minverites, picrites, keratophyres, soda-felsites and soda-granites. The spilitic suite was originally given a status comparable with that of the alkaline and calc-alkaline suites. The spilitic series is regarded as peculiar to districts that have undergone a long continued and gentle subsidence with few or slight upward movements and no important faulting. The lavas are poured out on the margins of geosynclines while their common sedimentary associates are black shales, limestones and radiolarian cherts. As geosynclines are the centres of subsequent fold movements many ancient spilites have become extensively folded and metamorphosed with production of new minerals, including albite of metamorphic origin. Eruptions having the spilitic facies have occurred repeatedly over a wide area and on a large scale. The analyses of average basalt and spilite are as follows:

	SiO_2	$A1_2O_3$	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	$H_2O(+)$	TiO_2	CO_2
Average basalt	49·06	15·70	5·38	6·37	6·17	8·95	3·11	1·52	1·62	1·36	..
Average spilite	46·01	15·21	1·35	8·69	4·18	8·64	4·97	0·34	2·48	2·21	4·98

(C. E. T.)

SPINA, an ancient city of Gallia Cispadana, Italy, between Ravenna and the mouths of the Po. In Etruscan times it was the principal port of Felsina. (*See* Bononia.) Near Comacchio, in the draining of the lagoon of Valle Trebba, a very extensive necropolis has been found and some 450 tombs have been excavated, ranging from the 6th to the 3rd century B.C. They contained fine Greek, Italic and Etruscan vases.

SPINACH (*Spinacia oleracea*), an annual plant, a member of the family Chenopodiaceae, which has been long cultivated for the sake of its succulent leaves. It is probably of Persian origin, being introduced into Europe about the 15th century. It should be grown on good ground, well worked and well manured; and for the summer crops abundant watering will be necessary. (*See* Vegetable.)

SPINAL COLUMN, SURGERY OF. Most operations on the vertebral column are designed to relieve some condition of the enclosed spinal cord. The essentially degenerative diseases (tabes dorsalis, disseminated sclerosis, etc.) offer little scope for surgery, which finds its richest field in cases of cord compression. Spina bifida, a congenital defect in development, calls for operation in selected cases only, for most sufferers from this condition die during the first weeks or months of life.

There is one fundamental fact which we must grasp if we wish to understand the possibilities of spinal surgery: that regeneration is impossible, so that once the cord, and the long conduction tracts of which it is composed, suffers actual anatomical damage, that damage is permanent and cannot be undone. It is, therefore, useless to operate if it is certain that the cord has actually been lacerated, or has been so long and so severely compressed that return of function is unlikely or impossible.

Spinal Injuries.—These are generally due to indirect violence, the fracture occurring at a point distant from that at which the force was applied. Thus most injuries of the cervical spine (neck) are due to injuries applied to the head, whilst forcible flexion of the trunk by a weight falling on the shoulders (the common mechanism in pit accidents from a fall of "roof" or "dirt") causes a fracture at the first lumbar vertebra. The 24 bones which make up the cervical, thoracic and lumbar spine are not equally prone to injury; the three predominant sites where fractures or dislocations occur are at the points where the qualities and range of movement change—at the second cervical, where the compound movements of the head change over into the ordinary movements of the neck, at the disc between the fifth and sixth cervical where the cervical mobility changes into the relative fixity of the chest, and at the first lumbar where the latter joins the rod-like lumbar portion. The bodies of the vertebrae can be compressed or broken without injury to the spinal cord (so-called "Kümmells' disease") provided there is no sliding of the broken parts on one another. A fact which colours our whole attitude towards spinal injury to-day is that when the cord is damaged the lesion is inflicted at the moment of injury. The old teaching was that the cord was being compressed by bone fragments and hence early operation was advised. To-day we treat these cases with conservatism, reduce fractures by manipulation, and operate only when deterioration is setting in or pain is severe. But operation is never done as an immediate urgency. X-Rays are of the greatest help. In summary, the cord lesion associated with most injuries is central haemorrhage or actual laceration, and operation will not often be of service in the worst cases.

Spinal Tumours.—Once the diagnosis is reasonably certain it is best to operate early, for these growths are commonly (Elsberg gives 82%) outside the cord and can be dislodged by laminectomy. An incision is made over the spinous processes, the laminae are exposed by clearing the muscles with a rongeur and some three of them are removed. The dura mater is incised, if the tumour has not already been found outside. The results in many cases are dramatic and the palsied may indeed be made to walk upright. When the tumour lies in the cord tissue, nothing of great service can be achieved. Deep X-Ray therapy is the only hope for such conditions, but only a few successes have so far been recorded. Little noticeable weakness follows a laminectomy *per se.*

Spinal Caries.—Tuberculosis of the vertebral column is commonest in the very young, and gives good results by fixation on frames or in plaster jackets. Long periods of recumbency (1–3 years) are generally required. In order to render sufferers ambulant at an earlier time, bone-grafting operations have been devised. Albee advised this so-called "internal splinting" and recommended that a long thick graft should be taken from the tibia and inserted into a bed prepared for it over the bared spinous processes and laminae at the region affected, including two healthy vertebrae above and below. Hibbs later introduced the operation of "spinal fusion"; in this no new bone is implanted but the spinous processes and laminae are split and turned up and down to produce a mass of bone which will lock the bones together. The operations are most useful in persons of less tender years than are the majority of sufferers from Pott's disease. In Great Britain and Europe generally, excellent results are obtained by less drastic means, but in those who cannot afford a long convalescence these operations should be considered.

Sometimes a tuberculous abscess forms within the neural canal, extends backwards from the diseased vertebrae, and presses on the cord. Happily most of these patients recover the function of their limbs when perfectly immobilised; laminectomy does not give the good results which one might theoretically expect from it.

Pain.—Much can be done for sufferers from agonising pain by judicious spinal surgery. The chief indications for operation are neuralgia of the body or limbs, often the sequelae of amputations or of herpes zoster, the agonising pains of spinal syphilis, and hopeless malignant growths. The usual operation heretofore has been section of posterior nerve roots just before they enter the spinal cord. The exposure is the same as for spinal tumours. The results of root sections have been inconsistent, and the operation is being replaced by section of the pain-carrying fibres in the cord itself (Spiller). This tract is the anterior spino-thalamic and lies just sufficiently far away from the motor pathway to the limbs (pyramidal tract) for its division to be effected without inflicting paralysis on the sufferer. As the pain fibres cross in the cord, the tract of the opposite side to that on which the pain is felt is the one to be cut, and of course at a point cephalad to the site of the pain. A cut 2·5 to 3·omm. deep is made into the antero-lateral aspect of the cord. A very fine and sharp knife is required and the operation must be most delicately and precisely performed. Brilliant results have generally followed, but it is too early to say what the late effects are.

Spinal Puncture.—No account of modern spinal surgery can omit some reference to the extended usefulness which is being made of lumbar puncture (puncture into the subarachnoid space and withdrawal of a specimen of cerebro-spinal fluid). Our knowledge of the changing chemistry of that fluid in disease conditions is still growing. When a tumour or the like grows in relation to the spinal cord it causes a block in the subarachnoid space, either by its own bulk or by compressing the membranes against one another should it be extra-dural. The cerebro-spinal fluid distal (caudal) to the obstruction is dammed back, for it is chiefly absorbed within the skull and thither it can not now return. A rise in albuminous content and a yellow tinge, xanthochromatosis (Froin's syndrome), are the results. This is of great diagnostic importance. Queckenstedt's test also makes use of the block, for when a normal person's jugular veins are compressed the consequent rise of intracranial venous pressure is transmitted to the cerebro-spinal fluid as a whole and can be measured by a manometer attached to a lumbar-puncture needle. If a tumour blocks the spinal canal the manometer records no change or modified changes only. This is most valuable in differentiating between the degenerative and compression groups of paralysis of the lower limbs. Lastly, Lipiodol, a heavy, opaque substance which when introduced into the cerebro-spinal fluid above the tumour sinks down through it to rest on the tumour, is proving most useful. It is a 40% solution of inert iodine in poppy-seed oil and is quite opaque to X-Rays so that the precise position and often the shape of the upper end of the tumour becomes definitely recognisable.

Bibliography.—Armour, "The Surgery of the Spinal Cord and its Membranes," *Lancet.* 1927, I. 423; Ayer, "Spinal subarachnoid block as determined by combined cistern and lumbar puncture," *Arch. Neurol. Psychiat.* 1922, vii. 38; Elsberg, *Tumours of Spinal Cord*

(London, 1925); Frazier, "Section of the antero-lateral columns of the spinal cord for the relief of pain," *Arch. Neurol, Psychiat,* 1920, iv., 137; Foerster, *Die Leitungsbahnen des Schmerzgefühls und die Chirurgische Behandlung der Schmerzzustande* (Berlin, 1927); Jefferson, "Spinal Injuries," *Proc. Roy. Soc. Med.*, 1928, xxi., 21. (G. J.)

SPINAL CORD, in anatomy, that part of the central nervous system in man which lies in the spinal canal formed by the vertebrae, and reaches from the foramen magnum to the lower margin of the first lumbar vertebra. It is about 18in. long, and only occupies the upper two-thirds of the spinal canal. The cord is protected by the same three membranes which surround the brain. Outside is the *dura mater,* which differs from that of the brain in not forming a periosteum to the bones, in sending no processes inward, and in having no blood sinuses enclosed within its walls; it is the continuation of only the inner layer of the dura mater of the skull. Inside the dura mater is the *arachnoid,* which is delicate and transparent, while between the two lies the *subdural space,* which reaches down to the second or third sacral vertebra. The *pia mater* is the innermost covering, and is closely applied to the surface of the cord into the substance of which it sends processes. Between it and the arachnoid is the *sub-arachnoid space,* which contains the cerebro-spinal fluid. Across this space, on each side of the cord, run a series of processes of the pia mater arranged like the teeth of a saw; by their apices they are attached to the dura mater, while their bases are continuous with the pia mater surrounding the cord. These ligaments, each consisting of twenty-one teeth, are the *ligamenta denticulata,* and by them the spinal cord is moored in the middle of the cerebro-spinal fluid.

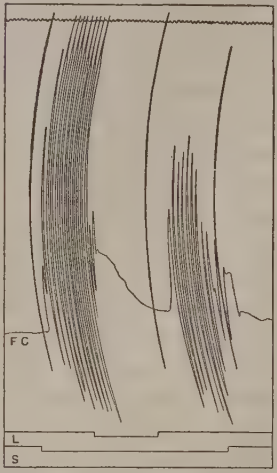


FIG. 1.—SPINAL CORD, SHOWING TRACINGS OF ANTAGONISTIC REFLEXES

The spinal cord itself is a cylinder slightly flattened from before backward. In the cervical region it is enlarged where the nerves forming the *brachial plexus* come off, while opposite the lower thoracic vertebrae the lumbar enlargement marks the region whence the lumbo-sacral nerves are derived. (*See* fig. 2.) Opposite the second lumbar vertebra the cylindrical cord becomes pointed and forms the *conus medullaris,* from the apex of which a glistening membranous thread runs down among the nerves which form the *cauda equina,* and, after blending with the termination of the dural sheath, is attached to the back of the coccyx.

Details of Structure.—In a transverse section of the cord (*see* fig. 3) two median fissures are seen; the antero-median is wide, and reaches about a third of the way along the antero-posterior diameter of the cord; it is lined by the pia mater and, in front, lies the single anterior spinal artery.

The postero-median fissure is much deeper and narrower, and has no reflection of the pia mater into it. Where the posterior nerve roots emerge is a depression which is called the *postero-lateral fissure,* while between this and the postero-median a slight groove is seen in the cervical region, the paramedian fissure (*see* also fig. 2). The anterior nerve roots do not emerge from a definite fissure.

The spinal cord, like the brain, consists of grey and white matter, but, as there is here no representative of the cortical grey matter of the brain, the white matter entirely surrounds the grey. In section the grey matter has the form of an H, the cross bar forming the grey *commissure.* In the middle of this the *central canal* can just be made out by the naked eye (*see* fig. 4). The anterior limbs of the H form the *anterior* or *ventral cornua,* while the posterior, which in the greater part of the cord are longer and thinner, are the *posterior* or *dorsal cornua.* At the tips of the latter is a lighter-coloured cap known as the *substantia gelatinosa Rolandi.* On each side of the H is a slighter projection, the *lateral cornu,* best marked in the thoracic region (*see* fig. 4).

The grey matter has different appearances in different regions of the cord, and in the cervical and lumbar enlargements, where the nerves to the limbs come off, the anterior horns are broadened (*see* fig. 4).

Histologically the grey matter is made up of neuroglia, medullated and non-medullated nerve fibres, and nerve cells (*see* NERVOUS SYSTEM). The nerve cells are arranged in three main columns, ventral, intermedio-lateral and posterior vesicular. The *ventral cell column* has the longest cells, and these are again subdivided into antero-mesial, antero-lateral, postero-lateral and central groups. The *intermedio-lateral cell column* is found in the lateral horn of the thoracic region.

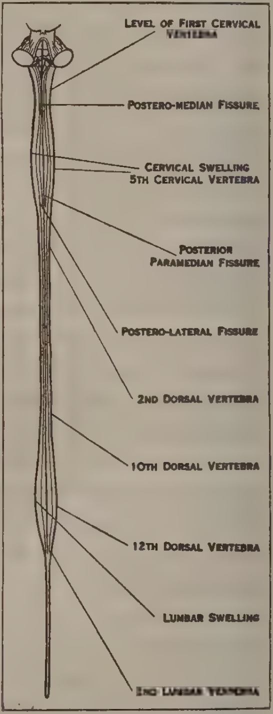


FIG. 2.—DIAGRAM OF DORSAL ASPECT OF SPINAL CORD, SHOWING CERVICAL AND LUMBAR SWELLINGS

The *posterior vesicular* or *Clarke's column* is also largely confined to the thoracic region, and lies in the mesial part of the posterior cornu. It is the place to which the sensory fibres of the sympathetic system (visceral afferents) run. The white matter, as has been shown, surrounds the grey and passes across the middle line to form the *white commissure,* which lies in front of the grey. It is composed of neuroglia and medullated nerve fibres, which are arranged in definite tracts, although in a section of a healthy cord these tracts cannot be distinguished even with the microscope. They have been and are still being gradually mapped out by pathologists, physiologists and embryologists.

A sensory nerve on passing into the cord (fig. 3) through the posterior nerve root lies close to the mesial side of the posterior horn of grey matter, where most of it runs upward. The next root higher up takes the same position and pushes the former one toward the middle line, so that the lower nerve fibres occupy an area close to the postero-median fissure known as the *tract of Goll,* while the higher lie more externally in the *tract of Burdach.* The greater part of each nerve sooner or later enters the grey matter and comes into close relation with the cells of Clarke's column, but some fibres run right up to the nucleus gracilis and cuneatus in the medulla (*see* BRAIN), while a few turn down and form a descending tract, which, in the upper part of the cord, is situated in the inner part of the tract of Burdach and is known as the *comma tract,* but lower down gradually shifts quite close to the postero-median fissure and forms the oval area of Flechsig. It will be obvious that both these tracts could not be seen in the same section, and that fig. 3 is only a diagrammatic outline of their position.

A few fibres of each sensory nerve ascend in a small area known as *Lissauer's tract* on the outer side of the posterior nerve roots, and eventually enter the substantia gelatinosa.

To the outer side of Lissauer's tract and lying close to the lateral surface of the cord is the *direct cerebellar tract,* the fibres of which ascend from the cells of Clarke's column to the cerebellum. As Clarke's column is only well developed in the thoracic region this tract obviously cannot go much lower.

In front of the last and also close to the lateral surface of the cord is another ascending tract, the *tract of Gowers,* or, as it is sometimes called, the lateral sensory fasciculus. It probably begins in the cells of the posterior horn, and runs up to join the fillet and also to reach the cerebellum through the superior cerebellar peduncle. The *crossed pyramidal tract* lies internal to the direct cerebellar tract, between it and the posterior cornu. It is the great motor tract by which the fibres coming from the Rolandic area of the cerebral cortex are brought into touch with the motor cells in the anterior cornu of the opposite side. This tract extends right down to the fourth sacral nerve.

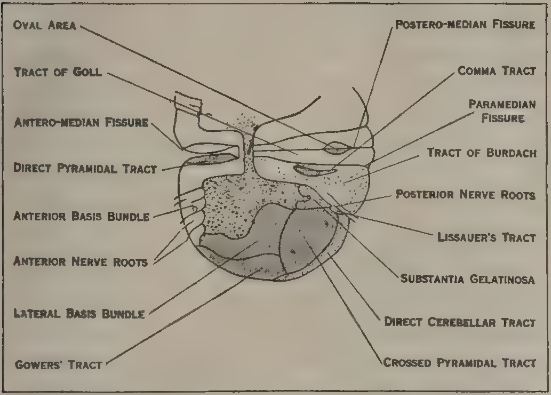

Oval Area
Tract of Goll
Antero-median Fissure
Direct Pyramidal Tract
Anterior Basis Bundle
Anterior Nerve Roots
Lateral Basis Bundle
Gowers' Tract
Postero-median Fissure
Comma Tract
Paramedian Fissure
Tract of Burdach
Posterior Nerve Roots
Lissauer's Tract
Substantia Gelatinosa
Direct Cerebellar Tract
Crossed Pyramidal Tract

FIG. 3.—TRANSVERSE SECTION OF CORD SHOWING TWO MEDIAN FISSURES AND SCHEMATIC ARRANGEMENT OF COLUMNS OF FIBRES IN THE WHITE MATTER OF ONE HALF

In front of the crossed pyramidal tract is the lateral basis bundle, which probably consists of association fibres linking up different segments of the cord.

The *anterior basis bundle* lies in front and on the mesial side of the anterior cornu, and through it pass the anterior nerve roots. Like the lateral bundle it consists chiefly of association fibres, but it is continued up into the medulla as the posterior longitudinal bundle to the optic nuclei.

The *direct pyramidal tract* is a small bundle of the motor fibres from the Rolandic area, which, instead of crossing to the other side at the decussation of the pyramids in the medulla, runs down by the side of the antero-median fissure. Its fibres, however, keep on gradually crossing to the opposite side through the anterior white commissure of the cord, and by the time the mid-thoracic region is reached it has usually disappeared.

The roots of the spinal nerves in the upper part of the canal rise from the cord nearly opposite the points at which they emerge between the vertebrae, but the farther one passes down the higher the origin of each root becomes above its point of emergence. Consequently the lumbar and sacral nerves run a long way down from the lumbar enlargement to their spinal foramina and are enclosed in the dural and arachnoid sheaths to form a mass like a horse's tail, which is therefore known as the *cauda equina*.

Embryology.—The early development of the neural tube from the ectoderm is outlined in the article on the BRAIN. When the neural groove becomes a tube it is oval in section with a very large laterally compressed central canal (*see* fig. 5). The original ectodermal cells elongate and, radiating outward from the canal, are now known as spongioblasts, while the inner ends of some of them bear cilia and so the canal becomes ciliated. A number of round cells, known as germinal cells, now appear close to the central canal, except at the thin mid-dorsal and mid-ventral laminae (roof-plate and floor-plate). From the division of these the primitive nerve cells or neuroblasts are formed and these later on migrate from the region of the canal and shoot out long processes—the axons. The permanent central canal of the cord was formerly said only to represent the ventral end of the large embryonic canal, the dorsal part being converted into a slit by the gradual closing in of its lateral walls, thus forming the postero-median fissure. A. Robinson, however, does not believe that the posterior fissure is any remnant of the central canal (*Studies in Anatomy*, Owens College, 1891). Probably the fissure is formed partly by an infolding and partly from the original central canal. The antero-median fissure is caused by the ventral part of the cord growing on each side, but not in the mid-line where no germinal cells are.

The anterior nerve roots are formed by the axons of the neuroblasts in the developing anterior cornua, but the posterior grow into the cord from the posterior root ganglia (*see* NERVE: *Spinal*), and, as they grow, form the columns of Goll and Burdach.

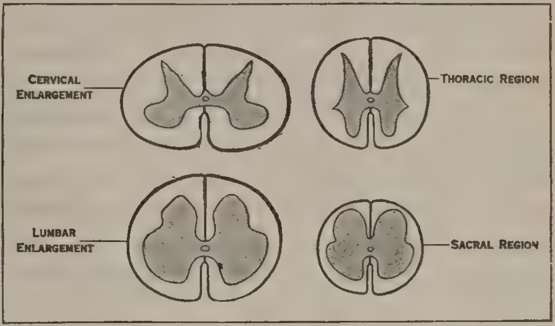
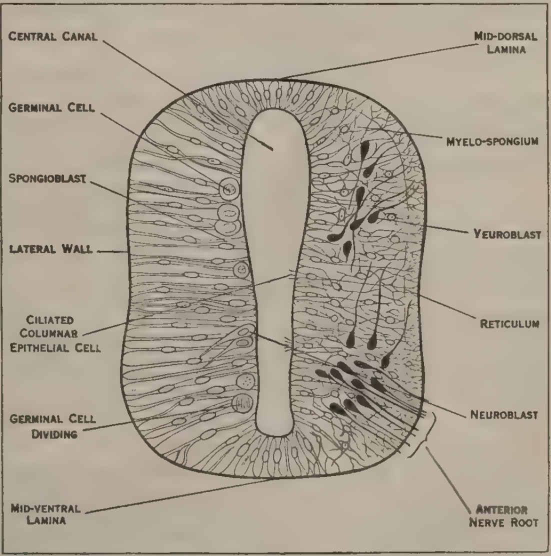

Cervical Enlargement
Thoracic Region
Lumbar Enlargement
Sacral Region

FIG. 4.—SECTIONS OF SPINAL CORD AT DIFFERENT LEVELS (2 X NAT. SIZE)

In the embryo up to the fifth month there is little difference in the appearance of the grey and white matter of the cord, but at that time the fibres in the columns of Burdach acquire their medullary sheaths or white substance of Schwann, the fatty matter of which is probably abstracted from the blood. Very soon after these the basis bundles myelenate and then, in the sixth month, the columns of Goll. Next follow the direct cerebellar tracts and, in the latter half of the eighth month the tracts of Gowers, while the fibres of the pyramidal and Lissauer's tracts do not gain their medullary sheaths until just before or after birth. At first the spinal cord extends as far as the last mesodermal somite, but neuroblasts are only formed as far as the first coccygeal somite, so that behind that the cord is non-nervous and degenerates later into the filum terminale. After the fourth month the nervous portion grows more slowly than the rest of the body


Central Canal
Germinal Cell
Spongioblast
Lateral Wall
Ciliated Columnar Epithelial Cell
Germinal Cell Dividing
Mid-ventral Lamina
Mid-dorsal Lamina
Myelo-spongium
Yeuroblast
Reticulum
Neuroblast
Anterior Nerve Root

FROM CUNNINGHAM, "TEXT BOOK OF ANATOMY" (OXFORD MEDICAL PUBLICATIONS)

FIG. 5.—SCHEMATIC REPRESENTATION OF TRANSVERSE SECTION THROUGH EARLY NEURAL TUBE (YOUNG), SHOWING AN EARLIER STAGE ON THE LEFT SIDE THAN ON THE RIGHT

and so the long cauda equina and filum terminale are produced. At birth the lower limit of the cord is opposite the third lumbar vertebra, but in post-natal development it recedes still farther to the lower level of the first.

For further details *see* standard text books, *e.g.*, Quain's *Anatomy* and J. P. McMurrich, *Development of the Human Body* (1906).

Comparative Anatomy.—In the Amphioxus there is little difference between spinal cord and brain; the former reaches the whole length of the body and is of uniform calibre. It encloses a central canal from which a dorsal fissure extends to the surface of the cord and it is composed of nerve fibres and nerve cells; most of the latter being grouped round the central canal or neurocoele, as they are in the human embryo. Some very large multipolar ganglion cells are present, and there are also large fibres known as *giant fibres,* the function of which is not clear.

When the reptiles are reached the cord shows slight enlargements in the regions of the limbs and these become more marked in birds and mammals.

In the lumbar region of birds the dorsal columns diverge and open up the central canal, converting it into a diamond-shaped space which is only roofed over by the membranes of the cord, and is known as the *sinus rhomboidalis.*

In all these lower vertebrates except the Anura (frogs and toads), the cord fills the whole length of the spinal canal, but in the higher mammals (Primates, Chiroptera and Insectivora) it grows less rapidly, and so the posterior part of the canal contains the cauda equina within its sheath of dura mater. In mammals below the anthropoid apes there are no direct pyramidal tracts in the cord, since the decussation of the pyramids in the medulla is complete. Moreover, the crossed tracts vary very much in their proportional size to the rest of the cord in different animals. In man, for example, they form 11·87% of the total cross area of the cord, in the cat 7·76%, in the rabbit 5·3%, in the guinea-pig 3%, and in the mouse 1·14%. In the frog no pyramidal tract is found. It is obvious, therefore, that in the lower vertebrates the motor fibres of the cord are not so completely gathered into definite tracts as they are in man.

A good deal of interest has lately been taken in a nerve bundle which in the lower vertebrates runs through the centre of the central canal of the cord, and takes its origin in the optic reflex cells in close relation to the posterior commissure of the brain. More posteriorly (caudad) it probably acquires a connection with the motor cells of the cord and is looked upon as a means by which the muscles can be made to respond to the stimulus of light. It is known as *Reissner's fibre,* and its morphology and physiology have been studied most carefully in cyclostomes and fishes. It is said to be present in the mouse, but hitherto no trace of it has been found in man. It was discovered in 1860, but for forty years was looked upon as an artifact.

See P. E. Sargent, "Optic Reflex Apparatus of Vertebrates," *Bull. Mus. Comp. Zool. Harvard,* vol. xlv. No. 3 (July, 1904); also for general details R. Wiedersheim, *Comparative Anatomy of Vertebrates* (London, 1907); Lenhossek, *Bau des Nervensystems* (1895).

(F. G. P.)

PHYSIOLOGY

The spinal cord is but a part of the nervous organ which throughout the length of the body forms the meeting-place of the nerve-paths arriving from and issuing to all regions with which nerve fibres communicate. To gain a true point of view for understanding the working of the spinal cord one must refer to the general function of the nervous system in the bodily economy.

Relation to General Nervous System.—An animal of microscopic size may continue throughout its life to be constituted entirely by one single cell. Animals of larger bulk, although each begins its existence as a single cell, attain their development by the multiplication of the original single cell, so that from it there comes to be formed a coherent mass of cells very many millions in number. In these multicellular animals each of the constituent cells is a minute self-centred organism, individually born, leading its own life and destined for individual death. The corporate power of the complex animal is the sum of the powers of those manifold individual existences, its cells. Of the agencies which integrate the complex animal, one of the most potent is nervous action. A certain number of the unit cells composing the animal are specially differentiated from the rest to bind the whole together by nervous action. These specially differentiated cells are called "neurones." They constitute living threads along which waves of physico-chemical disturbance are transmitted to act as releasing forces for the energy in distant cells.

It is characteristic of this nervous system, the system of neurones, that, although ramifying far and wide through the body, it is a continuum from end to end. The peripheral nerves are formed of bundles of neurones lying side by side, but these, although packed close together, are strictly isolated one from another as conductors and remain isolated throughout the whole length of the nerve. The points of functional nexus of the neurones one with another are confined to one region only of the whole system. All their conductive connections one with another take place solely in the central nervous mass which constitute the so-called central nervous system, a nervous organ extending axially along the length of the body midway between the body's lateral halves. Thither the neurones converge in vast numbers, those of each body segment converging to that fraction of the central organ which belongs to their body segment. The central nervous organ thus receiving these neurones is, where it lies in the head, called the brain, the rest of it is called in vertebrates the "spinal cord," in worms and arthropods the "nerve-cord." The central organ not only receives neurones which converge to it from outside, but many of its own neurones thrust out their conductive arms from it as nerve fibres carrying nervous influence outwards to regulate the activity of glands and muscles. In the vertebrates the ingoing neurones for each segment and similarly the outgoing neurone fibres are collected into a segmental nerve. To the spinal cord these are each attached by two roots, one dorsal, consisting of the afferent fibres, the other ventral, consisting of the efferent fibres.

The Reflex.—The simplest complete reaction of the system is a reflex. There are many reflexes which are extremely complex, being built up of a number of simpler reflexes combined. A reflex is a reaction started by the environment acting as a stimulus upon some nerve which communicates the excitement to other nerves by connections with them in the central nervous organ. The excitement so generated and transmitted finally travels outward from the central organ by one or more of the efferent nerves and through these reaches muscles or glands producing in them its final effect. The muscles and glands are from this point of view termed effector organs. The reaction is therefore "reflected" from the central organ. The nerve structures which include its trajectory are spoken of as a nervous arc. The whole purpose of the central nervous organ is to bring afferent neurones into touch with efferent neurones. The whole purpose of reflex arcs is to bind one part of the organism to another part in such a way that what the environment is doing to the organism at one place may appropriately call forth or restrain movement or secretion in the muscles or glands wherever situated in the organism.

Receptor Cells.—There is one condition for the due performance of these reactions which is not provided by the nervous system itself. The afferent neurones are not in most cases so constituted as to be excitable themselves directly by the environment—for instance, they cannot be stimulated by light. Their amenability to the environment, their sensitization to environmental agencies, is effected by special cells adjunct to their peripheral ends. These cells form organs called *receptors.* They are delicately adapted to be stimulated by this or that particular agent and are classifiable into various species, so that each species is easily excited by a particular agent which is "adequate" for it, and is inexcitable or excitable only with difficulty by agencies of other kinds. Thus in the skin some receptors are adapted for mechanical stimuli (touch) and not for thermal stimuli, while others (cold spots, warm spots) are adapted for thermal stimuli and not for mechanical. As far as it is known each afferent neurone is connected with receptors of one species only. The receptors thus confer upon the reflex arcs selective excitability.

Each arc is thus tuned to respond to certain stimuli, while other arcs not having that kind of receptor do not respond. The receptors, therefore, while increasing the responsiveness of the organism to the environment, prevent confusion of reactions (incoordination) by limiting to particular stimuli a particular reaction.

Proprioceptors.—The system of neurones is thus made accessible to the play of the external world acting on the body. And in addition to those receptors which are stimulated directly by the external world, are others lying within the mass of the organism itself, which are excitable by actions occurring in the organism itself. These are called *proprioceptors*. They are distributed preponderantly in the muscles and structures functionally adjunct to muscle, such as joints, ligaments, fasciae, etc. The reactions both passive and active induced in such motor structures, reflexly by environmental stimuli, tend therefore secondarily to be followed and accompanied by reflex reactions initiated from proprioceptors.

Conduction.—The process by which the excitement generated in the afferent neurone travels along the reflex arc is known as *conduction*. Conduction along afferent and efferent nerves differs in some important respects from that obtaining in the nerve centre, *i.e.*, in the piece of the central nervous system connecting the afferent nerve with the efferent nerve. In a nerve-trunk the excited state set up in it by a stimulus travels along its fibres as wave-like disturbance at a speed of about 100 metres per second, and does not alter in intensity or speed in its travel. A nerve-trunk when excited at some point along its length transmits the "impulse," *i.e.*, the wave-like excited state in both directions, *i.e.*, both up and down each fibre, from the point stimulated. This is true whether the fibre is afferent or efferent. The speed of travel of the nervous impulse along the nerve-trunk is the same whether the nervous impulse is weak or intense. The nerve-trunk shows practically no delay in its response to an effective, even though weak, stimulus and its response ceases practically at once on cessation of the exciting stimulus. When excited by repeated brief stimuli the rhythm of the response corresponds closely with that of the stimuli, even when the frequency of the latter is as high as 500 per second. With momentary stimuli a response even so brief as 20 can be given by the nerve-trunk. Finally, nerve-trunk conduction is singularly resistant to fatigue, to impoverished blood supply, and to many drugs which powerfully affect reflex actions.

Through the central nervous organ the travel of the impulse exhibits departure from these features. Its intensity is liable to be altered in transit. Its time of transit is much longer than for a similar length of nerve-trunk. Its direction of transmission becomes polarized, that is, confined to one direction along the nervous path. To a strong stimulus the central reaction instead of being as brief as an impulse, may endure for a whole second or more. A stimulus not capable of evoking a response from a centre when applied once may by simple repetition become effective (*temporal summation*). It is in the *grey matter* that conduction differs in these respects from conduction in nerve-trunks. In the grey matter each afferent fibre breaks up into branching threadlets which ramify in various directions and terminate in close apposition with other neurones. The point of nexus of one neurone with another is termed the *synapse*. If synapsis occurs by contiguity and not homogeneous continuity, it is fair to suppose that at it the transmission of nervous impulses must be different from that observable in the homogeneous conducting threads of nerve fibres. The conduction must traverse something of the nature of a membrane.

Reflex Reactions.—When the spinal cord is severed at any point the reflex arcs of the portion of the body behind the transection are quite cut off from the rest of the nervous system in front, including the brain. The reflex reactions elicited from the thus isolated region cannot therefore be modified by the action of the higher nervous centres. In the head the local centres are overlaid by higher centres which cannot by any simple severance be separated from them. By studying, therefore, the powers of the cord behind a complete spinal transection we can obtain information as to the powers of the purely local or segmental reflex mechanisms.

The so-called "flexion-reflex" of the limb is one of the most accessible of the local reflex reactions which can thus be studied with an isolated portion of the spinal cord as its centre.

Let it be supposed that the limb observed is the hind limb. The three main joints of the limb are the hip, the knee and the ankle. Each of these joints is provided with muscles which flex or bend it, and others which extend or straighten it. It is found that the reflex throws into contraction the flexor muscles of each of these joints. It matters little which of all the various afferent nerves of the limb is stimulated, whichever of these the afferent nerve may be, the centrifugal discharge goes to practically the same muscles, namely, always to the flexors of the joints.

Not only does the reflex action not discharge motor impulses into the nerves of the extensor muscles, but if the spinal cord happens to be discharging impulses into these nerves when the reflex is evoked this discharge is suppressed or diminished (*inhibited*). In this way the latter muscles are prevented from impeding the action of the contracting flexors. This inhibition prevents other reflexes from upsetting for the time being the due action of the flexion-reflex, for it renders the muscles opposing that reflex less accessible to motor discharge through the spinal cord whatever the quarter whence incitation to that discharge may come.

A feature of this reflex is its graded intensity. A weak stimulus evokes in the flexor muscles a contraction which is weak and in the extensor muscles a relaxation which is slight. In the case of the muscle-fibre any strength of stimulus if sufficient to excite it at all excites the fibre totally and evokes its full contraction (Keith-Lucas) and this latter remains the same in amount so long as the mechanical and nutritive conditions of the fibre remain constant. Each muscle-fibre reacting on this "all-or-none" principle and each nerve-fibre similarly responding on that same principle (Kato), different amounts of contraction yielded by the muscle under different strengths of stimulation of its nerve signify differences simply in the number of muscle-fibres which the stimulus excites. In other words the weaker stimuli excite fewer of the nerve-fibres innervating the muscle. When the tension developed by the muscle, *e.g.*, against a stiff spring, reaches the maximal obtainable from it, that fact tells us that all the muscle-fibres are then in contraction; when the tension development is less than maximal some of the muscle-fibres are not in action. A stimulus to the nerve which evokes maximal tension from the muscle is one which succeeds in exciting all the nerve-fibres innervating the muscle, and any stimulus which evokes less than maximal tension is leaving some of the nerve-fibres "idle."

The tension developed by a muscle under reflex excitation falls short of its maximal tension, even when the afferent nerve is stimulated maximally. The reflex activates a proportion only of the total aggregate of the muscle's fibres, and therefore a proportion only of the spinal motor neurones innervating the muscle. But within the range of the limit imposed by the maximal number of muscle-fibres which it *can* activate, the grading of the number activated in accordance with the grading of the strength of stimulation of the afferent nerve is very delicate, much more so than in the case of the motor nerve itself. The actual fractional proportion of the muscle's total aggregate of motor units which an afferent nerve, maximally stimulated, can activate, differs from one afferent nerve to another, and for the same afferent nerve in different experiments. A subconvulsive dose of strychnine raises the size of the fraction. The threshold value of stimulus for the reflex is usually higher than for the contraction of the muscle from the motor nerve. Spinal reflex action no more regards "muscles" than does a motor centre of the cerebral cortex. Both ignore muscles as entities and have in view movements purely. A weak flexion-reflex activates a few fibres of each of the several flexor muscles of the limb. The reflex treats a complex composed from some (*i.e.*, those of similar threshold for the particular afferent nerve) motor-units of hip-flexor, of knee-flexor and of ankle-flexor as functionally more homogeneous than is the total group of fibres composing any one of these muscles alone.

Reflex inhibition has its seat in the grey matter of the spinal centre. It acts at some point in the reflex arc up-stream from the all-or-none motor unit (motor nerve-fibre with its group of muscle-fibres). The inhibitory reflex is like the excitatory capable of very delicate grading; its effect in diminishing or precluding this or that amount of an excitatory reflex is effected entirely by regulating the number of the motor units thrown out of action or kept out of action. Intensity of contraction or of relaxation is thus in both cases a question simply of number of motor-units reacting. The reflex centre continues discharging impulses for a certain time after its exciting stimulus has ceased. This after-discharge succeeding a strong stimulus may persist even for several seconds.

Refractory Phase.—Besides characters common to all or many spinal reflexes certain spinal reflexes have features peculiar to themselves or exhibited by them in degrees not obvious in other reflexes. One of these features is refractory phase. The scratch-reflex exemplifies this. In the dog, cat and many other animals the hind limb often performs a rapid scratching movement, the foot being applied to the skin of the shoulder or neck as if to groom the hairy coat in that region. This movement is in the intact animal under control of the brain, and can be executed or desisted from at will. When certain of the higher centres in the brain have been destroyed, this scratching action occurs very readily and in an uncontrolled way. When the spinal cord has been severed in the neck this scratching movement of the hind limb can be elicited with regularity as a spinal reflex by merely rubbing the skin of the side of the neck or shoulder, or applying there a weak electric current to the skin. In this reflex the stimulus excites afferent nerves connected with the hairs in the skin and these convey impulses to the spinal centres in the neck or shoulder segments, and these in turn discharge impulses into nerve fibres entirely intraspinal passing backward along the cord to reach motor centres in the hind limb region. These motor centres in turn discharge centrifugal impulses into the muscles of the hind limb of the same side of the body as the shoulder which is the seat of irritation. The motor discharge is peculiar in that it causes the muscles of the hind limb to contract rhythmically at a rate of about four contractions per second, and the discharge is peculiar further in that it excites the flexor and extensor muscles of the joints alternately so that at the hip for instance the limb is alternately flexed and extended, each single phase of the movement lasting about an eighth of a second. Now this rhythmic discharge remains the same in rate whether the exciting stimulus applied to the skin be continuous or one of many various rates of repetition. Evidently at some point in the reflex arc there is a mechanism which after reacting to the impulses reaching it remains for a certain brief part of a second unresponsive, and then becomes once more for a brief period responsive, and so on. And this phasic alternation of excitability and inexcitability repeats itself throughout the continuance of the reflex. The phase of inexcitability is termed the *refractory* phase. Its seat lies in the spinal centre. A similar element almost certainly forms part of the co-ordinating mechanism for many other cyclic reflexes, including those of the stepping of the limbs, the movement of the jaw in mastication, the action of the eyelids in blinking, and perhaps the respiratory movements of the chest and larynx.

Fatigue.—Nerve trunks do not easily tire out under stimulation even most prolonged. Reflex actions on the other hand relatively soon tire. Some are more resistant, however, than are others. The flexion-reflex may be continued for ten minutes at a time. As a reflex tires, the muscular contraction which it causes tends to become less intense and less steady. The relatively rapid onset of fatigue in reflexes is counterbalanced by speedy recovery in repose. A long flexion-reflex, when from fatigue it has become weak, tremulous and irregular, will recommence after 30 seconds' repose with almost the same vigour and steadiness as if it had not recently been tired out.

The natural movements to which the artificially provoked reflexes seem to correspond do not demand prolonged motor activity, or when they do, demand it in rhythmic repetition with intervening pauses which allow repose.

Reflex Postures.—But there are certain reflexes which do persist for long periods at a time. These are reflex postures. The hind limbs of the "spinal" frog assume an attitude which is reflex, for it ceases on severance of the afferent spinal roots. This attitude is one of flexion at hip, knee and ankle, resembling the well-known natural posture of the frog as it squats when quiet in the tank. Similarly in the "decerebrate" dog or cat certain muscles, *e.g.*, the limb extensors, exhibit a persistent contraction. These tonic reflexes are related to attitudes. In the dog and cat they are exhibited by those muscles whose action antagonizes gravity in postures which are usual in the animal, thus the extensors of the knee and hip and shoulder and elbow are in tonic contraction during standing. The postural contraction is accompanied by electrical "action currents" like those of other contraction, though weak and indicative of self-smothering from the rhythms being asynchronous in the contributory fibre-groups. The postural contraction of the extensor muscles in the maintenance of the erect posture is traceable to a reflex, called the *stretch-reflex*. A stretch, *e.g.*, by a pull upon the tendon, lengthening the muscle by even so little as ½%, excites reflex contraction of some of its fibres. The passive stretch is a mechanical stimulus to some of the proprioceptive organs (perhaps the muscle-spindles) in the muscle. The reflex is therefore unobtainable when the afferent nerve-fibres of the muscle itself have been severed. The essential centre for the stretch-reflex is spinal, but mid-brain and cerebellar centres much reinforce it. In the erect posture the head, neck, tail and jaw would droop and the limbs fold up under their own weight and that of superincumbent parts, were not the "antigravity" muscles checked from yielding by the stretch-reflex which their own passive yield induces in themselves. Hence the reflexly maintained "standing" is a multiple stretch-reflex. Considerable latitude of actual pose is allowed to the individual parts because each muscle involved acts for itself and develops and regulates its own stretch-reflex.

Characteristic of reflex postural contraction is its continuance for long spells at a time without obvious fatigue. Attempts are uniformly unsuccessful to reproduce this feature by electrical stimulation of afferent nerves or of the muscle's motor nerve. The suggestion has therefore been made that the postural contraction of muscle is due to a different process in the muscle-fibre from that of the ordinary contraction executing movements and so easily and often studied under electrical stimulation in the laboratory. Forbes, however, has offered the satisfactory explanation that the postural contraction while the same process as that of ordinary reflex and other contraction involves usually relatively few motor units at a time and these as they fatigue, are replaced by others. The stretch which is the essential stimulus is automatically shifted to fresh motor-units so soon as those already in operation begin to yield and give out. Grafted, as it were, upon the reflex maintenance of the erect-posture are reflexes of locomotion which are also certainly spinal in essence, and essentially proprioceptive. The hind-limbs of the dog, after severance of the cord in the thoracic region, begin to step when released from the ground. Their stepping will go on sometimes quicker and sometimes slower for long periods at a time. Kinematograph analysis of this spinal stepping shows that it is identical with normal stepping except for a slight flexional yield when the limb is vertically on the ground in the normal step. Passively supported mid-flexion of knee and hip even of one hind limb alone at once causes the spinal reflex stepping to cease, in both limbs usually. The proprioceptive stimulus of the spinal stepping may therefore be the passive stretching of the hip and knee-flexor. From observations on stepping under narcosis Graham Brown regards the essential factor in "spinal" stepping to be the intrinsic activity of a "spinal stepping" centre or "centres." Certainly it is not uncommon for an extensor muscle of the limb in isolated attachment to the myograph and after its own afferent nerve fibres have been wholly destroyed and after all the other muscles of the limb have been put out of play by excision of nerve-section to start stepping on its own accord in the bulbospinal preparation. Skin stimuli, for instance, the contact of the sole with the ground, are not necessary for the reflex stepping. On the other hand the ground pressure against the toe pads and plantar cushion seems an important factor in the gallop—indeed the sudden brief though strong and almost simultaneous extension of all four limbs in the gallop can in the spinal animal be evoked by pressure simulating the ground pressure, and when applied even to one hind foot only.

The eyeballs are eminently organs which, the gaze being a posture, employ active postures throughout the waking day. The proprioception of the neck-muscles excites from the cervical spinal cord reflex influences acting on the nerves of the eyeball muscles. An instance is: turning of the neck toward one side excites turning of the eyeballs toward the opposite side. Or again, a clockwise partial rotation of the neck round its long axis excites from the neck proprioceptor a compensatory anti-clockwise rotation of the eyeballs. These reflex postures of the eyeballs are sometimes called compensatory, because they tend to keep truly vertical the vertical of the retina despite displacements of the head by the movements of the neck.

It may be mentioned here that the spinal and the bulbospinal animal (cat) although its composite stretch-reflex enables it when placed in the erect posture to maintain that attitude, even for hours at a time, is yet not capable of assuming that posture when laid, for instance, on its side. But when the mid-brain is retained in addition to hind-brain and cord the animal has that power of righting itself. These righting reflexes are likewise postural and largely evoked by the otolith organs. Although not truly spinal reflexes their field of nervous operation overruns into the spinal cord.

The Spinal Reflex Arcs of the Hind Limb.—When the skin of the limb is stimulated the flexion-reflex already described is evoked. The reflex is excited by nocuous stimuli such as a prick or squeeze applied to the skin anywhere in the limb, but most easily when applied to the foot. The reflex flexion of the ipsilateral hind limb is commonly accompanied by reflex extension of the opposite hind limb.

In the dog and cat extension of the ipsilateral hind limb can, however, be excited by stimulation of the skin in three limited regions. One of these is the sole of the foot; smooth pressure between the pads excites a strong brief extension. This is called the extensor thrust. It is accompanied by a similar sudden brief extension of all three other limbs. This reflex may be related to the action of galloping, and the pressure which excites resembles that which the weight of the body bears on the pads against the ground.

The two other regions are the skin of the front of the groin supplied by the crural branch of the genito-crural nerve, and the skin just below and mesial to the buttock. These always excite the extensor muscles, not the flexors. They may be concerned with sexual acts.

Reflexes of the Fore Limb.—The ipsilateral reflex is flexion at shoulder, elbow and wrist. The contralateral fore limb at the same time is extended at shoulder, elbow and wrist.

The Scratch Reflex.—The area from which it can be excited extends from the ear to the loin. Each of these reflexes is a coordinate reaction. It is seen, therefore, that through the medium of the spinal cord the body behind the head has at command a certain number of reflexes and that each of these manages the skeletal musculature in a co-ordinate way. The muscles worked by these several reflexes are to a large extent common to them all. Some resemble one another in regard to their action upon a particular muscle. Some act in opposite ways upon a particular muscle. In order to follow the co-ordination effected by the spinal cord we have to turn to a certain feature in the scheme of construction of the nervous system. This feature embodies what is termed the *principle of the common path.*

Interaction Between Reflexes.—At the commencement of every reflex-arc is a receptive neurone extending from the receptive surface to the central nervous organ. This neurone forms the sole avenue which impulses generated at its receptive point can use whithersoever be their destination. This neurone is therefore a path exclusive to the impulses generated at its own receptive point, and other receptive points than its own cannot employ it. A single receptive point may play reflexly upon quite a number of different effector organs. It may be connected through its reflex path with many muscles and glands in many different regions. Yet all its reflex arcs spring from the one single shank or stem, *i.e.,* from the one afferent neurone which conducts from the receptive point at the periphery into the central nervous organ.

But at the termination of every reflex arc we find a final neurone, the ultimate conductive link to an effector organ (muscle or gland). This last link in the chain, *e.g.,* the motor neurone, differs obviously in one important respect from the first link of the chain. It does not subserve exclusively impulses generated at one single receptive source, but receives impulses from many receptive sources situate in many and various regions of the body. It is the *sole* path which all impulses, no matter whence they come, must travel if they are to act on the muscle fibres to which it leads.

Therefore, while the receptive neurone forms a private path exclusively serving impulses of one source only, the final or efferent neurone is, so to say, a public path *common* to impulses arising at any of many sources of reception. A receptive field, *e.g.,* an area of skin, is analysable into receptive points. One and the same effector organ stands in reflex connection not only with many individual points, but even with many various receptive *fields.* Reflexes generated in manifold sense-organs can pour their influence into one and the same muscle. Thus a limb muscle is the *terminus ad quem* of many reflex arcs arising in many various parts of the body. Its motor nerve is a path common to all the reflex arcs which reach that muscle.

Reflex arcs show, therefore, the general features that the initial neurone of each is a *private* path exclusively belonging to a single receptive point (or small group of points); and that finally the arcs embouch into a path leading to an effector organ; and that their final path is common to all receptive points wheresoever they may lie in the body, so long as they have connection with the effector organ in question. Before finally converging upon the motor neurone the arcs converge to some degree. Their private paths embouch upon *internuncial* paths common in various degrees to groups of private paths. The terminal path may, to distinguish it from internuncial common paths, be called *the final common path.* The motor nerve to a muscle is a collection of final common paths.

Certain consequences result from this arrangement. One of these is the preclusion of essential qualitative difference between nerve-impulses arising in different afferent nerves. If two conductors have a tract in common there can hardly be essential qualitative difference between their modes of conduction.

A second consequence is that each receptor being dependent for final communication with its effector organ upon a path not exclusively its own but common to it with certain other receptors, such nexus necessitates successive and not simultaneous use of the common path by various receptors using it to *different or opposed* effect.

In the simultaneous correlation of reflexes some reflexes combine harmoniously, being reactions that mutually reinforce. These may be termed *allied reflexes,* and the neutral arcs which they employ *allied arcs.* On the other hand, some reflexes, as mentioned above, are *antagonistic* one to another and incompatible. These do not mutually reinforce, but stand to each other in inhibitory relation. One of them inhibits the other.

Allied Reflexes.—What happens when trains of impulses, travelling by convergent afferent arcs, meet at the same "common path?" With convergent reflexes which are "allied" in the above sense, this case must be one of extremely frequent occurrence and the management of the interaction between the convergent streams of impulses must be a fundamental factor in nervous co-ordination. The afferent path A embouches upon the intraspinal motor neurones of the knee-flexor and can activate 75% of them. The afferent path B embouches also upon the motor neurones of the same muscle and can activate 75% of them. When the muscle is reflexly contracting to A with a tension 75% of that of the muscle's maximal contraction, stimulation of B is added. The contraction tension in result rises to 85% of the maximal. The inference is that for 65% of the total motor units of the muscle the excitation from A acts upon the same motor units as would that from B. In other words 65% of the total aggregate of the motor units of the muscle are common to A and to B. The stream of impulses arriving at these common motor-units from B when A's stream is already activating them leaves their activity unchanged, failing either to increase or to diminish it. A's stream, which is engaging them, precludes B's stream from engaging them. This is termed *occlusion.* We may turn from the case of the group to that of the single individual unit. Suppose a to be a train of impulses reaching a central terminal of path A and impinging upon a motor-unit μ and activating it. Suppose β similarly a train impinging by one of path B's terminals upon the same motor unit μ already activated by a. It has been argued that the resultant response of μ to the double series of impulses impinging on it will show interference and interruption and unsteadiness from "inhibition," the impulses generated by the one train interfering with those generated by the other owing to the refractory phase following in the wake of each impulse. Experiment fails to substantiate such unsteadiness or other evidence of "interference inhibition" even when the impulse trains are each of them at 180 p. sec. Experiment in fact finds the reverse; the resultant contraction being steadier and more durable under the concurrent excitation of A and B than under either alone. An important kind of observation is the following, since it shows clearly that, against the interference view above, "occlusion" is not inhibition. An afferent A activates 50% of a given muscle's motor units. An afferent B activates a still larger percentage of the muscle's motor units. When afferent B is already activating the muscle the stimulation of A causes no outward result on the muscle, but if B's stimulus be then withdrawn A's continuing, the contraction at once falls to and remains at 50% of maximal. A's activation was occluded by B's already existent one, but there was no inhibition. A's activation was occluded throughout the large field amounting to 50% of the total aggregate of the motor units. Yet that not a single motor unit was inhibited, has been experimentally established by taking for B one of the relatively rare afferents which activate 100% of the muscle. Since B is then activating every motor unit it cannot be supposed that lack of A's effect when A is concurrently stimulated is due to inhibition of A's 50% of the motor units; for that would suppose those motor units to be at one and the same time both active and inhibited. The mutual support that the two trains yield each other in the actually observed result argues the immediate replacement of B's effect by A's when B's lapses or intermits; and *vice versa.* That this would be so is borne out by other observations. Where, during the concurrence of A and B, A's effect has been occluding B from activating, on abruptly ceasing to stimulate A, so that B remains under stimulation alone, B which has till then been ineffective owing to occlusion, at once appears as effective and without hesitation or pause replaces that of A step for step as A's after-discharge subsides. The final common path under this competition of allied arcs is comparable with a telephone line already "busy" for one subscriber and for that time "engaged" and non-available to other subscribers. The action of the principle of the final common path may be instanced in regard to "allied arcs" in the scratch-reflex as follows. If, while the scratch-reflex is being elicited from a skin point at the shoulder, a second point distant 10mm. from the other point but also in the receptive field of skin, be stimulated, the stimulation at this second point favours the reaction from the first point. This is well seen when the stimulus at each point is of subminimal intensity. The two stimuli, though each unable separately to invoke the reflex, yet do so when applied both at the same time. The "receptive field" of a reflex is really the common area of commencement of a number of allied arcs.

Antagonistic Reflexes.—But not all reflexes connected to one and the same common final path stand to one another in the relation of "allied reflexes." Suppose during the scratch-reflex a stimulus be applied to the foot not of the scratching side, but of the opposite side. The left leg, which is executing the scratch-reflex in response to stimulation of the *left* shoulder skin is cut short in its movement by the stimulation of the *right* foot, although the stimulus at the shoulder to provoke the scratch movement is maintained unaltered all the time. The stimulus to the right foot will temporarily interrupt a scratch-reflex, or will cut it short or will delay its onset; which it does of these depends on the time-relations of the stimuli. The inhibition of the scratch-reflex occurs sometimes when the contraction of the muscles innervated by the reflex conflicting with it is very slight. There is interference between the two reflexes and the one is inhibited by the other.

The reflex from the right foot evokes at the opposite (left) knee extension; in doing this it causes steady excitation of extensor neurones of that knee and steadily inhibits the flexor neurones. But the scratch-reflex causes rhythmic excitation of the flexor neurones. Therefore these flexor neurones in this conflict lie as a final common path under the influence of two antagonistic reflexes, one of which would excite them to rhythmical discharge four times a second, while the other would continually repress all discharge in them.

In all these forms of interference there is a competition, as it were, between the excitatory stimulus used for the one reflex and the excitatory stimulus for the other. Both stimuli are in progress together, and the one in taking effect precludes the other's taking effect as far as the final common path is concerned.

Again, if, while stimulation of the skin of the shoulder is evoking the scratch-reflex, the skin of the hind foot of the *same* side is stimulated, the scratching may be arrested. Stimulation of the skin of the hind foot by any of various stimuli that have the character of threatening the part with damage causes the leg to be flexed, drawing the foot up by steady maintained contraction of the flexors of the ankle, knee and hip. Here, therefore, there is an arc which embouches into a final path, common to it and to the scratch-reflex arc; both these arcs employ the same effector organ, namely, the knee-flexor, and employ it by the common medium of the final path FC. But though the channels for both reflexes embouch upon the same final common path, the excitatory flexor effect specific to each differs strikingly in the two cases. In the scratch-reflex the flexor effect is an intermittent effect; in the noci-ceptive flexion-reflex the flexor effect is steady and maintained. The scratch-reflex is set aside by that of the noci-ceptive arc from the homonymous foot.

The stimulation which previously sufficed to provoke the scratch-reflex is no longer effective, though it is continued all the time. But when the stimulation of the foot is discontinued the scratch-reflex returns. In that respect, although there is no enforced inactivity, there is an *interference* which is tantamount to, if not the same thing as, inhibition. Though there is no cessation of activity in the motor neurone one form of activity that was being impressed upon it is cut short and another takes its place. A stimulation of the foot too weak to cause more than a minimal reflex will often completely suffice to interrupt, or cut short, or prevent onset of, the scratch-reflex.

The kernel of the interference between the homonymous flexion-reflex and the scratch-reflex is that both employ the same final common path FC to different effect—just as in the interference between the crossed extension-reflex and the scratch-reflex. Evidently, the homonymous flexion-reflex and the crossed extension-reflex both use the same final common path FC. And they *use it to different effect.* The motor neurone to the flexor of the knee being taken as a representative of the final common path, the homonymous flexion-reflex inhibits it from discharging. Hence if, while the direct flexion-reflex is in progress, the crossed foot is stimulated, the reflex of the knee-flexor is inhibited. The crossed extension reflex therefore inhibits not only the scratch-reflex, but also the homonymous flexion-reflex.

Further, in all these interferences between reflexes the direction taken by the inhibition is reversible. Thus, the scratch-reflex is not only liable to be inhibited by, but is itself able to inhibit either the homonymous flexion-reflex or the crossed extension-reflex; the homonymous flexion-reflex is not only capable of being inhibited by the crossed extension-reflex, but conversely in its turn can inhibit the crossed extension-reflex. These interferences are therefore reversible in direction. Certain conditions determine which reflex among two or more competing ones shall obtain mastery over the final common path and thus obtain expression.

As to the intimate nature of the mechanism which thus, by summation or by interference, gives co-ordination where neurones converge upon a common path, it is difficult to surmise. In the central nervous system of vertebrates, afferent neurones A and B in their convergence toward and impingement upon another neurone Z, towards which they conduct, do not make any lateral connection directly one with the other—at least, there seems no clear evidence that they do. It seems, then, that the only structural link between A and B is neurone Z itself. Z itself should therefore be the field of coalition of A and B if they transmit "allied" reflexes.

Factors Determining the Sequence.—The formation of a common path from tributary converging afferent arcs is important because it gives a co-ordinate mechanism. There the dominant action of one afferent arc, or set of allied arcs in condominium, is subject to supersession by another afferent arc, or set of allied arcs, and the supersession normally occurs without intercurrent confusion.

Whatever be the nature of the physiological process occurring between the competing reflexes for dominance over the common path, the issue of their competition, namely, the determination of which one of the competing arcs shall for the time being reign over the common path, is largely conditioned by four factors. These are spinal induction, relative fatigue, relative intensity of stimulus, and the functional species of the reflex.

1. Induction occurs in two forms, one of which has been named *immediate induction.* The stimulus which excites a reflex tends by central spread to facilitate and lower the threshold for reflexes allied to that which it particularly excites. A constellation of reflexes thus tends to be formed which reinforce each other, so that a reflex figure results. If the prepotent stimulus shifts, allied arcs are by the induction particularly prepared to be responsive to it or to a similar stimulus.

Immediate induction only occurs between allied reflexes. Its tendency in the competition between afferent arcs is to fortify the reflex just established, or, if transition occur, to favour transition to an allied reflex. Immediate induction seems to obtain with highest intensity at the outset of a reflex, or at least near its commencement.

The other form of spinal induction is *successive induction.* It is in several ways the reverse of the preceding. If the crossed-extension reflex of the limb of the "spinal" dog be elicited at regular intervals, say once a minute, by a carefully adjusted electrical stimulus of defined duration and intensity, the resulting reflex movements are repeated each time with much constancy of character, amplitude and duration. If in one of the intervals a strong prolonged (*e.g.*, 30″) flexion-reflex is reduced from the limb yielding the extensor-reflex movement, the latter reflex is found intensified after the intercurrent flexion-reflex. The intercalated flexion-reflex lowers the threshold for the aftercoming extension-reflexes, and especially increases their after-discharge. This effect may endure, progressively diminishing, through four or five minutes, as tested by the extensor reflexes at successive intervals. Now, as we have seen, *during* the flexion-reflex the extensor arcs were inhibited: *after* the flexion-reflex these arcs are in this case evidently in a phase of exalted excitability. The phenomenon presents obvious analogy to visual contrast. The exaltation after-effect may ensue with such intensity that simple discontinuance of the stimulus maintaining one reflex is immediately followed by "spontaneous" appearance of the antagonistic reflex.

The so-called "mark-time" reflex of the "spinal" dog is an alternating stepping movement of the hind limbs which occurs on holding the animal up so that its limbs hang pendent. It can be inhibited by stimulating the skin of the tail. On cessation of that stimulus the stepping movement sets in more vigorously and at quicker rate than before. This after-increase might be explicable in either of two ways. It might be due to the mere repose of the reflex centre, the repose so recruiting the centre as to strengthen its subsequent action. But a similar period of repose obtained by simply supporting one limb—which causes cessation of the reflex in both limbs, the stimulus being stretch of the hip-flexors under gravity—is not followed by after-increase of the reflex, or the after-increase might result from the inhibition being followed by a rebound to superactivity. This latter seems to be the case. The after-increase occurs even when both hind limbs are passively lifted from below during the whole duration of the inhibitory stimulus applied to the tail. And the reflex inhibition of the knee-extensor by stimulation of the central end of its own nerve is followed by marked rebound to superactivity of the extensor itself. Again, the knee jerk, after being inhibited by stimulation of the hamstring nerve, is more brisk than before the inhibition.

By virtue of this spinal contrast, therefore, the extension-reflex predisposes to and may actually induce a flexion-reflex, and conversely the flexion-reflex predisposes to and may actually induce an extension-reflex. This process is qualified to play a part in linking reflexes together in alternating sequence.

Much of the reflex action of the limb that can be studied in the "spinal" dog bears the character of locomotion. This has been shown recently with particular clearness by the observations of Phillipson. In the stepping of the limb the flexion that raises the foot and carries it clear of the ground prepares the antagonistic arcs of extension, and, so to say, sensitizes them to respond later in their turn by the supporting and propulsive extension of the limb necessary for progression. The reflex "stepping" of the "spinal" dog proceeds without an *external* skin stimulus: it will continue when the dog is held in the air. The cat walks well when all four feet are anaesthetized.

A reflex movement must generate in its progress a number of further stimuli and throw up a shower of centripetal impulses from the moving muscles and joints into the spinal cord. Squeezing of muscles and stimulation of their afferent nerves and those of joints, etc., elicit reflexes. The primary reflex movement might be expected, therefore, of itself to initiate further reflex movement, and that secondarily to initiate further still, and so on. Yet on cessation of the external stimulus to the foot in the flexion-reflex the whole reflex comes usually at once to an end. The scratch-reflex, even when violently provoked, ceases usually within two seconds of the discontinuance of the external stimulus that provoked it. We have as yet no satisfactory explanation of this.

2. Another condition influencing the issue of competition between reflexes of different sources for possession of one and the same final common path is fatigue. A spinal reflex under continuous excitation or frequent repetition becomes weaker, and may cease altogether. This decline is progressive, and takes place earlier in some kinds of reflexes than it does in others. In the "spinal" dog the scratch-reflex under ordinary circumstances tires much more rapidly than does the flexion-reflex.

A reflex as it tires shows other changes besides decline in amplitude of contraction. Thus in the flexion-reflex, the original steadiness of the contraction decreases; it becomes tremulous, and the tremor becomes progressively more marked and more irregular. Finally, an irregular phasic tremor of the muscles is all that remains. It is not the flexor muscles themselves which tire out, for these, when under fatigue of the flexion-reflex contract no longer for that reflex, contract in response to the scratch-reflex which also employs them.

Similar results are furnished by the scratch-reflex, with certain differences in accord with the peculiar character of its individual charge. One of these latter is the feature that the individual beats of the scratch-reflex usually become slower and follow each other at slower frequency. Also the beats, instead of remaining fairly regular in amplitude and frequency, tend to succeed in somewhat regular groups. The beats may disappear altogether for a short time, and then for a short time reappear.

When the scratch-reflex elicited from a spot of skin is fatigued, the fatigue holds for that spot, but does not implicate the reflex as obtained from the surrounding skin. The reflex is, when tired out to stimuli at that spot, easily obtainable by stimulation two or more centimetres away.

The local fatigue of a spinal reflex seems to be recovered from with remarkable speed. A few seconds' remission of the stimulus suffices for marked though incomplete restoration of the reaction. Fatigue seems a process elaborated and preserved in the selective evolution of the neural machinery. One obvious use attaching to it is the prevention of the too prolonged continuous use of a common path by any one receptor. It precludes one receptor from occupying for long periods an effector organ to the exclusion of all other receptors. It prevents long continuous possession of a common path by any one reflex of considerable intensity. It favours the receptors taking turn about. It helps to ensure serial variety of reaction. The organism, to be successful in a million-sided environment, must in its reaction be many sided. Were it not for such so-called fatigue, an organism might, in regard to its receptivity, develop an eye, or an ear, or a mouth, or a hand or leg, but it would hardly develop the marvellous congeries of all those various sense-organs which it is actually found to possess.

The final efferent-root neurone forms the instrument for many different reflex arcs and acts. It is responsive to them in various rhythms and in various grades of intensity. In accordance with this, it seems from experimental evidence to be *relatively indefatigable*.

3. In the transition from one reflex to another a final common path changes hands and passes from one master to another. A fresh set of afferent arcs becomes dominant on the supersession of one reflex by the next. Of all the conditions determining which one of competing reflexes shall for the time being reign over a final common path, the *intensity* of reaction of the afferent arc itself relatively to that of its rivals is probably the most powerful. An afferent arc that strongly stimulates is *caeteris paribus* more likely to capture the common path than is one excited feebly. A stimulus can only establish its reflex and inhibit an opposed one if it have intensity. This explains why, in order to produce examples of spinal inhibition, recourse has so frequently been made in past times to *strong* stimuli. A strong stimulus will inhibit a reflex in progress although a weak one will fail. Thus in inhibition of micturition in the "spinal" dog a *forcible* squeeze of the tail will do it, but not a weak squeeze. So, likewise, any condition which raises the excitability and responsiveness of a nervous arc will give it power to inhibit other reflexes, just as it would if it were excited by a strong stimulus.

Crossed reflexes are usually less easy to provoke, less reliable of obtainment, and less intense than are direct reflexes. Consequently we find crossed reflexes usually more easily inhibited and replaced by direct reflexes than are these latter by those former. Thus the crossed stepping-reflex is easily replaced by the scratch-reflex, though its stimulus be continued all the time, and though the scratch-reflex itself is not a very potent reflex. But the reverse can occur with suitably adjusted intensity of stimuli.

Again, the flexion-reflex of the dog's leg is, when fully developed, accompanied by extension in the opposite leg. This crossed extensor movement, though often very vigorous, may be considered as an accessory and weaker part of the whole reflex, of which the prominent part is flexion of the homonymous limb. When the flexion-reflex is elicitable poorly, as, for instance, in spinal shock or under fatigue or weak excitation, the crossed extension does not appear. But, where the flexion-reflex is well developed, if not merely one but *both* feet be stimulated simultaneously with stimuli of fairly equal intensity, steady flexion at knee, hip and ankle results in *both* limbs, and extension occurs in neither limb. The contralateral part of each reflex is inhibited by the homolateral flexion of each reflex. In other words, the more intense part of each reflex obtains possession of the final common paths at the expense of the less intense portion of the reflex. But if the intensity of the stimuli applied to the right and left feet be not closely enough balanced, the crossed extension of the reflex excited by the stronger stimulus is found to exclude even the homonymous flexion that the weaker stimulus should and would otherwise evoke from the leg to which it is applied.

It was pointed out above that in a number of cases the transference of control of the final common path FC from one afferent arc to another is *reversible*. The direction of the transference can *caeteris paribus* be easily governed by making the stimulation of this receptor or that receptor the more intense. A factor largely determining whether a reflex succeed another or not is therefore intensity of stimulus.

4. A fourth main determinant for the issue of the conflict between rival reflexes seems the functional species of the reflexes. Reflexes initiated from a species of receptor apparatus that may be termed *noci-ceptive* appear to dominate particularly the majority of the final common paths issuing from the spinal cord. In the simpler sensations we experience from various kinds of stimuli applied to our skin there can be distinguished those of touch, of cold, of warmth and of pain. The pain ending may be regarded as adapted to a whole group of excitants, a group of excitants which has in relation to the organism one feature common to all its components, namely, a *nocuous* character.

With its liability to various kinds of mechanical and other damage, in a world beset with dangers amid which the individual and species have to win their way in the struggle for existence, we may regard nocuous stimuli as part of a normal state of affairs. The skin has evolved a *specific sense of its own injuries*. As psychical adjunct to the reactions of that apparatus we find a strong displeasurable effective quality in the sensations they evoke. This may be a means for branding upon memory, of however rudimentary a kind, a feeling from past events that have been perilously critical for the existence of the individuals of the species. In other words, if we admit that damage to such an exposed sentient organ as the skin must in the evolutionary history of animal life have been sufficiently frequent in relation to its importance, then the existence of a specific set of nerves for skin-pain seems to offer no genetic difficulty, any more than does the clotting of blood or innate immunity to certain diseases. That these nerve-endings constitute a distinct species is argued by their all evoking not only the same species of sensation, but the same species of reflex movement as regards "purpose," intensity, resistance to "shock," etc. And their evolution may well have been unaccompanied by evolution of any specialized end-organ, since the naked free nerve-endings would better suit the wide and peculiar range of stimuli, reaction to which is in this case required. A low threshold was *not* required because the stimuli were all intense, intensity constituting their harmfulness; but response to a wide range of stimuli of *different* kinds was required, because harm might come in various forms. That responsive *range* is supplied by naked nerve itself, and would be cramped by the specialization of an end-organ. Hence these nerve-endings remained free.

It is those areas, stimulation of which, as judged by analogy, can excite pain most intensely, and it is those stimuli which, as judged by analogy, are most fitted to excite pain which, as a general rule, excite in the "spinal" animal—where pain is of course non-existent—the *prepotent* reflexes. The nervous arcs of pain-nerves, broadly speaking, dominate the spinal centres in peculiar degree. Pain is thus the psychical adjunct of an imperative protective reflex. It is preferable, however, since into the merely spinal and reflex aspect of the reaction of these nerves no sensation of any kind can be shown to enter, to avoid the term "pain-nerves." Remembering that the feature common to all this group of stimuli is that they threaten or actually commit damage to the tissue to which they are applied, a convenient term for application to them is *nocuous*. In that case what from the point of view of *sense* are cutaneous pain-nerves are from the point of view of *reflex-action* conveniently termed *noci-ceptive* nerves.

In the competition between reflexes the noci-ceptive as a rule dominate with peculiar certainty and facility. This explains why such stimuli have been so much used to evoke reflexes in the spinal frog, and why, judging from them, such "fatality" belongs to spinal reflexes.

One and the same skin surface will in the hind limb of the spinal dog evoke one or other of two diametrically different reflexes according as the mechanical stimulus applied be of noxious quality or not, a harmful insult or a harmless touch. A needle-prick to the planta causes invariably the drawing up of the limb—the flexion-reflex. A harmless smooth contact, on the other hand, causes extension—the extensor-thrust above described. This flexion is therefore a noci-ceptive reflex. But the scratch-reflex—which is so readily evoked by simple light irritation of the skin of the shoulder—is relatively mildly noci-ceptive. When the scratch-reflex and the flexion-reflex are in competition for the final neurone common to them, the flexion-reflex more easily dispossesses the scratch-reflex from the final neurone than does the scratch-reflex the flexion-reflex. If both reflexes are fresh, and the stimuli used are such as, when employed separately, evoke their reflexes respectively with some intensity, in my experience it is the flexion-reflex that is usually prepotent. Yet if, while the flexion-reflex is being moderately evoked by an appropriate stimulus of weak in-scratch-reflex from the final neurone than does the scratch-reflex is applied, the steady flexion due to the flexion-reflex is replaced by the rhythmic scratching movement of the scratch-reflex, and this occurs though the stimulus for the flexion-reflex is maintained unaltered. When the stimulus producing the scratch is discontinued the flexion-reflex reappears as before.

In decerebrate rigidity, where a tonic reflex is maintaining contraction in the extensor muscles of the knee, stimulation of the noci-ceptive arcs of the limb easily breaks down that reflex. The noci-ceptive reflex dominates the motor neurone previously held in activity by the postural reflex. And noci-ceptive reflexes are relatively little depressed by "spinal shock."

Besides those receptors attuned to react to direct *noxa*, the skin has others, concerned likewise with functions of vital importance to the species and colligate with sensations similarly of intense affective quality; for instance, those concerned with sexual functions. In the male frog the sexual clasp is a spinal reflex. The cord may be divided both in front and behind the brachial region without interrupting the reflex. Experiment shows that from the spinal male at the breeding season, and also at other times, this reflex is elicited by any object that stimulates the skin of the sternal and adjacent region. In the intact animal, on the contrary, other objects than the female are, when applied to that region, at once rejected, even though they be wrapped in the fresh skin of the female frog and in other ways made to resemble the female. The development of the reflex is not prevented by removal of the testes, but removal of the seminal reservoirs is said to depress it, and their distension, even by indifferent fluids, to exalt it. If the skin of the sternal region and arms is removed the reflex does not occur. Severe mutilation of the limbs and internal organs does not inhibit the reflex, neither does stimulation of the sciatic nerve central to its section. The reflex is, however, depressed or extinguished by strong chemical and pathic stimuli to the sternal skin, at least in many cases. The tortoise exhibits a similar sexual reflex of great spinal potency.

It would seem a general rule that *reflexes arising in species of receptors which considered as sense-organs provoke strongly affective sensation* caeteris paribus *prevail over reflexes of other species when in competition with them for the use of the "final common path."*

Of all reflexes it is those of ordinary posture that are the most *easily* interrupted by other reflexes. Even a weak stimulation of the noci-ceptive arcs arising in the foot often suffices to lower or abolish the knee-jerk or the reflex extensor tonus of the elbow or knee. If various *species* of reflex are arranged, therefore, in their order of potency in regard to power to interrupt one another, the reflexes initiated in receptors which considered as sense-organs excite sensations of strong affective quality lie at the upper end of the scale, and the reflexes that are answerable for the postural tonus of skeletal muscles lie at the lower end of the scale. One great function of the tonic reflexes is to maintain habitual attitudes and postures. They form, therefore, a nervous background of active equilibrium. It is of obvious advantage that this equilibrium should be easily upset, so that the animal may respond agilely to the passing events that break upon it as intercurrent stimuli.

Results.—Intensity of stimulation, fatigue and freshness, spinal induction, functional species of reflex, are all, therefore, physiological factors influencing the result of the interaction of reflex-arcs at a common path. It is noticeable that they all resolve themselves ultimately into *intensity of reaction.* Thus, intensity of stimulus means as a rule intensity of reaction. Those species of reflex which are habitually prepotent in interaction with others are those which are habitually intense; those specially impotent in competition are those habitually feeble in intensity, *e.g.*, skeletal muscular tone. The tonic reflexes of attitude are of habitually low intensity, easily interfered with and temporarily suppressed by intercurrent reflexes, these latter having higher intensity.

The high variability of reflex reactions from experiment to experiment, and from observation to observation, is admittedly one of the difficulties that has retarded knowledge of them. Their variability, though often attributed to general conditions of nutrition, or to local blood-supply, etc., seems far more often due to changes produced in the central nervous organ by its own functional conductive activity apart from fatigue. This functional activity itself causes from moment to moment the temporary opening of some connections and the closure of others. The chains of neurones, the conductive lines, have been, especially in recent years, by the methods of Golgi, Ehrlich, Apathy, Cajal and others, richly revealed to the microscope. Anatomical tracing of these may be likened, though more difficult to accomplish, to tracing the distribution of blood vessels after Harvey's discovery had given them meaning, but before the vasomotor mechanism was discovered. The blood vessels of an organ may be turgid at one time, constricted almost to obliteration at another. With the conductive network of the nervous system the temporal variations are even greater, for they extend to absolute withdrawal of nervous influence. Under reflex inhibition a skeletal muscle is relaxed to its post-mortem length, *i.e.*, there may then be no longer evidence of even a tonic influence on it by its motor neurone. The final common path is handed from some group of a *plus* class of afferent arcs to some group of a *minus* class, or of a rhythmic class, and then back to one of the previous groups again, and so on. The conductive web changes its functional pattern with certain limits to and fro. It changes its pattern at the entrances to common paths. The changes in its pattern occur there in virtue of interaction between rival reflexes: occlusion, substitution by equivalence, inhibition, immediate induction, successive induction, fatigue, are factors. As a tap to a kaleidoscope, so a new stimulus that strikes the receptive surfaces causes in the central organ a shift of functional pattern of the linkage. The central organ is a vast network whose lines of conduction follow a certain scheme of pattern, but within that pattern the details of connection are, at the entrance to each common path, mutable. The grey matter may be compared with a telephone exchange, where, from moment to moment, though the end-points of the system are fixed, the connections between starting-points and terminal points are changed to suit passing requirements, as the functional points are shifted at a great railway junction. In order to realize the exchange at work, one must add to its purely spatial plan the temporal datum that within certain limits the connections of the lines shift to and fro from minute to minute. An example is the "reciprocal innervation" of antagonistic muscles—when one muscle of the antagonistic couple is thrown into action the other is thrown out of action. This is only a widely spread case of the general rule that antagonistic reflexes interfere where they embouch upon the same final common paths. And that general rule is part of the general principle of the mutual interaction of reflexes that impinge upon the same common path. *Unlike reflexes have successive but not simultaneous use of the common path; like reflexes mutually reinforce each other on their common path.* Expressed teleologically, *the common path, although economically subservient for many and various purposes, is adapted to serve but one purpose at a time. Hence it is a co-ordinating mechanism and prevents confusion by restricting the use of the organ, its minister, to but one action at a time.*

In the case of simple antagonistic muscles, and in the instances of simple spinal reflexes, the shifts of conductive pattern due to interaction at the mouths of common paths are of but small extent. The co-ordination covers, for instance, one limb or a pair of limbs. But the same principle extended to the reaction of the great arcs arising in the projicient receptor organs of the head.

e.g., the eye, which deal with wide tracts of musculature *as a whole*, operates with more multiplex shift and wider ambit. Releasing forces acting on the brain from moment to moment shut out from activity whole regions of the nervous system, as they conversely call vast other regions into play. *The resultant singleness of action from moment to moment is a keystone in the construction of the individual whose unity it is the specific office of the nervous system to perfect.* The interference of unlike reflexes and the alliance of like reflexes in their action upon their common paths seem to lie at the very root of the great psychical process of "attention."

The spinal cord is not only the seat of reflexes whose "centres" lie wholly within the cord itself; it supplies also conducting paths for nervous reactions initiated by impulses derived from afferent spinal nerve, but involving mechanisms situate altogether headward of the cord in the brain. Many of these reactions affect consciousness, occasioning sensations of various kinds.

Besides the paths followed by headward-running impulses the spinal cord contains paths for impulses passing along it backwards from the brain. These paths lie almost entirely in the ventrolateral columns of the cord. The fibres of which they are composed cross but little in the cord. Their sources are various, some come from the hind brain and some from the mid brain, and in the higher mammalia, especially in man and in the anthropoid apes, a large tract of fibres in the lateral column (the crossed pyramidal tract) comes from the cortex of the neopallium of the fore brain. This last tract is the main medium by which impulses initiated by electrical stimulation of the motor cortex reach the moto-neurones of the cord and through them influence the activity of the skeletal muscles. Of the function of the other tracts descending from the brain into the cord little is known except that mediately or immediately they excite or inhibit the spinal motoneurones by various levels. How they harmonize one with another in their action or what their purpose in normal life may be is at present little more than conjecture. Such terms, therefore, as "paths for volition," etc., are at present too schematic in their basis to warrant their discussion here. (C. S. S.)

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SPINAL MENINGITIS. Inflammation of the membranes (meninges) surrounding the brain and spinal cord. An equivalent term is cerebro-spinal meningitis.

The meninges, like the pleura, pericardium and peritoneum, are subject to infection with a wide variety of cocci and bacilli. According to the microbic incitant, the infection is termed tubercular, pneumococcal, streptococcal, staphylococcal, influenzal (*B. pfeifferi*), typhoid, etc., meningitis. The precise diagnosis is accomplished by means of the bacteriological examination of fluid (cerebro-spinal) withdrawn by lumbar puncture. The above-mentioned class of bacterial infections of the meninges tends to arise sporadically; as a rule it accompanies the corresponding bacterial infection affecting other parts of the body, the lungs, middle ear, tonsils, etc.

Epidemic Form.—In sharp contrast with the sporadic varieties of meningitis is the epidemic form, incited by the diplococcus discovered by Weichselbaum in 1887, now called meningococcus, of which many epidemic outbreaks have been recorded. The meningococcus appears not as a single, sharply defined species, but as a group in which the composing strains, while showing many properties in general, are yet distinguishable by power to ferment carbohydrates, reaction to specific agglutinating agents, etc.

Certain strains of meningococci have greater virulence for man than others and the more virulent strains show greater fixity of biological properties. During epidemics of meningitis virulent strains have the wider distribution; while in interepidemic periods the weaker, less defined strains are more frequently encountered.

A pandemic of meningitis prevailed during the first two decades of the present century. It embraced Europe, America, Asia, Africa and many islands of the seas. This pandemic was characterized by high mortality and by those multiple clinical features which have been noted in previous severe epidemics of the disease. A part only of the cases, usually not a large part, was attended by the visible haemorrhages in the skin and mucous membranes to which the name of spotted fever was applied in earlier times. Usually the very severe and rapidly fatal so-called fulminating cases fell into this category.

The fatality of the epidemic outbreaks, whether in Europe, in America or in more distant countries, in the years between 1904 and 1910 did not vary greatly. In the United States the percentage figures were from 75 to 90; in Great Britain 70 to 80; in Germany 60 to 70; in France, Italy and Belgium 75 to 80; in Palestine 80; in Greece 60; in the Transvaal 75. In other words, the pandemic seems to have been little affected by locality or race. As in all previous epidemics closely observed, the mortality was influenced by the age period of the attacked; the very young and the very old rarely survived attack. Patients between 5 and 30 years of age have the best chance of recovery.

Serum Treatment.—The outlook for recovery has been greatly modified by the discovery and use of the antimeningococcic serum since 1904. Attempts to produce a curative serum were carried out simultaneously in Germany by Jochmann and Wassermann, and in America by Flexner. The former failed perhaps because the manner of use was wrong: the serum was injected chiefly subcutaneously. The latter succeeded, because repeated injections were made directly into the inflamed meninges by means of lumbar puncture. Flexner's method was based on an experimental study in which the meninges of monkeys were infected with the meningococcus, and the treatment was applied by lumbar puncture. The serum-treated monkeys survived, while the untreated and those treated by subcutaneous injections of the serum succumbed.

This result agrees with what is known of the anatomical-physiological conditions affecting the passage of chemical substances from the blood into the cerebro-spinal fluid. Such passage, even when the membranes are inflamed, takes place to a very small extent or not at all.

Results of Serum Treatment.—The consensus of competent opinion is that given a strong polyvalent antimeningitis serum, its proper employment is capable of greatly modifying the course of the disease, of reducing the mortality, and of preventing crippling consequences.

A number of tabulations have been published showing the effects of the serum according to age groups, days of first injection, etc. The largest compilation is that of Flexner, dealing with about 1,300 cases in which the mortality among those treated in the first three days of illness was 18·1, the second three days 27·2 and after the seventh day 36·5%. The total mortality among these cases was 30·8%, as compared with 75 to 80% among corresponding non-serum-treated cases. Netter's figures for the corresponding three periods are 7·14, 11·1 and 23·5%; and Dopter's 8, 20, 14·4 and 24·1%. Flexner's figures are compiled from the reports of physicians at many places, while Netter's and Dopter's are based on personal experiences largely. Similarly, the influence of age on the results of the treatment is shown as follows: According to Flexner, under one year 50%, one to 20 years 75%, over

20 years 60% recovered; according to Netter, under one year 40%, one to 20 years 79% recovered; and according to Dopter, under one year 53%, one to 20 years 78%, and over 20 years 76% recovered.

Certain important objective effects are produced when antimeningitis serum is administered. Perhaps the most immediately impressive is the modified character of the clinical course of the disease itself. Briefly stated, this relates to the essential disappearance of the chronic cases slowly moving through weeks and months to a fatal issue, attended by hydrocephalus, extreme emaciation and other sequels. Either the cases fail to respond and terminate quickly, or in a few days the real infection is over and the patient convalescent. The growth and multiplication of the meningococcus within the cerebro-spinal fluid are quickly arrested. Next, epidemic meningitis is a disease from which when recovery occurs spontaneously it tends to take place slowly, gradually, or by "lysis"; under the influence of the serum, sudden termination by "crisis" frequently takes place. Finally, the severe consequences, as of hydrocephalus, impairment of vision and mentality, paralysis and joint affections, are diminished. The one severe complication which has not been influenced is deafness, which occurs in a varying, usually small percentage of the cases, and usually very early in the disease.

Mode of Infection.—The meningococcus gains access to the interior of the body by way of the mucous membrane of the nose and throat. The incidence of meningitis bears relationship to the proportion of nasopharyngeal carriers of the meningococcus. When the cases are few in any community or group of persons the carrier rate is low. When the carrier rate rises the cases tend to increase in number. During sharp outbreaks, among an exposed personnel, the carrier rate may reach 20%; ordinarily it is 2 to 3% or less.

Probably the meningococcus passes from the nasal mucous membrane into the blood, with which it is carried to the meninges. Whether it ever passes along the direct lymphatic channels stretching from the nasal membrane to the meninges may be doubted. Instances are known in which meningococci were present in the blood some time before signs of meningitis appeared. The intravenous injection of the anti-meningitis serum has been successful in removing the microbe from the blood and of curing the general or blood infection. No meningitis followed. It is because of the occurrence of meningococci in the blood stream that early intravenous injection of the serum is recommended by certain authorities as a regular part of its intraspinal use in the treatment of epidemic meningitis. To be of value, the intravenous injection should be carried out very early in the disease, and it should not be substituted for the direct injection into the inflamed meninges. As a rule, a number of intraspinal serum injections on successive days is required to control the infection.

The successful employment of the anti-meningococcus serum has led to efforts being made to control other microbic varieties of meningitis in a similar manner, but thus far without notable success.

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(S. F.)

SPINDLE-TREE (*Euonymus europaeus*), so-called from its tough wood being formerly used for spindles, a small tree of the family Celastraceae, native to Europe and sparingly naturalized in eastern North America. The wood furnished good charcoal. (*See* EUONYMUS; WAHOO.)

SPINEL, in mineralogy, the name given to a group of minerals, of the general composition $R''O{\cdot}R_2'''O_3$, where R''=Mg, Fe, Mn, Zn, and R'''=Al, Fe''', Cr'''. The typical member is $MgO{\cdot}Al_2O_3$, a magnesium aluminate to which the name (Fr. *spinelle*, from the Latin "*spina*," perhaps in allusion to the sharp angles of the crystals) was originally restricted. All spinels crystallize in the cubic system, typically in octahedra. Twinning is common, the octahedral face being the twin plane, giving a characteristic form known as the spinel twin.

The group of spinel minerals includes the following members:—

Magnesia-spinel	$MgAl_2O_4$	Magnesioferrite	$MgFe_2O_4$
Pleonaste	$(Mg,Fe)Al_2O_4$	Magnetite	$FeFe_2O_4$
Hercynite	$FeAl_2O_4$	Gahnite	$ZnAl_2O_4$
Picotite	$(Mg,Fe)(Al,Cr)_2O_4$	Franklinite	$(Zn,Mn)Fe_2O_4$
Chromite	$FeCr_2O_4$		

Cleavage is typically absent in these minerals with the exception of the zinc spinel (cleavage on 111), but an octahedral parting is observable in magnetite and franklinite. The hardness is variable, in ordinary spinel 7·5–8, but magnetite H=6 and chromite H=5·5. The sp. gr. varies with the composition, from 3·6 (magnesia-spinel) to 5·2 (magnetite). The light refraction shows a range from 1·718 (pure $MgAl_2O_4$), hercynite 1·80, to picotite 2·05, chromite 2·10 and magnetite 2·42. Spinels vary much in colour. Magnesia spinels are pink, red and blue, and are used as gem-stones. The pure magnesia spinel is colourless, hercynite is dark green in thin slices and picotite and chromite are brown in the thinnest sections. Spinels are readily produced artificially. Magnesia spinel melts at 2135° C and between this compound and $FeAl_2O_4$ there is complete miscibility as revealed in spinel analyses, but solid solution between $(Mg, Fe)Al_2O_4$ and magnetite is very limited. The spinels used in jewellery are found mostly in gem gravels, the chief localities being Ceylon, Siam and Upper Burma.

Spinels occur both in igneous and metamorphic rocks. The home of the magnesia spinel is in thermally altered dolomites where it arises by reaction of alumina with dolomite. Here it is usually accompanied by calcite and forsterite. The iron-rich member, pleonaste, is common both in ultrabasic rocks such as dunites and in quartz-less argillaceous hornfelses and gneisses. In these latter it is almost universally accompanied by cordierite and frequently by sillimanite, andalusite or corundum. Hercynite is characteristic of the granulites of Saxony in association with garnet, sillimanite, etc. The chromiferous spinel, picotite, is relegated to the ultrabasic rocks, as dunite, lherzolite and the serpentines derived from them. Gahnite, the zinc spinel, occurs in schists associated with zinc ores, and in pegmatites in Finland and at Broken Hill, New South Wales; while franklinite is associated with zinc and manganese minerals in limestone at Franklin Furnace, New Jersey. (*See* also CHROMITE; MAGNETITE.)

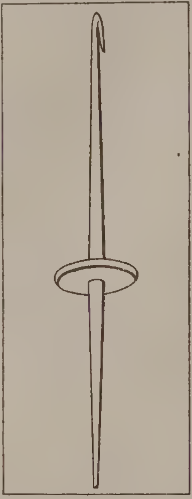
(C. E. T.)

SPINELLO, ARETINO (*c.* 1330–1410), Italian painter, the son of a Florentine named Luca, who had taken refuge in Arezzo in 1310 when exiled with the rest of the Ghibelline party, was born at Arezzo about 1330. Spinello was a pupil of Jacopo di Casentino, a follower of Giotto, and his own style was a sort of link between the school of Giotto and that of Siena. In the early part of his life he worked in Florence painting frescoes, nearly all in terra verde in the churches, the Carmine, Sta. Maria Novella and elsewhere. These works are no longer extant. Between 1360 and 1384 he was occupied in painting many frescoes in and near Arezzo, almost all of which have now perished. After the sack of Arezzo in 1384 Spinello returned to Florence, and in 1387–1388 with some assistants covered the walls and vault of the sacristy of S. Miniato near Florence with a series of frescoes, the chief of which represent scenes from the life of St. Benedict. Of his later works the chief are the very fine series of frescoes painted in 1407–1408 in the Salia di Balia in the Palazzo Pubblico at Siena; these are the finest of Spinello's existing frescoes. Spinello died at Arezzo on March 14, 1410.

See Sir Dominic Colnaghi, *Dictionary of Florentine Painters* (1928).

SPINET or **SPINNET,** names given in England to all small keyboard instruments irrespective of shape, having one string to a note, plucked by means of a quill or plectrum of leather. The earliest name recorded for this instrument is clavicymbalum, which occurs in the rules of the Minnesingers (1404), and also in the *Wunderbuch* (1440), a ms. preserved in what was formerly the grand-ducal library at Weimar. (*See* PIANOFORTE.)

SPINNING, the forming of threads by drawing out and twisting various fibres. There is ample evidence of the great antiquity and wide diffusion of the art of spinning, for spinning necessarily precedes weaving (*q.v.*) whenever short fibrous materials have to be made into threads, and weaving is one of the primal and most universal employments of mankind. No art which has been so long and widely practised remained so unprogressive as that of spinning. On the other hand, since about the middle of the 18th century, when human ingenuity bent itself in earnest to improve the art, there have not been developed in the whole range of mechanical industries machines of greater variety, delicacy of action and capacity than those now in use for spinning.



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AN EARLY SPINDLE

Used in primitive thread-making, it was made of wood and was from 9in. to 15in. long

The primitive thread-making implement consisted of a wooden spindle, from 9 to 15in. long, which was rounded and tapered at both extremities, as in the accompanying figure. Near the top there was usually a notch in which the yarn was caught while undergoing the operation of twisting, and lower down a whorl, or wharve, composed of a perforated disk of clay, stone, wood, or other material was secured to give momentum and steadiness to a rotating spindle. Long fibres were commonly attached to a distaff of wood, which was held under the left arm of the operator, but short fibres were spun from carded rolls. After attaching some twisted fibres to the spindle, a rotatory motion was given to the latter either by rolling it by hand against one thigh, or by twirling it between the fingers and thumb of the right hand, after which the fibres were drawn out in a uniform strand by both hands and converted into yarn. When the thread was of sufficient strength, the spindle was suspended by it until a full stretch had been drawn and twisted, after which that portion was wound upon the body of the spindle, and the operation continued until the spindle was filled. The quantity thus rolled up gives the name to a now definite measure of linen yarn, namely "the spindle," or 14,400 yards. Simple as was this primitive apparatus, a dexterous spinner could produce yarn of an evenness, strength and delicacy such as has scarcely been exceeded by elaborate modern appliances. The yarns for the gossamer-like Dacca muslins of India were so fine that 1 lb. weight of cotton was spun into a thread nearly 253m. long. This was accomplished with the aid of a bamboo spindle not much bigger than a darning needle, and which was lightly weighted with a pellet of clay. Since such a tender thread could not support even the weight of so slight a spindle, the apparatus was rotated upon a piece of hollow shell. The spindle as here described was, so far as is known, the sole apparatus with which yarn was spun until comparatively recent times.

Modern Spinning.—Modern changes have had for their object: (1) the providing of mechanical means to rotate the spindle, (2) an automatic method of drawing out the fibres, and (3) devices for working a large group of spindles together, at rapid speeds.

The first improvement consisted in cutting a ring groove in the wharve, mounting the spindle horizontally in a frame, and passing a band from a large wheel round the wharve. A rotatory motion was then given to the spindle by turning the wheel with the left hand. After attaching the filaments to the spindle they were attenuated with the right hand, and when fully twisted the thread was moved to form a right angle with the spindle and coiled upon it. Such a wheel has long been known in India, and from a drawing in a 14th-century manuscript in the British Museum it is obvious that it was not unknown, although far from being in general use, in Europe at that early date. It came ultimately to be known in England as the "bobbing wheel," and was in constant use down to the beginning of the 19th century for spinning coarse and fine yarns. But fine yarns received two spinnings; the first consisted in drawing out and slightly twisting the fibres into what is still known as a roving, and by the second spinning the roving was fully attenuated and twisted. In 1533, a citizen of Brunswick is said to have cranked the axis of the large wheel and added a treadle, by which the spinner was enabled to rotate her spindle with one foot and have both hands free to manipulate the fibres.

It is not possible accurately to fix the dates at which all improvements in spinning appliances were made; it is certain that many were known and used long before they were generally adopted. Thus the flyer, which twists yarn before winding it upon a bobbin, is shown in a drawing by Leonardo da Vinci, together with a device for moving the bobbin up and down the spindle so as to effect an even distribution of the yarn. During the 16th century a machine of the foregoing type was widely used, and came to be known as the Saxony wheel. It changed spinning from an intermittent to a continuous operation. The spindle had affixed upon its outer end a wooden flyer, whose forked legs were far enough apart to enclose a double-flanged spool, and at short intervals bent wires, known as the heck, were inserted in each leg for the purpose of guiding the thread evenly upon the spool. This spool was loosely threaded upon the spindle and one of its flanges was grooved to take a driving band from the large wheel, hence the spindle and the spool were separately driven, but the former at a higher speed than the latter. The twisted filaments were drawn through an eye in the flyer, led along one of its legs, and made fast to the spool. By operating the treadle the flyer twisted all the fibres about a common axis once for each revolution, and the spool wound up the length thus spun: the thread being slipped from tooth to tooth of the heck at regular intervals to direct it evenly across the spool.

The remaining part of the problem which lay before inventors was to draw out masses of parallel fibrous material, and twist them into uniform strands by mechanical means. The first stage in the evolution of mechanical spinning was effected by the invention of Lewis Paul, of Birmingham, who obtained a patent in 1738, and who was assisted by John Wyatt. The essential features of this invention consisted in passing carded slivers between pairs of parallel rollers, each succeeding pair of which moved faster than the preceding pair, to attenuate the sliver to the required extent. From Paul's specification it would appear that he attempted to turn the rollers about their horizontal and vertical axes simultaneously, in order to draw out the fibres and twist them at one operation. But he also mentions a plan for which he procured a patent 20 years later, namely, the use of only one pair of rollers working in conjunction with a bobbin which drew off the thread faster than the rollers delivered the sliver, and coiled the thread about itself. The bobbin, therefore, attenuated, twisted and wound the material. Neither plan proved a commercial success. Thomas Highs, of Leigh, and others, laboured upon the problem, but it was left to Richard Arkwright, a barber, of Preston and Bolton, to achieve what his predecessors vainly struggled for. He obtained patents, in 1769 and 1775, for a machine which was subsequently known as the water-twist frame by reason of water-power being applied to drive it. Arkwright's first machine did not contain any really new feature, for it consisted of Paul's drawing rollers, and the spindle, flyer and spool from the Saxony wheel, but the spindles and rollers were grouped in sets of four. Later the water-twist frame was changed into the "throstle" frame, which in turn has almost ceased to be used. In 1829 C. Danforth (1797–1876), an American spinner, invented a dead spindle, on the top of which he placed a hollow cap to serve as the winding point, and inside the cap he rotated a spool: a plan still used by worsted spinners. In 1828 Mr. Thorpe, also an American, invented the ring spinning frame, whose principal feature consisted in the substitution for the flyer of a flanged annular ring, and a light C-shaped traveller. By means of the traveller a thread was held in the best position for winding upon a spool, as well as put under the necessary tension. Later inventors have so altered the construction of the ring, traveller and spindle that a speed of upwards of 11,000 revolutions per minute can now be attained. This represents the highest development of continuous spinning.

Whilst endeavours were being made to perfect continuous spinning, attention was also directed to perfecting the intermittent process as represented by the bobbing wheel. Between the years 1764 and 1767, James Hargreaves, of Standhill, invented the spinning jenny, by the aid of which 16, or more, threads could be spun simultaneously by one person. All the spindles were placed vertically and rotated from a drum, but the rovings were mounted in a movable carriage and passed between a clamp that opened and shut like a parallel ruler. After securely clamping the rovings and attaching them to the spindles, the carriage was drawn out slowly by one hand and the spindles revolved by the other. The rovings were thus stretched to the proper degree of tenuity, and sufficiently twisted. This was followed by the inward run of the carriage, when the stretch of spun threads was wound upon the spindles, and the operation repeated. Hargreaves therefore returned to the first principles of spinning, viz., simultaneous drawing and twisting. But although the jenny gave a greatly increased output, it was ill adapted for fine spinning. During the years 1774 to 1779, Samuel Crompton, of Bolton, combined, in the mule, the drawing rollers of Paul with the stretching of Hargreaves. But his rollers did not fully attenuate the rovings before twisting them, as is the case with continuous spinning, neither was stretching alone relied upon. From its introduction this machine was able to spin finer and more elastic threads than any of its rivals, but for a time the preparation of suitable rovings was a source of great trouble. The immediate consequence of the decision of the court of king's bench, in 1785, to throw open to the public Arkwright's preparatory machinery, was an enormous increase in the usefulness of the mule. Since Crompton's time a host of inventors have laboured to render all parts of the mule thoroughly automatic; this has led to many changes and additions, but none of its essential features has been discarded. The inventions of Paul, Arkwright, Hargreaves and Crompton are at the foundation of all modern systems of spinning; details regarding them are given in the article on COTTON: *Cotton-Spinning Machinery*. (T. W. F.)

SPINOLA, AMBROSE, MARQUIS DE LOS BALBASES (1569–1630), Spanish general, born in Genoa, then practically a protected state under the power of Spain. The family of Spinola was of great antiquity, wealth, and power, and a rival of the house of Doria for authority within the republic. Unsuccessful in a lawsuit against the Dorias, Spinola decided to advance the fortunes of his house by serving the Spanish monarchy in Flanders. In 1602, he and his brother Frederick entered into a contract with the Spanish government. It was a speculation in which Spinola risked the whole great fortune of his house. Frederick, who was to form a squadron of galleys for service on the coast, was killed in action with the Dutch (May 24, 1603). Spinola's first landing in Flanders resulted in nothing definite and he returned at the end of 1602 for more men. On Sept. 29, 1603, he laid siege to Ostend and took it on Sept. 22, 1604, winning thereby a high reputation among the soldiers of his time. A visit to the Spanish court at Valladolid, resulted in his being appointed commander-in-chief in Flanders. The wars of the Low Countries consisted at that time almost wholly of sieges, and Spinola made himself famous by the number of places he took in spite of the efforts of Maurice of Nassau to save them.

On the outbreak of the Thirty Years' War Spinola conducted a vigorous campaign in the lower Palatinate, and was rewarded by the grade of captain-general. The most renowned victory of his career—the capture of Breda after a long siege (Aug. 28, 1624–June 5, 1625)—is the subject of the great picture by Velazquez, known as "Las Lanzas"; the portrait of Spinola is from memory. The taking of Breda was the culmination of Spinola's career. The enmity of Olivares and the want of money paralysed his efforts. Appointed plenipotentiary and general in the war over the succession to the Duchy of Mantua, Spinola landed at Genoa on Sept. 19, 1629. In Italy, Olivares caused him to be deprived of his powers as plenipotentiary, and, broken down in health, he died on Sept. 25, 1630, at the siege of Casale.

See A. Rodriguez Villa, *Ambrosio Spinola . . .* (Madrid, 1905). (D. H.)

SPINOZA, BENEDICTUS DE (1632–1677), Dutch philosopher and maker of lenses. The surname occurs in various forms: Espinoza, d'Espinoza, Despinoza, de Spinoza, and simply Spinoza. His first name was Baruch (Hebrew for "Blessed"); but, in accordance with the custom of the time, it was rendered into its Latin equivalent (*Benedictus*).

THE LIFE AND WRITINGS OF SPINOZA

Early Years (1632–1654).—Spinoza was born in Amsterdam on November 24, 1632. The house in which he first saw the light, and in which he passed his early years, occupied the site of what is now No. 41, Waterlooplein. His grandfather (Abraham) and his father (Michael) were Portuguese crypto-Jews, that is, descendants of Jews whom the Inquisition had compelled to embrace Christianity but who remained Jews at heart. When the Netherlands revolted against Spain and the Spanish Inquisition, in 1567, and the Union of Utrecht decreed, in 1579, that "every citizen shall remain free in his religion," many crypto-Jews in Spain and Portugal turned their eyes to Holland in the hope of finding refuge there from their common oppressors. The destruction of the Spanish Armada, in 1588, probably favoured schemes of escape. So in 1593 the first batch of Jewish refugees arrived in Amsterdam. Among these early arrivals were Spinoza's father and grandfather. They hailed from Vidigueira, near Beja, in the South of Portugal, but appear to have stayed for a while in Nantes (France) before settling in Amsterdam. Spinoza's mother came from Lisbon. She died in 1638, when Spinoza was barely six years old.

The Spinozas were fairly well-to-do merchants. Spinoza's grandfather was regarded as the head of the Amsterdam Jewish community from about 1628 onwards, and Spinoza's father was Warden of his synagogue on many occasions, also Warden of the Jewish School, and President of a Jewish Charity which granted loans free of interest. Under the circumstances it may be assumed that Spinoza attended the school for Jewish boys, founded about 1638. The curriculum of this school is well known, so we have a sufficiently clear idea of Spinoza's early education. The school hours were 8 till 11 A.M. and 2 till 5 P.M. The subjects were all Hebrew—the Old Testament, the Talmud, Hebrew Codes, and the works of Ibn Ezra, Maimonides, Crescas and others. Outside school hours the boys had private lessons in secular subjects. The vernacular used in the Jewish school and in Jewish homes was Spanish. Spinoza learned Latin from a German scholar, Jeremiah Felbinger, who may also have taught him German. Spanish and Portuguese Spinoza learned from his father, Dutch from his environment, and he also knew some French and Italian. When exactly he learned mathematics and physics is not known. There were plenty of Hebrew books dealing with these sciences, and the Jewish School had a good lending library, so that Spinoza may have commenced these studies during his school years. Hence probably his choice of the profession of a maker of lenses.

Of Spinoza's teachers at the Jewish School the most eminent were Saul Morteira and Manasseh ben Israel. Morteira was born in Venice in 1596, and studied medicine under Montalto, the crypto-Jewish Court physician of Maria de Medici. He came to Amsterdam in 1616, and in 1638 was elected presiding Rabbi of the Amsterdam synagogues. Manasseh ben Israel was born in Lisbon in 1604. His father was one of 150 Jews whom the Inquisition condemned to the flames in 1605. They managed to save their lives at the expense of their fortunes, and fled at the earliest opportunity. Manasseh's parents brought him to Amsterdam about 1606. In 1622 he became the youthful Rabbi of one of the Amsterdam synagogues (the "Habitation of Peace"). In 1627 he started a Hebrew printing press, and in 1640 he was appointed to one of the senior posts in the Jewish School.

In March 1654 Spinoza's father died. There was some litigation over the estate, as Spinoza's only surviving step-sister claimed it all. Spinoza won the lawsuit, but allowed her to retain nearly everything. Henceforth Spinoza had to fend for himself.

Critical Years (1654–1656).—Spinoza was in his twenty-second year when his father died. His studies so far had been mainly Jewish. But he was an independent thinker and he had found more than enough in his Jewish studies to wean him from orthodox theology. In the Biblical commentary by Abraham Ibn

Ezra (1092–1167) one meets with many "a word to the wise" directing attention to some inconsistency in Scripture, to the post-Mosaic authorship of parts at least of the so-called "Five Books of Moses," or to the different authorship of the two parts of *Isaiah*. In the *Guide of the Perplexed* of Moses Maimonides (1135–1204) attention is drawn to various crudities in Biblical theology, and to the provisional character of certain Biblical ordinances. In the writings of Gersonides (1288–1344) rationalism encroaches on miracles and prophecy in an attempt to eliminate the element of supernaturalism. Already Maimonides had insisted on interpreting Scripture in such a way as to harmonize it with reason. Gersonides went further than that. He faced the possibility of a conflict between Reason and Revelation, and maintained that, in such an event, the Bible "cannot prevent us from holding that to be true which our reason prompts us to believe." Again, the popular conception of the world's creation out of nothing was denied by both Ibn Ezra and Gersonides, who believed in the eternity of matter. Maimonides also repudiated the belief that man is the centre of creation, maintaining that each thing exists for its own, not for man's, sake; he also suggested the relativity of good and evil. The Jewish Mystics had taught that Nature is animated. Crescas (1340–1410) ascribed extension to God, denied the validity of the conception of final causes (or the explanation of objects and events by reference to their alleged purposes), and, like Ibn Ezra, maintained a thoroughgoing determinism. Here was food enough for thought, and incentive enough for heresy.

Moreover, the tendency to revolt against mere tradition and authority was very much in the air since the Renaissance, and it affected young Jews as others. There was the tragic figure of Gabriel da Costa, or Uriel Acosta (1585–1640). A crypto-Jewish refugee from Oporto, in Portugal, he settled in Amsterdam. He was opposed to the belief in immortality, and to various Jewish rites, on the ground that they were not Biblical. He was excommunicated by the Jewish authorities, recanted, then returned to the charge, was excommunicated again, recanted again under humiliating conditions, and shot himself. In his naturalistic outlook he was a forerunner of Spinoza. Especially interesting for the understanding of Spinoza is the case of another Jewish doctor of Amsterdam—Daniel de Prado (d. 1663). He too was opposed to supernaturalism and traditionalism, and appears to have influenced young people to adopt similar views. He was persuaded to recant in the synagogue in 1656, but there was no material change in his attitude. The synagogue authorities tried to bribe him to go abroad, but he declined, and was excommunicated in 1657. A contemporary poet, punster and protector of the faith (Isaac Orobio de Castro) wrote an invective in verse against de Prado as a philosophaster who led astray young students, Jewish and non-Jewish. Some of the allusions in this invective most probably refer to Spinoza, the record of whose excommunication faces the page in the communal minute book on which de Prado's recantation is recorded. Some of the writings of Jewish authors of the period (Samuel da Silva, Manasseh ben Israel, Orobio de Castro, etc.) in defence of immortality, revelation and tradition afford considerable evidence of the intellectual ferment in Amsterdam Jewry. And the religious leaders of the day were not particularly tactful or tolerant. They were alarmed by heresies which were at least as anti-Christian as anti-Jewish, and were afraid of giving offence in a country of which they were not yet regarded as citizens. This alarm shows itself in the attempt to bribe de Prado and Spinoza into silence. But they were also imbued with something of the intolerant spirit of the Inquisition, whose victims they had been. In 1640, they actually put the ban on Manasseh ben Israel for some trivial reason, though they rescinded it soon afterwards.

The views which brought Spinoza into collision with the synagogue authorities were essentially the same as those of Farrar, Acosta and de Prado. In conversation with other students he told them that there is nothing in the Bible to support the views that God has no body, that there really are angels (as distinguished from merely imaginative visions of them), and that the soul is immortal. He also expressed his belief that the author of the Pentateuch was no wiser in matters pertaining to physics or even theology than they were. These utterances were reported to the Jewish authorities, who after vainly trying to silence him with bribes and threats excommunicated him in July 1656. The fact of his excommunication was formally reported to the civil authorities—a gesture intended to absolve the Jewish community from all responsibility for Spinoza's heresies. And Spinoza was banished from Amsterdam for a short period.

There is no evidence that Spinoza really wanted to break away from the Jewish community. Such evidence as there is rather points the other way. On December 5, 1655, he attended service in the synagogue and made an offering. In view of his impecuniosity, offerings must have been rare events for him, and it may be assumed that he also went to the synagogue after that date, certainly in March 1656, the anniversary of his father's death. Shortly before or after his excommunication he also addressed an *Apology* (or defence of his views) to the synagogue authorities. Apparently he was not entirely indifferent to their opinions of him. Possibly if Manasseh ben Israel had not been away in London at the critical time, the whole storm would have blown over. As it was, tactlessness, mischief making, alarm and intolerance were in the saddle and rode for a fall. In his 24th year Spinoza stood alone, but unafraid, and uplifted by his destiny to become one of the great lights of humanity.

Years of Re-Orientation (1656–1660).—Already before his estrangement from the synagogue Spinoza had become acquainted with a number of Christians. Among these was a certain Francis van den Enden, an ex-Jesuit and ex-bookseller, but an ardent classical scholar and something of a poet and dramatist, who opened a school in Amsterdam in 1652. For a time Spinoza stayed with Van den Enden, assisting with the teaching of the school children, and receiving help in his own further education. In this way Spinoza improved his knowledge of Latin, learned some Greek, was introduced to the Neo-Scholastic philosophy of such writers as Burgersdijck (d. 1632) and Heereboord (d. 1659), and possibly also to the works of Descartes. In any case Spinoza's other Christian acquaintances were mostly Collegiants who were especially interested in the "new philosophy" of Descartes. At the same time he was learning the science and art of making lenses, in which he became a great expert. After his excommunication Spinoza spent some weeks, or possibly months, at Ouwerkerk, a village south of Amsterdam, and then returned to his native city, where he stayed until 1660. He supported himself partly by grinding and polishing lenses for spectacles, telescopes and microscopes, and partly by helping various people with their private studies. Holland was a country of many religious sects whose friction with the predominant Calvinist clergy imparted considerable vitality to theological problems and connected philosophical questions. As all these reformation movements were, or professed to be, "back to the Bible," a knowledge of Hebrew was felt to be necessary, and Hebrew experts like Spinoza were in some demand. The same was true of philosophy as an aid to theology. Accordingly, a number of amateur theologians secured the services of Spinoza to help them with their studies, and through them he also came into contact with others. Of his friends and acquaintances during this period the most important were Pieter Balling, Jarig Jelles, Lodewijk Meyer, Simon Joosten de Vries, and Jan Rieuwertsz. The sincerity of Simon Joosten de Vries's admiration for Spinoza was shown in many ways. At one time he pressed Spinoza to accept a gift of 2,000 florins, at another time he wanted to make Spinoza his sole heir, but in vain. By his will he left Spinoza an annuity of 500 florins, but Spinoza would not accept more than 300. Some or all of these and certain others formed a kind of reading and discussion circle for the study of religious and philosophical problems under the guidance of Spinoza. At first, we may assume, Cartesian philosophy played an important part in these discussions. For at that time there was something like a coalition between the "new philosophy" and liberal, dissenting theology, for they were both opposed by the dominant Calvinists. Most of his Collegiant friends remained Cartesian to the end, though Spinoza himself never followed Descartes in anything except his science.

To judge from the opening passage of his *Treatise on the Improvement of the Understanding,* which was written shortly afterwards, the years 1656 to 1660 must have been years of storm and stress in Spinoza's mental history. Cut off from kith and kin, and left stranded as the result of his honest attempt to think independently, worldly aims must have seemed at times more alluring than the beck of the spirit. But his higher self won through, partly perhaps with the help of the faith which his unsophisticated friends and disciples placed in knowledge and in him. His new orientation was accomplished by the end of this period. He had learned to view life and its problems from other angles than those of his native environment, and he had acquired a knowledge of a language and a system of concepts more suitable to serve as a vehicle for the great thoughts that were taking shape in his mind, and more suitable, too, for the wider influence which they were destined to exercise. What he needed now was peace and quiet in which to collect his thoughts and reduce them to system. He withdrew accordingly to Rijnsburg, a quiet unworldly village on the old Rhine, about six miles from Leyden.

Life at Rijnsburg (1660–1670).—Rijnsburg was the headquarters of the Collegiants. Arrangements for his stay there were no doubt made by his Collegiant friends. He lodged with a surgeon named Hermann Homan, whose humanitarianism is obvious from the inscription on the cottage wall:

Alas! if all men were but wise,
And would be good as well,
The Earth would be a Paradise,
Where now 'tis mostly Hell.

(From Kamphuysen's *May Morning*). In this cottage (now *Het Spinozahuis*) Spinoza wrote his *Short Treatise on God, Man and his Well-being,* the *Treatise on the Improvement of the Understanding,* the greater part of his *Geometric Version of Descartes' Principia* with the appendix on *Metaphysical Thoughts,* and the first book of his *Ethics.* Part of the *Short Treatise* consists of notes which he had prepared in connection with the study circle in Amsterdam. This circle continued to meet after Spinoza's departure from Amsterdam, and periodically Spinoza sent them the various parts of his *Short Treatise* and other works for study and discussion. This is clear from Letters VIII. and IX. (*The Correspondence of Spinoza,* pp. 101 *seq.*) and from the closing sentences of the *Short Treatise* (pp. 149 *seq.* in A. Wolf's edition). The *Short Treatise* and the *Treatise on the Improvement of the Understanding* were ready in or before April 1662, and were originally intended to be one work, as is clear from Spinoza's third letter to Oldenburg (*Correspondence,* pp. 98 *seq.*). Already in these earlier writings Spinoza's attitude is anti-Cartesian.

During his stay in Rijnsburg Spinoza met various interesting people. Especially noteworthy are Steno, the founder of modern geology, and Oldenburg, one of the first two secretaries of the Royal Society of London. Steno subsequently turned Roman Catholic and tried to persuade Spinoza to do likewise (see *Correspondence,* pp. 324 *seq.*); but he has the merit of having recognized in Spinoza "the reformer of the new philosophy." Oldenburg is of special interest in a biography of Spinoza because the most important part of Spinoza's correspondence passed between him and Oldenburg. Oldenburg visited Leyden in 1661. His countryman Coccejus was professor there. Spinoza must have acquired a reputation somehow, for Oldenburg went out of his way to visit him in Rijnsburg. The deep impression which Spinoza made on Oldenburg (who was about 18 years older than Spinoza) is evident from his first letter to Spinoza (see *Correspondence,* pp. 73 *seq.*). In Rijnsburg also Spinoza first met the brothers Koerbagh whose subsequent tragic fate showed how little freedom of thought there really was even in Holland. Casearius, another student at the University of Leyden, came to spend a year or so in Rijnsburg, and stayed in the same cottage as Spinoza, who instructed him in the philosophy of Descartes. For this purpose Spinoza made a geometrical version of the second part of Descartes' *Principia.* While on a visit to Amsterdam, in 1663, Spinoza showed this to his Cartesian friends, who persuaded him to do the same with the first part of the *Principia.* He did so in a fortnight. These two parts, together with an appendix called *Metaphysical Thoughts,* were accordingly published by his friends in 1663. L. Meyer wrote the introduction explaining that Spinoza did not really share the views expressed in the book; J. Rieuwertsz was the publisher; and J. Jelles defrayed the cost. This was the only book published in Spinoza's life-time with his name on the title-page. P. Balling prepared a Dutch translation of this book, and published it in 1664.

Early in 1662 Spinoza had completed the first draft of his philosophy in one work combining the *Short Treatise* and the *Treatise on the Improvement of the Understanding.* He was not satisfied with its style or with its method of exposition. He had tried the dialogue form without success, so he tried the geometrical method, in the manner of Euclid's *Elements,* which gave him more satisfaction. He therefore decided to lay aside his earlier attempts and make a new start. Thus originated his *Ethics,* the first book of which was finished, and in the hands of his friends, early in 1663. The title of the whole work was not yet intended to be *Ethics,* but "On God, the Rational Soul, and the Highest Happiness of Man," and the work was planned in three parts corresponding to the three parts of the title, instead of the five parts into which it eventually developed. The publication of his version of Descartes' *Principia* was intended to prepare the way for the publication of his own philosophy. For this purpose two things were necessary. He had to secure the patronage of influential men who could shield him and his book from the remorseless hostility of the Calvinist clergy and other fanatics, and he had to show to the more philosophically minded people, who were mostly Cartesians, that his rejection of Cartesianism was not due to ignorance (see *Correspondence,* pp. 123 *seq.,* and *The Oldest Biography of Spinoza,* pp. 57 *seq.,* 147 *seq.*). Spinoza appears to have succeeded so far as to win the interest of a few people belonging to the governing class. These afforded him some protection, but not sufficient to enable him to publish his philosophy in his life-time. Among these were J. Hudde (who subsequently became Sheriff and then Burgomaster of Amsterdam, and a member of the States of Holland), H. Boxel (Pensionary of Gorkum), C. Burgh (who became Treasurer General of the United Netherlands in 1666), possibly also C. van Beuningen (at one time Burgomaster of Amsterdam) and Jan de Witt (Grand Pensionary of Holland).

In June 1663 Spinoza moved from Rijnsburg to Voorburg, near The Hague. Here Spinoza got to know Vossius the philologist, who was subsequently appointed Canon of Windsor, and Christian Huygens, the discoverer of Saturn's rings, inventor of the pendulum clock, and originator of the undulatory theory of light.

Though busy with his *Ethics* and his lenses, Spinoza kept up his correspondence with various people, especially with Oldenburg. Oldenburg kept Spinoza informed of the doings of the Royal Society (which had obtained its charter in July 1662) and of the researches of Robert Boyle and others, and solicited news from Spinoza about Huygens and others. But about 1665 the correspondence was interrupted. The Great Fire of London (1666) and the continuation of the war were no doubt responsible for this. In 1667 Oldenburg was suspected of espionage and clapped into the Tower of London for a time. He was released, but became nervous and cautious, so that his correspondence with Spinoza was not resumed until 1675.

From a letter written in June 1665 it appears that Spinoza was then nearing the completion of his *Ethics* (*Correspondence,* p. 202). In the following August or September, however, Spinoza informed Oldenburg that he was engaged on a theological treatise (see *Correspondence,* pp. 204, 206). During the next few years Spinoza was at work on his *Tractatus Theologico-Politicus,* which was published anonymously in 1670. Why did he put aside his *Ethics* in order to write a treatise on the Scriptures? The chief reason is stated on the very title-page of the *Tractatus,* which states that its object is "to show that not only is perfect liberty to philosophize compatible with devout piety and with the peace of the State, but that to take away such liberty is to destroy the public peace and even piety itself." Already in 1665 Spinoza mentioned this object to Oldenburg. But he also mentioned another, namely, he wanted to clear himself of the charge of atheism which had been brought against him. It would appear that, with the completion of the *Ethics* in sight, Spinoza was considering the question of its publication, but found that such a step was impracticable in the then state of public opinon, which under the increasing influence of the clerics and monarchists became very intolerant and restive, as the troubles caused by the war multiplied. Spinoza consequently conceived the plan of vindicating the cause of freedom of thought in a manner that would at once serve the general interest of the Republic and also prepare the way for the publication of his own philosophy. The chief obstacle was the Calvinist clergy with their constant appeal to Scripture, which they interpreted in any manner that served their fanaticism. So Spinoza set himself the task of showing that the Bible, properly understood, gives no support to the intolerance of the clerics and their interference in civil and political affairs.

Last Years (1670–1677).—In May 1670, shortly after the anonymous appearance of the *Tractatus Theologico-Politicus,* Spinoza moved into The Hague, possibly in order to be nearer some of his influential friends. He certainly needed protection. His book created a stir, and went through five editions in as many years. But it stirred a hornet's nest, and denunciations came fast and furious. At first Spinoza stayed on the *Stille Veerkade,* but in 1671 he went to stay with the Van der Spycks in the *Paviljoensgracht* near by, and remained in their house (now *Domus Spinozana*) to the end of his days. His work on the *Tractatus* involved the resumption of his earlier Hebrew studies, and it was about this time that he commenced his *Hebrew Grammar*. He did not, however, finish it, but returned to his *Ethics,* though the prospect of its publication became more and more remote. In 1672 the French invaded Holland, which was unprepared, and so suffered many disasters. The populace, fomented by the monarchists, sought a scapegoat, and murdered the brothers Jan and Cornelius de Witt. Spinoza was beside himself. He prepared a placard expressing his disgust with "the very lowest of barbarians," and was going to post it up on the scene of the crime. Fortunately Van der Spyck locked the door, and saved him from the fate of the De Witts. As it was, his *Tractatus* was denounced as an instrument "forged in hell by a renegade Jew and the devil, and issued with the knowledge of Mr. Jan de Witt." In 1673, while the French army was at Utrecht, Spinoza received an invitation to visit Prince Condé there. It was inspired by a Colonel Stoupe, who was in command of a Swiss regiment under Condé. Stoupe had been a Calvinist minister, and his service with Catholic France against Calvinist Holland evoked the severe censure of some of his countrymen. Stoupe was an unscrupulous adventurer, but was anxious to save appearances. So he conceived the idea of showing that the Dutch were really heretics, and for this purpose he wanted to use Spinoza as his cat's paw. He actually published later in that year a little book in which he denounced the Dutch for tolerating an atheist like Spinoza, and for making no attempt to answer his atheistical treatise. Spinoza only saw in the invitation a possible opportunity of initiating peace negotiations. So he consulted some people of authority, and, armed with the necessary safe-conducts, set out for Utrecht in May 1673. In the meantime Condé had been called away, and Spinoza after waiting for him several weeks in vain, returned to The Hague, where a suspicious rabble greeted him with scowls and stones, but did him no harm. Earlier in the same year another kind of invitation had reached Spinoza. It was an invitation from the Elector Palatine to the Chair of Philosophy in the University of Heidelburg. Spinoza declined the offer with many thanks. He had trouble enough with the clerics and theologians as a recluse, he would not court worse trouble by becoming a public character. So he stayed in The Hague, polishing his *Ethics* and his lenses, and generally practising the art of plain living and high thinking. The impression he made on the people about him may be gathered from the fact that one day his pious Lutheran hostess asked him whether he considered her religion the right way to salvation. Spinoza, of course, reassured her.

In 1675 the *Ethics* was finished finally, and Spinoza went to Amsterdam to see whether it might be published. But rumour had preceded him. Not only the clerics and theologians but even the "stupid Cartesians" were up in arms and brewing mischief. Spinoza, accordingly, abandoned the idea of publishing it. But manuscript copies of it were in the hands of his intimate friends. Once more he turned his attention to political problems, and began his *Political Treatise,* which he did not live to finish.

In 1675 Tschirnhaus visited Spinoza, and also brought about the resumption of the correspondence between Oldenburg and Spinoza. In 1676 Leibniz was staying in The Hague. Already in 1671 he had heard of Spinoza as an authority on optics and had sent him a copy of an optical tract. Since then he had read the *Tractatus Theologico-Politicus,* of which Spinoza then sent him a copy; and he had also learned from Tschirnhaus something about Spinoza's philosophy. He was evidently interested deeply. For, according to his own account, he visited Spinoza frequently and "conversed with him often and at great length."

The days of Spinoza were drawing to an end. The glass dust from the lenses had done its worst. He was in the last stage of consumption. About the middle of February 1677 he sent to Amsterdam for his medical friend Schuller. On Sunday, February 20, about 3 o'clock in the afternoon, Spinoza passed away in the presence of Schuller. Four days later he was buried in the New Church on the Spuy. He was only 44.

In accordance with his previous instructions his manuscripts were sent to Rieuwertsz in Amsterdam. Jelles, Meyer and Schuller prepared them secretly for the press. The *Opera Posthuma* by B. D. S. (and the Dutch version, *De Nagelate Schriften*) were published before the end of 1677. They consisted of the *Ethics,* the *Political Treatise,* the *Treatise on the Improvement of the Understanding,* the *Letters* and the *Hebrew Grammar.* The *Short Treatise* had disappeared, but two copies of a Dutch version were recovered in 1852 and an edition was published in 1862. Two short essays on *The Rainbow* (1687) and *The Calculation of Chances* were also lost for a time, but were found and published, *The Rainbow* in 1862, and both essays in 1883.

For about a century Spinoza's name was anathema. His writings were indeed studied and his ideas were borrowed to a greater extent than is commonly supposed. But people dared not mention his name with respect, much less acknowledge their indebtedness to him. In time, however, things improved. Lessing, Goethe and Coleridge did most to rehabilitate his name, and others followed suit. The monument at The Hague, the *Spinozahuis* at Rijnsburg, and the *Domus Spinozana* in The Hague bear testimony to the reverence in which the memory of Spinoza is now held throughout the civilized world.

THE PHILOSOPHY OF SPINOZA

General Account.—The pioneers of modern thought were inspired by a revulsion from the mediaeval reliance on authority, and the subordination of reason to it. The Humanists of the Renaissance attempted to vindicate the autonomy of reason as against the authority of books and institutions. This rationalist spirit affected some of the Jews of Amsterdam, and, as already remarked, brought them into conflict with established authority. It was the same spirit that brought about the crisis in the early life of Spinoza, who eventually became the prince of rationalists. He insisted that even the Scriptures must be submitted to the test of reason, and produced the most effective protest against the subordination of reason to their authority. This revolt against mere authoritarianism, however, only represented the negative side of rationalism. Important as this was, it was only preparatory to its positive aspect. The positive side of rationalism may be seen in the great classics of science in the 16th and 17th centuries—the works of Copernicus, Vesalius, Galileo, Gilbert, Kepler, Harvey, Boyle, Descartes, Huygens, Pascal, Leibniz and Newton, to mention only a round dozen of the most famous names of the period. Their discoveries were the positive results of reason, whose main function it is to trace the connections between things, to discover their laws, and to display the order which makes things intelligible. It may be said, without any disrespect for these famous men, that the positive side of rationalism also found its fullest expression in Spinoza. For he attempted a synthesis of the whole of reality. This attempt shocked some of the above-mentioned geniuses, and would have shocked the rest, had they heard of it. For none of them dreamed of the possibility of bridging the chasm between the natural and the supernatural. Spinoza conceived of the whole of reality, including the human and the divine, as an organically interconnected cosmos, in which there is nothing capricious or contingent, but everything happens in an orderly manner according to law.

Spinoza arrived at his conception partly as follows. Whatever object or event be considered, it can only be explained by reference to innumerable others which condition it. Each of these is, in turn, dependent on innumerable others. Each finite thing seems to send out innumerable tendrils and derive support from all directions. Is it conceivable that reality should be composed entirely of such conditional, dependent things? Spinoza, like others, said No. There must be some self-existing, independent or absolute Being as the ground of all that is dependent. But what is the relation of this absolute Being to the world of dependent things and events? The common answer is that this absolute Being is God, an omnipotent supernatural Being who created the world out of nothing, maintains its existence, and occasionally interferes with it in miraculous ways. This conception was almost universal at that time. Newton subscribed to it. And Descartes made a special entry in his diary to record his belief in the three miracles, namely, the creation out of nothing, free-will, and the God-man. But Spinoza rejected the idea of an external Creator suddenly, and apparently capriciously, creating the world at one particular time rather than another, and creating it out of nothing. The solution appeared to him more perplexing than the problem, and rather unscientific in spirit as involving a break in continuity. He preferred to think of the entire system of reality as its own ground. This view was simpler; it avoided the impossible conception of creation out of nothing; and was religiously more satisfying by bringing God and man into closer relationship. Instead of Nature, on the one hand, and a supernatural God, on the other, he posited one world of reality, at once Nature and God, and leaving no room for the supernatural. This so-called *Naturalism* of Spinoza is only distorted if one starts with a crude materialistic idea of Nature and supposes that Spinoza degraded God. The truth is that he raised Nature to the rank of God by conceiving Nature as the fulness of reality, as the One and All. He rejected the specious simplicity obtainable by denying the reality of Matter, or of Mind, or of God. The cosmic system comprehends them all. In fact, God and Nature become identical when each is conceived as the Perfect Self-Existent. This constitutes Spinoza's *Pantheism*.

God or Nature consists of Attributes. God, as the complete system of Attributes, is *absolutely* infinite or complete; each Attribute is only infinite of its kind. By Attribute Spinoza means an ultimate or irreducible quality or energy. He names two such Attributes, namely, Extension and Thought, but he allows for the possibility of an infinity of Attributes. The Attributes do not belong to, but are identical with, Substance. Reality, moreover, is essentially dynamic, not static—to be is to be doing. Thus the Attribute Extension is really the whole of material energy, and the Attribute Thought is the whole of mind-energy. All material things and events are changing modes or states of Extension; and all mental events or experiences are similarly modifications or states of Thought. Each Attribute exhausts its kind of reality, is an ultimate character, activity or "world-line" of Nature, and gives rise to its entire series of objects and events in accordance with its own laws. These finite objects and events are real enough while they last, but as finite modes they change and pass; not, however, into mere nothingness, for the Attribute, of which they are states, abides. The cosmic process never stops.

Spinoza's conception of Extension and Thought, or Matter and Consciousness, as concurrent Attributes or Energies of Reality cast a new light on the problem of the relation between body and soul. Indeed, it was this problem which led him to the conception of concurrent Attributes. Under the influence of Plato and of Christianity, body and soul had come to be regarded as antagonistic to each other, and their apparently intimate relation caused much perplexity to Cartesians and others. Materialists tried to explain away the soul; idealists sought to explain away the body; the Cartesian Occasionalists fell back on the miraculous intervention of God to synchronize body and soul (that is, physical and mental processes) like the wire-puller in a Punch and Judy show. Spinoza realized the *difference* between the mental and the material, but rejected the Cartesian conception of their *antagonism*. So he did not hesitate to attribute to God both Extension and Thought. And man, a finite mode of God, is thus both physical and mental, and functions in both ways concurrently, even if each series of events is self-contained. This solution committed Spinoza to the view that all physical beings are animated, though in very different degrees; and Spinoza accepted this view.

Theory of Knowledge.—Spinoza commenced a treatise specially devoted to the problem of Knowledge. But this work, the *Treatise on the Improvement of the Understanding,* was never completed. In his other works epistemological discussions are intimately linked with the rest of his philosophy. Indeed, even in the *Treatise on the Improvement of the Understanding* epistemological views are almost inseparably connected with ethical and religious ones. That is the consequence of his characteristic conception of "Knowledge." For Spinoza "Knowledge" is "life," not in the sense that contemplation is the highest life, but in the sense that knowledge is the means of holding together the threads of life in a systematic unity that can fill its proper place in the cosmic system. In this sense the effort after the highest knowledge becomes part of the cosmic activities by which cosmic unity is maintained, and so part of the very life of God. There are two things which must be borne in mind in connection with Spinoza's conception of knowledge. The first is his insistence on the *active* character of knowledge. The ideas or concepts by means of which thought construes reality are not like "lifeless pictures on a panel"; they are activities by which reality is apprehended; they are part of reality, and reality is activity. The second point is that Spinoza does not divorce knowing from willing. Man always acts according to his lights. If a man's endeavours appear to fall short of his knowledge, that is only because his knowledge is not really what it is held to be, but is wanting in some respect. On the one hand, reason, for Spinoza, is essentially the "practical reason." On the other hand, the highest expression of willing is experienced in that striving for consistency and harmony which is so characteristic of reason. For Spinoza, then, as for Bacon and all the Renaissance thinkers, "Knowledge is power," but in a much deeper sense than Bacon intended.

Spinoza's account of knowledge is particularly interesting as a clue to the way in which he gradually built up his ontology. He distinguishes three ascending grades of knowledge, namely, opinion, reason and intuition. By "opinion" Spinoza means the lowest grade of knowledge in which one assents to what one hears, perceives or imagines. It is the pre-scientific stage of knowledge. Its main characteristic is that objects and events are apprehended as detached things, without any insight into their connections or laws. The second grade, or "reason," is that in which we have an insight into the connections of things and events, and their laws; it is the stage of scientific knowledge. This grade of knowledge is greatly superior to the first, inasmuch as a knowledge of their connections and laws makes things more intelligible. But even this stage is imperfect because rather abstract. It reveals the course of single threads in the fabric of reality, not the whole pattern; it traces "world-lines," but affords no synoptic vision of the cosmos as a whole. It is the function of the third grade of knowledge, "intuition," to complete the scheme. In intuitive knowledge the cosmic system is grasped as a whole. This highest stage is only possible for a mind that has been through the discipline of the rational stage. Unlike the mystics, Spinoza does not regard intuitive vision as a substitute for thought and entirely different from it, but rather as its highest fruit—it is "thoughtfulness matured to inspiration." The three stages of knowledge might be roughly compared with the three stages in the acquisition of the knowledge of a new language.

First come the separate letters of the alphabet; then combinations of letters into words and of words into sentences, etc., in accordance with the laws of grammar; lastly comes the stage when the significance of a whole sentence or paragraph is grasped at a glance. So it is with the great book of Nature. First comes the perception of apparently isolated facts and events; next comes the understanding of their interconnections and laws; finally comes the intuition of the structure and significance of the whole—the vision which sees all things in God, and God in all things.

Spinoza's theory of knowledge appears to make the ontological assumption that reality is an interconnected system. Spinoza himself regarded it as an ultimate intuition. And his theory of knowledge was in some ways a justification of that view. To realize this it is necessary to grasp the fundamental distinction which Spinoza draws between "opinion" and "reason," or perception and understanding. A percept or an image is, for Spinoza, something entirely different from an idea or concept. Conception or understanding is an activity which grasps interconnections, and has nothing to do with images as such. Perception and imagination, on the other hand, are concerned with images and not with connections. And the laws of these two kinds of activities are as different as are their objects. Perception, or imagination, is concerned with images and follows the laws of association; conception or understanding is concerned with connections and follows the laws of logic. Hence Spinoza's insistence that "we can not *imagine* God, but we can *conceive* Him" (*Correspondence,* p. 289). Hence also Spinoza's rejection of Baconian empiricism. From observations of particulars as such it would be impossible, according to Spinoza, to derive laws or necessary connections. The laws or general truths of science rest, in the last resort, not on their correspondence with objects of perception, but on their harmonious interconnection in a system of truths. Spinoza, accordingly, dispenses with an external criterion of truth. "The true," he maintains, "reveals itself and the false." The ultimate test of truth is more truth or more knowledge, or the coherence of all that is known. The false or untrue betrays itself by its incoherence with what is already known. In fact, Spinoza for the most part regards ideas or concepts from the point of view of their *adequacy* rather than their *truth,* in order to avoid the suggestion of a merely external correspondence such as is usually associated with the term "truth." Concepts (or "ideas" in this sense) are acts of thought by which the laws and interconnections of things and events are apprehended. They are *adequate* in so far as they really enable us to systematize a certain range of facts. In that case they are also true, for they agree with the facts. The primacy, however, is with the *adequacy* of the concept, because until we have the adequate concept we can not apprehend the facts in such a way that it can be said to agree with them, or to be *true.*

In the history of philosophy Spinoza was the first to elaborate the coherence theory of truth. In his time mathematics was the only science that could serve as a model of such a coherent system. Hence his addiction to the method of geometry. The significance of his use of this method has been misinterpreted. His sole aim was to express his philosophy in as coherent and objective a manner as possible. Two points should be noted in particular. In the first place, Spinoza did not suppose that science or philosophy can dispense with observation or experience. He fully realized the importance of experience in the very setting of the problems which science and philosophy seek to solve; and it is known from his letters that he carried out many chemical and physical experiments. All that he insisted upon was that science involves much more than mere observation, that it needs concepts not derived from experience. It was his intention to write about scientific method, and to show that Bacon's ideas about it were inadequate; but this was one of several plans which he did not live long enough to carry out. The second point is that Spinoza had no delusions about the conclusiveness of the geometrical method. He himself had expounded the philosophy of Descartes in that method, although he thoroughly disagreed with it.

Above all it is important to note that, for Spinoza, the highest knowledge ("intuitive" or "clear" knowledge) is something much fuller and richer than the abstract assertions usually associated with the term knowledge. In the *Short Treatise* (p. 69 ed. Wolf) he describes it as "feeling and enjoying the thing itself." One must try to realize his meaning by thinking of what happens when a train of thought interests a thinker so deeply as to master him completely, and he gets so absorbed in the object of his thought as to identify himself with it. If we can conjure up all this vividly and warmly, then we may realize how Spinoza came to identify the highest "knowledge" with that "intellectual love of God" in which the individual realizes himself as part of the living Universe. In this state he does not merely picture reality in an external manner, but feels its very heart throb, and feels himself as part of it. But here we are on the verge of the mystical where all but the greatest poets cease to be articulate.

Substance, Attributes, Modes.—Spinoza's ideas relating to the character and structure of reality are expressed by him in terms of *substance, attributes,* and *modes.* These terms are very old and familiar; but not in the sense in which Spinoza employs them. To understand Spinoza, it is necessary to lay aside all preconceptions about them, and follow Spinoza closely. Spinoza, as already explained, found it impossible to understand the finite, dependent, transient objects and events of experience without assuming some reality not dependent on anything else but self-existent, not produced by anything else but eternal, not restricted or limited by anything else but infinite. Such an uncaused, self-sustaining reality he called *substance.* So, *e.g.,* he could not understand the reality of material objects and physical events without assuming the reality of a self-existing, infinite and eternal physical force which expresses itself in all the movements and changes which occur, as we say, in space. This physical force he called *Extension,* and described it, at first, as a *substance,* in the sense just explained. Similarly, he could not understand the various dependent, transient mental experiences with which we are familiar without assuming the reality of a self-existing, infinite and eternal consciousness, mental force, or mind-energy, which expresses itself in all these finite experiences of perceiving and understanding, of feeling and striving. This consciousness or mind-energy he called *Thought,* and described it also, at first, as a *substance.* Each of these "substances" he regarded as infinite of its kind (that is, as exhaustive of all the events of its own kind), and as irreducible to the other, or any other, substance. But in view of the intimate way in which Extension and Thought express themselves conjointly in the life of man, Spinoza considered it necessary to conceive of Extension and Thought not as detached realities, but as constituting one organic whole or system. And in order to express this idea, he then described Extension and Thought as *Attributes,* reserving the term *Substance* for the system which they constitute between them. This change of description was not intended to deny that Extension and Thought are substances in the sense of being self-existent, etc. It was only intended to express their coherence in one system. The system of course would be more than any one attribute. For each attribute is only *infinite of its kind;* the system of all the attributes is *absolutely infinite,* that is, exhausts the whole of reality. Spinoza, accordingly, now restricted the term "substance" to the complete system, though he occasionally continued to use the phrase "substance or attribute," or described Extension as a substance. As commonly used, especially since the time of Locke, the term substance is contrasted with its attributes or qualities as their substratum or bearer. But this meaning must not be read into Spinoza. For Spinoza, Substance is not the support or bearer of the Attributes, but the system of Attributes—he actually uses the expression "Substance or the Attributes." If there is any difference at all between "Substance" and "the Attributes," as Spinoza uses these terms, it is only the difference between the Attributes conceived as an organic system and the Attributes conceived (but not by Spinoza) as a mere sum of detached forces. Something is still necessary to complete the account of Spinoza's conception of Substance. We have so far only considered the two Attributes, namely, Extension and

Thought. Spinoza, however, realized that there may be other Attributes, unknown to man. If so, they are all part of the one Substance or cosmic system. And using the term "infinite" in the sense of "complete" or "exhaustive," he ascribed to Substance an infinity of Attributes, that is, all the Attributes there are, whether known to man or not.

Now reality, for Spinoza, is activity. Substance is incessantly active, each Attribute exercising its kind of energy in all possible ways. Thus the various objects and events of the material world come into being as modes (modifications or states) of the attribute Extension; and the various minds and mental experiences come into being as modes of the attribute Thought (or Consciousness). These modes are not external creations of the Attributes, but immanent results—they are not "thrown off" by the Attributes, but are states (or modifications) of them, as air-waves are states of the air. Each Attribute, however, expresses itself in its finite modes not immediately (or directly) but mediately (or indirectly), at least in the sense to be explained now. Galilean physics tended to regard the whole world of physical phenomena as the result of differences of motion or momentum. And, though erroneously conceived, the Cartesian conception of a constant quantity of motion in the world led Spinoza to conceive of all physical phenomena as so many varying expressions of that store of motion (or motion and rest). Spinoza might, of course, have identified Extension with energy of motion. But, with his usual caution, he appears to have suspected that motion may be only one of several types of physical energy. So he described motion simply as a mode of Extension, but as an *infinite* mode (because complete or exhaustive of all finite modes of motion) and as an *immediate* mode (as a direct expression of Extension). Again, the physical world (or "the face of the world as a whole," as Spinoza calls it) retains a certain sameness in spite of the innumerable changes in detail that are going on. Accordingly, Spinoza described also the physical world as a whole as an *infinite* mode of Extension ("infinite" because exhaustive of all facts and events that can be reduced to motion), but as a *mediate* (or indirect) mode, because he regarded it as the outcome of the conservation of motion (itself a mode, though an *immediate* mode). The physical things and events of ordinary experience are *finite* modes. In essence each of them is part of the Attribute Extension, which is active in each of them. But the finiteness of each of them is due to the fact that it is restrained or hedged in, so to say, by other finite modes. This limitation or determination is negation in the sense that each finite mode is *not* the whole attribute Extension, it is not the other finite modes. But each mode is positively real and ultimate as part of the Attribute.

In the same kind of way the Attribute Thought exercises its activity in various mental processes, and in such systems of mental process as are called minds or souls. But in this case, as in the case of Extension, Spinoza conceives of the finite modes of Thought as mediated by infinite modes. The immediate infinite mode of Thought he describes as "the idea of God"; the mediate infinite mode he calls "the infinite idea" or "the idea of all things." The other Attributes (if any) must be conceived in an analogous manner. And the whole Universe or Substance is conceived as one dynamic system of which the various Attributes are the several world-lines along which it expresses itself in all the infinite variety of events.

Having regard to the persistent misinterpretation of Spinozism it may be as well to emphasize the dynamic character of reality as Spinoza conceived it. The cosmic system is certainly a logical or rational system, according to Spinoza, for Thought is a constitutive part of it; but it is not *merely* a logical system—it is dynamic as well as logical. His frequent use of geometrical illustrations affords no evidence at all in support of a purely logico-mathematical interpretation of his philosophy; for Spinoza regarded geometrical figures, not in a Platonic or static manner, but as things traced out by moving particles or lines, etc., that is, dynamically.

Emergence.—A few words may be added here to indicate the merits of Spinoza's conception of the Universe in relation to the doctrine of emergent evolution as maintained by C. Lloyd Morgan and S. Alexander. (*See* EMERGENCE and PHILOSOPHY, HISTORY OF.) If reality is considered from the point of view of the finite modes (or *Natura naturata*, in Spinoza's terminology) instead of from that of Substance or the Attributes (or *Natura naturans*), then beginning with the simplest kinds of modes and passing on to more and more complex combinations of them, each such combination will always be something more than the mere sum of its components. To this extent something new emerges at every stage where a system is formed out of simple constituents. At a certain stage we reach the various infinite modes, then the several Attributes, and finally God. For Spinoza, however, God or the Attributes and the Infinite Modes are eternal, so that the process of evolution can only concern the world of finite modes. This kind of emergent evolution Spinoza can be said to recognize when he identifies moral progress with ever widening synthesis—"the more perfection (*i.e.*, reality) anything has, the more does it participate also in Deity" (*Correspondence*, p. 151). But Spinoza's conception has an advantage over the new conception of "emergence" (including the emergence of Deity). For the new doctrine involves the conception of the emergence of something out of nothing, inasmuch as the "emergent" is not contained in the sum of its conditions, but is something new. For Spinoza, on the other hand, the fulness of reality in all its essentials is always there, and the emergence of higher modes with the increasing synthesis or "holism" (*q.v.*) of lower modes does not involve a miraculous emergence of something out of nothing, but merely a rearrangement of what is already real.

Moral Philosophy.—For Spinoza, reality means activity, and the reality of anything expresses itself in a tendency to self-preservation—to exist is to persist. In the lowest kinds of things, in so-called inanimate matter, this tendency shows itself as inertia; in living organisms, it shows itself as a "will to live." Regarded physiologically this effort is called *appetite;* when we are conscious of it, it is called *desire.* The moral categories, good and evil, are intimately connected with desire, though not in the way commonly supposed. Man does not desire a thing because he thinks it is good, or shun it because he considers it bad; rather he considers anything good if he desires it, and regards it as bad if he has an aversion for it. Now whatever is felt to heighten vital activity gives pleasure; whatever is felt to lower such activity causes pain. Pleasure coupled with a consciousness of its external cause is called love, and pain coupled with a consciousness of its external cause is called hate—"love" and "hate" being used in the wide sense of "like" and "dislike." All human feelings are derived from pleasure, pain and desire. Their great variety is due to the differences in the kinds of external objects which give rise to them, and to the differences in the inner conditions of the individual experiencing them. Spinoza gives a detailed analysis of the whole gamut of human feelings, and his account is one of the classics of psychology. For the present purpose the most important distinction is that between "active" feelings and "passive" feelings (or "passions"). Man, according to Spinoza, is active or free in so far as any experience is the outcome solely of his own nature; he is passive, or a bondsman, in so far as any experience is due to other causes besides his own nature. The active feelings are all of them forms of self-realization, of heightened activity, of strength of mind, and are therefore always pleasurable. It is the passive feelings (or "passions") which are responsible for all the ills of life, for they are induced largely by things outside us and frequently cause that lowered vitality which means pain. Spinoza next links up his ethics with his theory of knowledge, and correlates the moral progress of man with his intellectual progress. At the lowest stage of knowledge, that of "opinion," man is under the dominant influence of things outside himself, and so is in the bondage of the passions. At the next stage, the stage of "reason," the characteristic feature of the human mind, its intelligence, asserts itself, and helps to emancipate him from his bondage to the senses and external allurements. The insight gained into the nature of the passions helps to free man from their domination. A better understanding of his own place in the cosmic system and of the place of all the objects of his likes and dislikes, and his insight into the necessity which rules all things, tend to cure him of his resentments, regrets and disappointments. He grows reconciled to things, and wins peace of mind. In this way reason teaches acquiescence in the universal order, and elevates the mind above the turmoil of passion. At the highest stage of knowledge, that of "intuitive knowledge," the mind apprehends all things as expressions of the eternal cosmos. It sees all things in God, and God in all things. It feels itself as part of the eternal order, identifying its thoughts with cosmic thought and its interests with cosmic interests. Thereby it becomes eternal as one of the eternal ideas in which the Attribute Thought expresses itself, and attains to that "blessedness" which "is not the reward of virtue, but virtue itself," that is, the perfect joy which characterises perfect self-activity. This is not an easy or a common achievement. "But," says Spinoza, "everything excellent is as difficult as it is rare."

Two things at least must be added to prevent a misunderstanding of this slight sketch of Spinoza's ethics. The first is that he did not teach asceticism. Circumstances compelled him to be extremely frugal and live on a few pence a day; but he affected no contempt for the joys of life. On the contrary, he urged that "it is the part of a wise man to use the world and delight himself in it as best he may, though not to satiety, for that is no delight." The second point is that Spinoza, though compelled by circumstances to live the life of a recluse more or less, laid great stress on the social character of the moral life. "Men," he says, "will find that their needs are best satisfied by mutual help, and that only by uniting their strength can they escape the dangers that beset them everywhere." He insists further that the good pursued by reasonable men is a good that may be enjoyed by all, and that the virtuous man wants no special privileges, but desires also for his fellow men whatever he desires for himself. The third point is that Spinoza's contention that the conception of goodness, like that of purpose, is inapplicable to the cosmic system as a whole does not mean that he denied the validity of the distinction between good and evil in the realm of human conduct. The notions "good" and "evil" involve the conception of an ideal that is desired but not yet realized, and the realization of which is helped by some things, hindered by others. Now the cosmic system, or God, is completely real or perfect, and therefore "beyond good and evil." But with finite modes like men it is quite different. Much can be done that really heightens or lowers human life. Whatever enriches it really is good; whatever impoverishes it really is bad, even if its badness is something negative, a defect, rather than something positive.

Political Philosophy.—Spinoza agreed with Hobbes that if each man had to fend for himself, with nothing but his own right arm to rely upon, then the life of man would be "nasty, brutish and short." The truly human life is only possible in an organized community, that is, a state or commonwealth. The state ensures security of life, limb and property; it brings within reach of every individual many necessaries of life which he could not produce by himself; and it sets free sufficient time and energy for the higher development of human powers. Now the existence of a state depends upon a kind of implicit agreement on the part of its members or citizens to obey the sovereign authority which governs it. In a state no one can be allowed to do just as he pleases. Every citizen is obliged to obey its laws; and he is not free even to interpret the laws in a special manner. This looks at first like a loss of freedom on the part of the individuals, and the establishment of an absolute power over them. Yet that is not really so. In the first place, without the advantages of an organized state the average individual would be so subject to dangers and hardships of all kinds and to his own passions that he could not be called free in any real sense of the term, least of all in the sense in which Spinoza used it. Man needs the state not only to save him from others but also from his own lower impulses and to enable him to live a life of reason, which alone is truly human. In the second place, state sovereignty is never really absolute. It is true that almost any kind of government is better than none, so that it is worth while bearing much that is irksome rather than disturb the peace. But a reasonably wise government will even in its own interests endeavour to secure the good will and co-operation of its citizens by refraining from unreasonable measures, and will permit or even encourage its citizens to advocate reforms, provided they employ peaceable means. In this way the state really rests, in the last resort, on the united will of the citizens, on what Rousseau, who read Spinoza, subsequently called the "general will." Spinoza sometimes writes as if he upheld absolute sovereignty. But that is due mainly to his determined opposition to every kind of ecclesiastical control over the state. Though he is prepared to support what may be called a state religion, as a kind of spiritual cement, yet his account of this religion is such as to make it acceptable to the adherents of any one of the historic creeds, to deists, pantheists and all others, provided they are not fanatical believers or unbelievers. It is really in the interests of freedom of thought and speech that Spinoza would entrust the civil government with something approaching absolute sovereignty in order to effectively resist the tyranny of the militant churches.

One of the most striking features in Spinoza's political theory is his basic principle that Right is Might. This principle he applied systematically to the whole problem of government, and seemed rather pleased with his achievement, inasmuch as it enabled him to treat political theory in a scientific spirit, as if he were dealing with applied mathematics. The identification or correlation of right with power has caused much misunderstanding. People supposed that Spinoza reduced justice to brute force. But Spinoza was very far from approving *Realpolitik*. In the philosophy of Spinoza the term "power" (as should be clear from the above account of his moral philosophy) means a great deal more than physical force. In a passage near the end of his *Political Treatise* he states explicitly that "human power chiefly consists in strength of mind and intellect"—it consists in fact, of all the human capacities and aptitudes, especially the highest of them. Conceived correctly, Spinoza's whole philosophy leaves ample scope for ideal motives in the life of the individual and of the community.

Spinoza discusses the principal kinds of states, or the main types of government, namely, Monarchy, Aristocracy and Democracy. Each has its own peculiarities and needs special safeguards, if it is to realize the primary function of a state. Monarchy may degenerate into Tyranny unless it is subjected to various constitutional checks which will prevent any attempt at autocracy. Similarly, Aristocracy may degenerate into Oligarchy, and needs analogous checks. On the whole, Spinoza favours Democracy, by which he meant any kind of representative government. In the case of Democracy the community and the government are more nearly identical than in the case of Monarchy or Aristocracy; consequently a democracy is least likely to experience frequent collisions between the people and the government, and so is best adapted to secure and maintain that peace which it is the business of the state to secure.

Bible Criticism.—Spinoza was not only the real father of modern metaphysics and moral and political philosophy, but also of the so-called higher criticism of the Bible. This part of his work was incidental to his plea for freedom of thought and speech. His *Tractatus Theologico-Politicus* undertook to show that the Scriptures properly understood gave no authority for the militant intolerance of the clergy who sought to stifle all dissent by the use of force. To achieve his object, Spinoza had to show what is meant by a proper understanding of the Bible. And this gave him occasion to apply criticism to the Bible. To appreciate his services in this connection it must be remembered that his age was remarkably lacking in historical sense, especially in matters relating to religion. Saintly contemporaries like John Bunyan and Manasseh ben Israel made the most fantastic use of Scripture texts; while militant clerics, relying on the ignorant bibliolatry of the masses, misapplied Bible texts to gain their ends. Spinoza, who permitted no supernatural rival to Nature and no rival authority to the civil government of the state, rejected also all claims that Biblical literature should be treated in a manner entirely different from that in which any other document is treated that claims to be historical. His contention that the Bible "is in parts imperfect, corrupt, erroneous, and inconsistent with itself, and that we possess but fragments of it" roused a great storm at the time, and was mainly responsible for his evil repute for a century at least. Nevertheless, the intelligent world has gradually come round to his views, and has learned to agree with him that the real "word of God," or true religion, is not something written in books but "inscribed on the heart and mind of man." And many ministers of religion now praise Spinoza's services in the correct interpretation of Scripture as a document of first rate importance in the progressive development of human thought and conduct.

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(A. Wo.)

SPINY SQUIRREL, a group of African ground squirrels, characterized by the spiny nature of the fur. They form the genera *Xerus, Euxerus, Atlantoxerus* and *Geoscivrus*, being characterized by the small size or absence of the ears, and the long, nearly straight, claws. Typical spiny squirrels live in clefts or holes of rocks, or in burrows. (*See* RODENTIA.)

SPION KOP, a mountain in Natal on the north side of the Tugela river, and 24 m. W.S.W. of Ladysmith. It is celebrated as the scene of a battle (Jan. 24, 1900) in the Transvaal War, in which the British forces under Sir Redvers Buller were defeated by the Boers (*see* TRANSVAAL and LADYSMITH).

SPIRAEA, in botany, a genus of shrubs of the rose family (Rosaceae, *q.v.*), comprising about 75 species, natives of the northern hemisphere. They are mostly slender shrubs, 2 to 8 ft. high, usually with simple leaves and small white, pink or reddish flowers arranged in dense showy clusters. *S. salicifolia* (meadow-sweet) occurs in England and Scotland. *S. latifolia* (American meadow-sweet), *S. alba* (white meadow-sweet) and S. *tomentosa* (hardhack, *q.v.*) are representative species of eastern North America. *S. Douglasii* (western meadow-sweet) occurs on the Pacific coast. Among the best-known cultivated forms are *S. prunifolia* (bridal-wreath) and the popular hybrid *S. Van Houttei.*

SPIRAL: *see* CURVES.

SPIRE, in architecture, a steep, pyramidal form, crowning a tower. The origin of the form was the simple, four-sided, pyramidal roof frequently erected over Romanesque towers, as in many crude 11th century examples in Normandy, some of the Italian campaniles of the 11th and 12th centuries, and many German Romanesque towers, mostly of the 12th century. This form is abrupt and stunted and may easily be ungraceful, and various experimental attempts were made to soften the line. Thus the late 11th century tower at Le Puy en Velay has the successive stages of the tower receding and broken up by projecting bays on the sides. Furthermore, the pyramidal roof itself is decorated with corner finials and small, round-headed dormers. In Germany the form was varied by ending each face of the square tower in a gable, the plane determined by adjacent gable slopes establishing the slope of the pyramid, as in the square tower of the abbey church of Laach (*c.* 1156). The pleasanter effect of the octagonal spires over octagonal towers, like another of the towers at Laach, or the older of the two towers at Mainz (late 12th century), led to attempts to combine an octagonal spire with a square tower. This was accomplished in various ways, one of the simplest being the so-called broach spire, in which small, triangular planes of a less steep pitch than that of the spire proper occur at the bottom of the corner spire faces, with their lower points coinciding with the corners of the towers, as seen in the 12th century church of S. Columba at Cologne.

A more developed form of broach spire lies in the substitution of a small pyramid at the bottom of the corner faces, instead of the triangular plane. This is a type which became common in English Gothic spires. It may be described geometrically as the intersection of a four-sided pyramid of low slope by an eight-sided pyramid of steep slope, as in the 14th century spire of St. Mary's at Stamford. A more elaborate method of softening the junction between square and octagon was to carry the corner faces down unbroken to the top of the tower and fill the triangular corners thus left with decorative finials. An early example is the crossing tower of the church of S. Ours, at Loches, France (12th century).

In the south-west tower of Chartres cathedral (end of the 12th century) a further advance is made in connecting tower and spire, by adding high, gabled dormers on the faces of the spire, over the centres of the tower faces, as well as richly developing the corner pinnacles. In the spire at Senlis cathedral (13th century) a vertical, octagonal stage, or lantern, is placed between the square tower and the octagonal spire. The corners of the square tower are occupied by pinnacles and eight slim dormers surround the spire base. The edges of the Chartres and Senlis spires are decorated with projecting roll mouldings, and those at Senlis are further enriched by crockets which form an admirable fretting of the silhouette. It is probable that similar crocketed spires were almost universally intended over the great towers of most of the French cathedrals. The towers at Laon, for instance, were once so crowned and spires at Reims and Amiens were begun.

Gothic Climax.—It was in Normandy, England and Germany that Gothic spire design reached its climax. Particularly famous are the spires of S. Sauveur at Caen (14th century); S. Pierre at Caen (1308) and the magnificent group of spires at Coutances cathedral (13th century), in which the spire dormers and the corner pinnacles are treated with the utmost richness and the sense of height and slimness emphasized in every possible manner. The customary lavishness of the French Flamboyant style is magnificently illustrated in its pierced and intricately traceried spires. The two most remarkable examples are the northern spire of Chartres cathedral (1506–13), by Jehan Texier, and the so-called Tour de Beurre (*c.* 1520) of the cathedral at Rouen.

Spires of a simple type crown many of the Italian campaniles, and during the 13th, 14th and 15th centuries, spires and lanterns were frequently added to earlier towers. In neither Italy nor Spain, however, was the highly developed spire a native form, and Italian spires were simple, slate, tile or metal covered, pyramidal or conical roofs of timber. Burgos cathedral is unique in Spain in possessing two western spires of intricate, open-work masonry, which date from the 15th century. These, however, are known to have been designed by a German architect.

German luxuriance, which had already appeared in the numerous varieties of timber spires used on the Rhenish Romanesque churches, found equally congenial expression in the stone spires of the Gothic period. The early, simple type is seen in the solid spires of S. Elizabeth at Marburg (not completed until the middle of the 14th century but probably from a 13th century design). The cathedral at Freiburg has a spire (1270–88) which is of a new and infinitely richer type. The low, square tower carries a high, octagonal lantern, each side of which is capped by a slim gable and filled with delicate tracery, the corners of the square being filled with rich, triangular pinnacles, one of which is continued up as an open, spiral staircase, giving access to the upper portion. The spire rises above the lantern, a mere cage of openwork tracery, with crocketted edges, amazingly light and delicate in effect. Somewhat similar, although even more intricate in their pierced stone-work are the western spires of Regensburg cathedral (late 15th century), by Roritzer. These open-work spires became the rule in Germany, as illustrated in the intricate cage of Strasbourg cathedral (spire, 1435); the west towers of Cologne cathedral, built in the 19th century from mediaeval drawings; the over-complicated lace-work of the cathedral at Vienna (1433) and the spire at Ulm, over 500 ft. high, built in the last years of the 19th century, from 15th century drawings.

The spire of Oxford cathedral (1220) is a perfect example of the Early English spire type; it is octagonal, has a marked entasis or convex curve, and is decorated with dormers on each face and corner pinnacles. The great spire of Salisbury cathedral (1250), 406 ft. high, shows the tremendous aesthetic advantage of the greater steepness there present, which became the rule in the later English spires. During the Decorated period it became customary to finish the top of the tower with a parapet, either battlemented or of pierced tracery, and to set back the base of the spire behind the face of the wall. With this change the use of broaches disappeared and tall, corner pinnacles, sometimes supported on corner buttresses, filled the tower corners. An early example of the parapeted tower with a spire, in which broaches remain and the corner pinnacles are raised up to the top of the broach, is that of Ashbourne church, Derbyshire (14th century). Among the loveliest of Decorated spires are the two western spires of Lichfield cathedral, with heavy but effective, corner pinnacles. The highly developed type of spire with corner pinnacles and a parapet below can be seen in St. Peter's, Kettering, and Sts. Peter and Paul, Oundle (both in Northamptonshire), both of the Perpendicular period. In other examples a little flying buttress connects the corner pinnacles with the face of the spire, as in the exquisite Perpendicular spire of Louth church, Lincolnshire. Many Perpendicular spires are often ornamented with crockets up the angles.

Renaissance.—The spire was a form never thoroughly absorbed by the Renaissance, which preferred domed lanterns crowning towers. Nevertheless, during the 17th century in Germany, most effective, fantastic, spire-like forms were developed. These, based partly on Italian Baroque prototypes, usually had profiles of broken concave and convex lines, crowned at the top with a sort of onion dome, the whole rising to a considerable height, and, in imaginative quality, far surpassing any of the Italian examples. It is such fantastic spires crowning the simple towers of village churches, which give much of their character to the little towns of south Germany and Austria. At the same time, in England, the spire idea was receiving a much simpler and more straightforward, and equally effective, Renaissance expression, through the efforts of Sir Christopher Wren and his followers, particularly in the churches built after the Great Fire of London in 1666, such as St. Martin's, Ludgate hill, St. Mary-le-Bow and St. Bride's, Fleet street, all by Wren. St. Mary-le-Strand (early 18th century) and St. Martin's-in-the-Fields (1721–1726) both by James Gibbs, which simplified and refined upon their Wren prototypes, are very successful.

Even more effective are many American colonial spires, which, although originally based upon the work of Wren and Gibbs, achieved a fresh beauty through still further simplification. Particularly noteworthy is the type in which a small, octagonal, arcaded lantern crowns a simple, square tower and carries, usually above an attic, a simple, slim, white spire, as in the Old South Meeting House, Boston (1729) and the extremely delicate, white, wooden steeple of the church at Farmington, Conn. (*c.* middle 18th century). Such steeples as that of S. Paul's chapel, New York (*c.* 1767), Christ church, Philadelphia (1754) and S. Michael's, Charleston, S.C. (1742, occasionally attributed to James Gibbs himself), although more monumental in treatment and more English in effect, still retain the characteristic American delicacy. This trend toward the more slender and attenuated proportions reached its climax in the exquisitely light spire of Park street church, Boston (1819), by Peter Banner. (For bibliography *see* GOTHIC ARCHITECTURE.) (T. F. H.)

SPIRE LIGHT, the term given to the windows in a spire which are found in all periods of English Gothic architecture and are an important feature in French spires. They are not glazed, and, if of large size, sometimes have transoms to strengthen the mullions.

SPIRES: *see* SPEYER.

SPIRITS. In the chemical sense the word is sometimes applied to acids having a volatile character, as "spirits of salts" or hydrochloric acid. The name is generally restricted to distilled liquors. The *Spiritus Rectificatus* of the British Pharmacopoeia is a mixture of ethyl alcohol and water in the volume proportions of 90 to 10. There are also four standard diluted alcohols recognized by the same authority containing respectively 70, 60, 45 and 20% of ethyl alcohol by volume. The spirits of the British Pharmacopoeia (*e.g.*, Sp. aetheris nitrosi; sp. chloroformi; sp. camphorae) are solutions of various substances obtained either by distilling them with, or dissolving them in, rectified spirit.

According to the British Spirits Act of 1880 "spirits" means spirits of any description and includes all liquors mixed with spirits, and all mixtures, compounds, or preparations made with spirits. The same enactment defines "plain spirits" as "British spirits (except low wines and feints) which have not had any flavour communicated thereto or ingredient or material mixed therewith," and "spirits of wine" as "rectified spirits of the strength of not less than 43 degrees above proof," *i.e.,* 75·36% of alcohol by weight or 81·59% by volume.

In its popular use "spirits" is generally understood to mean alcoholic beverages, *e.g.,* brandy, rum, whisky, distilled from liquids which have undergone a process of fermentation.

Proof Spirit.—The British standard spirit is "proof spirit," which was defined by the Spirits Act of 1816 as "that which at the temperature of 51° F weighs exactly $\frac{12}{13}$ of an equal measure of distilled water." The temperature of the water was not defined, but there is some documentary evidence indicating that it was intended to be 51° F. A mixture of water and ethyl alcohol complying with this condition has, at 60° F, a specific gravity of 0·91976 and contains 49·28% of alcohol by weight and 51·10% by volume. Mixtures in other proportions are said to be "over proof" or "under proof," the expression of strength being based upon the number of volumes of proof spirit which could be obtained from one hundred volumes of the mixture at 50° F. Thus a strong spirit 100 volumes of which would, on the addition of water, give 166 volumes of proof spirit, is described as having a strength of 166% proof, or 66 degrees over proof, whilst one which contains, in 100 volumes, sufficient alcohol to give 45 volumes of proof spirit has a strength of 45% proof, or 55 degrees under proof. The proof gallon equivalent of a mixture, the strength and volume of which have been determined, can be ascertained by multiplying the volume in gallons by the strength and dividing by 100. Absolute alcohol has a strength of 75·35 degrees over proof.

The instrument in general use for determination of spirituous strength in Great Britain and the British Dominions is the Sikes hydrometer, legalized by 56 Geo. III. c. 40 in 1816. It is usually made of gilded brass and consists of a hollow sphere provided at one pole with a graduated rectangular stem of uniform section. At the other pole is a stem terminating in an oval counterpoise intended to give stability to the instrument when floating and to serve as a means of attachment for additional poises. The graduations of the upper stem consist of divisions marked respectively 0 to 10 from top to bottom, each division having five subdivisions. There are nine additional poises marked respectively 10, 20, etc. up to 90, the stem indication being added to the number of the requisite poise for the purpose of reading. The tables used with the instrument correlate proof strengths with the hydrometer readings. The original tables were compiled by Sikes and were legalized with the instrument. New tables were substituted by the Finance (No. 2) Act of 1915. They show the strength appropriate to each indication of the hydrometer at every degree Fahrenheit from 30 to 100, the range of strength at 60° F being from water at indication 100 to 66·7 overproof at indication 0·0. For higher strengths two additional instruments have been introduced, viz., Sikes' "A" hydrometer, which at 60° F records strengths from 66·7 o.p. to 73·5 o.p and Sikes' "B" hydrometer which renders possible the determination of the highest strengths at temperatures up to 85° F.

As already stated, the proof strengths are based upon percentages by volume at 50° F but, owing to the difference in the coefficient of expansion of water and alcohol, the volume proportions at other temperatures differ from those at 50° F. Sikes' system does not take account of this and the strength recorded is that of the mixture when at the basic temperature. Although this may be open to some objection it is of advantage to the revenue and to the trader as it renders possible the identification of a spirit and the recording of the same strength regardless of the temperature when tested.

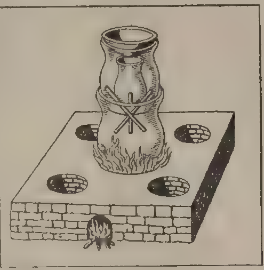

FIG. 1.—ANCIENT FORM OF STILL, USED IN TIBET

This method of assessment of alcoholic strength depends upon the difference in the respective specific gravities of alcohol and water, and the determination of the specific gravities appropriate to mixtures of these two substances is therefore of great importance. At the request of the British Government the Royal Society undertook an investigation of this problem towards the close of the 18th century and entrusted the work to Sir Charles Blagden, the secretary, and George Gilpin, clerk to the Society. The results of their experiments were published in the Philosophical Transactions 1790–94 and were of such great merit that they not only formed the basis of Sikes's values but are incorporated in many of the official tables of the present day, including those legalized in Britain in 1915. Tralles in 1911 conducted a similar investigation for the Prussian Government, whilst Gay Lussac (Paris, 1824), McCulloch (Washington, 1848), Baumhauer (Amsterdam, 1860), Mendeleeff (St. Petersburg, 1865), the Kaiserliche Normal Eichungs Kommission (Berlin, 1889), and Bureau of Standards (Washington, 1913 and 1929) were also responsible for considerable work under the auspices of their respective Governments. In the United States of America a "proof" standard is adopted; Section 3249 of the Revised Statutes provides that "proof spirit shall be held to be that alcoholic liquor which contains one-half its volume of alcohol of a specific gravity of 0·7939 at sixty degrees Fahrenheit." In Holland also a "proof" spirit forms the basis of the revenue charge, the standard being 50% by volume of anhydrous alcohol at 15° C.

Historical.—The origin of the practice of distillation is lost in antiquity. Olympiodorus, in a commentary on the second book of Aristotle's *Meteors*, states that sailors boiled the sea water and suspended large sponges from the mouth of a brazen vessel in order to imbibe the "sweet water" which is evaporated. According to Fairley the Chinese distilled liquor; *Sautchoo* was known long before the Christian era and *arrack* was made in India as early as 800 B.C. According to this and other evidence accumulated from ancient literature there is little doubt that spirits were manufactured in the East many centuries before Christ. It appears to be well established that about the end of the fourth century A.D. Zosimus described an apparatus for distilling, whilst Geber, who is said to have lived in the seventh century of the Christian era, gave an account of the process, which he described as "the raising of aqueous vapour in any vessel in which it is placed." According to Fairley (*The Analyst,* 1905) the earliest known reference to the preparation of a spirituous liquor by distillation in Great Britain is contained in the "Mead Song" by the Welsh bard Taliesin in the sixth century. Fairley also points out that distillation from fermented grain liquor was practised in Ireland before the distillation of wine was introduced. St. Patrick is credited by an old Irish legend with having first taught the Irish the art of distillation; it is certain that at the time of the first English invasion of Ireland (1170–72) the manufacture of a spirit distilled from grain (*i.e.,* whisky) was known. It is probable also that the distillation of spirit in Scotland dates back to the same early period. Towards the end of the century much home-produced spirit was obtainable in England from apothecaries and vintners. The dissolution of the monasteries under Henry VIII. resulted in many of the disestablished monks setting up in business as distillers, brewers and vinegar makers, and during the Tudor period the distilling trade became firmly established. The production of a spirit from wine (*i.e.,* brandy) appears to have been known in the ninth century but according to Morewood the first attempt at the distillation of wine in France is attributed to Arnaldus de Villa Nova in the 13th century. As a manufacturing industry the distillation of brandy in France began in the 14th century.

Official Control of Spirit Trade.—For centuries the preparation and sale of spirits in Great Britain has been under Government control. During the reign of Elizabeth a royal patent was issued to Candishe and later to Richard Drake to survey "the corrupt sorts of aqua vitae, aqua composita and usquebagh." In 1643 excise duties on spirits were regularly imposed, the tax being collected by the newly constituted excise department. By an act passed in 1657, the excise authorities were given wide powers of control over spirit manufacturers and dealers. Under the Spirits Act of 1880 the conditions imposed upon the trade are exceedingly strict. A distiller must give notice to the authorities of the erection of any new plant or apparatus and must obtain their approval. He must notify the excise officer of the time of many of his manufacturing operations. He may not upon his distillery or any premises communicating therewith brew beer, refine sugar, deal in wine or make sweets, vinegar, cider or perry. He must keep records in the form prescribed by the Commissioners of Customs and Excise of the quantities of materials used in each operation and of the results of observations to be made at various stages.

There are three methods of assessing duty and whichever gives the highest amount is adopted. The first is the "attenuation charge." This consists of levying the charge due on one gal. of proof spirit for every 100 gal. of worts collected and for every five degrees of attenuation observed, the latter being calculated by taking the difference between the highest specific gravity of the worts and the lowest gravity of the wash after complete fermentation. The second method is the "low wines" charge calculated upon the bulk quantity at proof strength of the low wines produced by the distillation of the wash. The third is the "feints and spirits" charge, assessed upon the number of proof gallons of feints and spirits produced by the final operations.

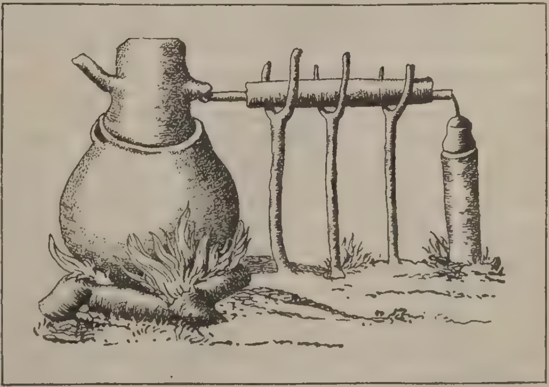

FIG. 2.—STILL OF ANCIENT TYPE AS USED IN TAHITI

Production and Consumption.—The development of official control has been coincident with a steady increase in the rate of duty on spirit and the total contribution to the national revenue from this source showed a corresponding growth until other influences affected the consumption of alcoholic beverages. Thus in 1643 the rate of customs or excise duty on "strong waters or aqua vitae" was 8d. per gallon. The customs duties on spirits

Spirits Retained for Consumption in Each Part of the United Kingdom†

Year (ended March 31)	England			Scotland			Ireland			Total		
	Home-made	Imported	Total	Home-made	Imported	Total	Home-made	Imported	Total	Home-made	Imported	Total
Total quantities	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons	Proof gallons
1922–23	9,722,699	1,869,806	11,592,505	2,757,190	330,451	3,087,641	378,771	103,432	482,203	12,858,660	2,303,689	15,162,349
1923–24	9,941,823	1,955,116	11,896,939	2,641,323	309,579	2,950,902	313,749	131,515	445,264	12,896,895	2,396,210	15,293,105
1924–25	9,473,180	1,781,558	11,254,738	2,532,494	310,867	2,843,361	281,361	121,122	402,483	12,287,035	2,213,547	14,500,582
1925–26	9,349,948	1,748,301	11,098,249	2,453,838	281,811	2,735,649	250,835	103,555	354,390	12,054,621	2,133,667	14,188,288
1926–27	8,397,592	1,433,180	9,830,772	2,099,235	222,081	2,321,316	215,175	86,415	301,590	10,712,002	1,741,676	12,453,678
Quantities per capita												
1913–14*	·48	·13	·61	1·31	·14	1·45	·62	·10	·72	·58	·13	·71
1921–22*	·27	·06	·33	·63	·10	·73	·30	·06	·36	·31	·06	·37
1922–23	·25	·05	·30	·56	·07	·63	·30	·08	·38	·29	·05	·34
1923–24	·26	·05	·31	·54	·06	·60	·24	·10	·34	·29	·05	·34
1924–25	·24	·05	·29	·52	·06	·58	·22	·09	·31	·27	·05	·32
1925–26	·24	·04	·28	·50	·06	·56	·20	·08	·28	·27	·05	·32
1926–27	·21	·04	·25	·42	·05	·47	·17	·07	·24	·24	·04	·28

*Figures for United Kingdom: those for later years refer to Great Britain and Northern Ireland only.
†This table does not include spirits delivered for methylation, use in arts and manufacture, or in fortified wines.

imported into Great Britain and Northern Ireland per proof gallon are, in 1929, as follows: Brandy and rum, £3.15.4; Imitation rum, Geneva, £3.15.5; Sweetened spirits, *e.g.*, liqueurs, cordials, etc., £3.15.11; Unsweetened spirits, *e.g.*, liqueurs, cordials, etc., £3.15.5.

There are many modifications of these rates, preferential treatment being accorded for instance, to goods of Empire origin, while a reduction is also allowed for spirits which can be proved to be of a certain maturity. The corresponding maximum excise duty is £3.14.0 per proof gallon.

The total revenue derived from spirits in recent years has been as follows:

Spirit Duties (Net Receipts)

Year	Customs (Imported)				Excise (home made)	Total
	Rum	Brandy	Other sorts	Total		
	£	£	£	£	£	£
1923–24	4,839,167	2,646,265	1,407,222	8,892,654	45,144,092	54,036,746
1924–25	4,189,670	2,475,646	1,563,616	8,228,932	42,824,674	51,053,606
1925–26	3,995,727	2,411,630	1,530,582	7,937,939	41,989,706	49,927,645
1926–27	3,110,118	2,103,573	1,280,588	6,494,279	37,058,506	43,552,785

The production of spirit in the United Kingdom amounted in 1907 to roughly 50,000,000 proof gallons. In the decade 1880–90 the quantity annually distilled remained practically stationary at about 40,000,000 gal., but during the years 1890–1900 there was a rapid increase, the maximum being attained in 1898 when nearly 64,000,000 gal. were produced. A point had then been reached at which the production considerably exceeded the consumption, due in part to the desire of the spirit trade to meet the increased demand for "matured" spirits and in part to the fact that an excessive amount of capital had, owing to the increased popularity of Scotch whisky, been attracted to the distilling industry. This overproduction led to a vast increase in the quantity of spirit remaining in warehouse. In 1906 production and consumption were about equal and the quantity of spirit in warehouse represented roughly five years' supply.

Of late years the consumption of spirits has shown a marked decline. Whereas in the opening years of the century it reached approximately one gallon per annum per head of the population, in the subsequent decade it fell to 0·75 gallon and as will be seen from the above table this decrease has continued. This is doubtless due, in part, to the high duties, but in all probability it may be attributed in some measure to a change in popular taste.

The number of distilleries in the British Isles has fluctuated in a manner corresponding to the consumption of spirit, but the variation has been chiefly in Scotland.

In 1906 the respective totals for the three countries were: Scotland 150, Ireland 28, England 8. Since that time there has been a steady decrease, the number for Great Britain and Northern Ireland being 140 in 1923 and 121 in 1926. Of the spirits distilled in the United Kingdom Scotland produces approximately one half, England and Ireland being responsible for the remainder in about equal proportions. The apparent anomaly between the number of distilleries and the quantity of spirit produced in the different parts of the kingdom is explained by the fact that the great majority of the distilleries in Scotland and Ireland are small pot still distilleries, whereas the English plants are all of considerable capacity. Illicit distillation has almost ceased in Great Britain.

The spirit produced in the United Kingdom is made almost exclusively from malt, unmalted grain (chiefly maize, rye, barley, wheat and oats) and molasses. The relative proportions of malt to unmalted grain have shown a slight upward tendency. On the other hand the quantity of molasses employed has increased very largely, owing mainly to the fact that home made spirit has largely displaced the foreign article for several industrial purposes and particularly for methylation.

In the Dominions the consumption per head of the population shows in some parts a tendency to decrease, thus, for Canada the figure for 1921 was 0·857 gal. and for 1927, 0·323 gal., and New Zealand 0·790 in 1921 and 0·518 in 1925, but in Australia there has been an increase from 0·36 gal. in 1921–22 to 0·44 gal. in 1925–26. The sale of alcoholic beverages is now prohibited in the United States of America. In other countries the consumption of spirits per head of the population, expressed in litres of absolute alcohol, has been as follows:—

Year	Denmark	Norway	Sweden	Switzerland	Germany	Holland	Belgium	France
1920	1·51	..	3·00	2·02	0·7	2·58	1·24	2·26
1921	1·51	0·44	2·40	2·16	1·0	1·45	0·99	2·09
1922	1·70	0·44	1·90	1·95	2·0	1·44	1·21	2·42
1923	1·90	0·55	1·95	2·55	1·1	1·21	1·29	2·67
1924	2·10	0·39	2·10	2·29	0·6	1·15	1·13	2·60
1925	..	0·26	2·20	2·32	1·0	..	0·97	2·70

Manufacture.—The manufacture of spirits can be divided into two or three stages according to the materials used. If they are of a saccharine nature (*e.g.*, grape juice or molasses), the first step is the conversion of the sugar into alcohol, the second operation being the separation by distillation of the alcohol and, incidentally, other volatile substances from solid matter which may be present either in suspension or in solution. If the raw material is of a farinaceous character the preliminary stage is the conversion of the starch into sugar.

Brandy.—The manufacture of genuine brandy, although requiring great care in order to obtain a high class product, is not a complicated process. The quality of the brandy produced depends primarily upon the character of the wine employed, whilst the degree of excellence of the spirit offered for sale depends in great measure on the experience of the manufacturers in blending the products of various distillations. The character of the wine is therefore of the first importance and is dependent upon the soil, climate and methods of cultivation. The soil of the Cognac and other districts of France is particularly suitable, and brandy of excellent quality is also distilled from wine of British Empire origin. In France the cultivation of the vine has improved since the replanting of the vineyards after their devastation by the phylloxera epidemic of 1875–78. The best French brandies are obtained from the Charente wines which, although possessing no particular virtue as such, are peculiarly suitable for the production of a spirit of a fine and delicate flavour. The wines of other districts, although more highly flavoured, are not so suitable for the production of brandy. The type of still and method of distillation depend upon the character of the wine employed. In Charente, where as stated above, the most suitable wine is obtained, a simple pot still having a capacity of not more than 200 gal. is usually employed, the distillation being carried out very slowly. The spirit first obtained—*brouillis*—is redistilled to give a product of a higher strength—*bon chauffe*. In other districts where the wine is not so suitable a more complicated apparatus is employed. This includes a distilling column which renders possible a higher degree of rectification and the removal of fractions of the distillate which are considered undesirable.

Rum.—This spirit may be divided into two main classes "Jamaica" and "Demerara." The greater proportion of the former is of the type usually imported into Britain. It is prepared by the fermentation of a wash consisting of cane molasses, scum drawn from the solution during the manufacture of cane sugar, "dunder" the viscous mass obtained from the bottom of the still during the previous operation, and "megass," the last, which is the fibrous part of the crushed cane, being added to promote fermentation. The fermentation is slow, extending to 12 days or even longer. When this operation is complete the spirit is distilled off in a pot still. There are two other types of Jamaica rum. That intended for local use is obtained by rapid fermentation and is of comparatively poor quality. The third, known as "German rum" has a very strong flavour and is used for blending purposes or for imparting to plain spirit the characteristics of ordinary rum. Demerara rum is lighter in flavour than the Jamaica varieties and has a lower proportion of secondary ingredients. It is usually prepared by the fermentation of molasses dissolved in water, the spirit being then distilled off in patent stills or in pot stills of a type more complicated than those generally used in Jamaica. For the manufacture of industrial spirit, *see* ALCOHOL.

Spirits of Farinaceous Origin.—The raw materials used for these include cereal grains, such as barley, rye, oats, wheat, maize, etc., which produce whisky, "corn brandy," vodka, plain spirit and industrial alcohol. Potatoes are used in the manufacture of industrial alcohol. The first stage in the preparation of spirit from starch is the conversion of the latter into dextrine-maltose and intermediate products. This is accomplished by the action of a diastatic ferment such as that present in malted grain (*see* BREWING) or secreted by certain living organisms, or by an acid such as sulphuric acid. The latter process is little employed at the present time. The materials employed by the distiller and the methods of preparation and treatment to which they are subjected before and after entering the distillery are in some respects similar to those employed by the brewer. The great difference, apart from the actual process of distilling, is that, whereas the object of the brewer is to produce beer, of which alcohol forms only a relatively small proportion, the distiller, broadly speaking, desires to produce alcohol.

Malting.—Where malt is employed as the main raw material, as for instance in Scotch pot still and some other whiskies, the process of preparation usually does not differ widely from that used in making brewers' malt. The spirit manufacturer, however, need not be so particular as to the quality and character of the malt, which need only be sound and contain a high percentage of starch to serve his purpose. Barley intended for operations in a patent still is usually "steeped" and "floored" for periods longer than in brewery malting. In distilleries where barley malt is used not as a principal raw material but primarily as a diastatic agent,—for instance in potato and maize distilleries—these two processes are particularly lengthy, the steeping being prolonged until the increase in weight due to the absorbed water is about 40 or 45%. The brewers' malt is almost invariably highly kilned in order to restrict the diastatic power. As the object of the distiller is to produce the highest proportion of alcohol possible he does not desire to restrict the diastatic power in this way, and if possible uses a green malt. The malt whisky manufacturer, however, depends in great measure upon the kilning process to yield the characteristic flavour of his product. For this reason, and also because of the difficulty of obtaining green malt in hot weather, a malt is often used which has undergone a mild kilning process in which a temperature of 130° F is seldom exceeded. In order to reduce the danger of bacterial infection at subsequent stages some antiseptic such as lime is introduced during the steeping.

Although green or low dried barley malt is the saccharifying agent usually employed both in the United Kingdom and on the Continent of Europe, malts prepared from other materials are not infrequently employed.

Oat malt, notwithstanding its low transforming power, possesses certain advantages, inasmuch as it is easily and rapidly prepared, it acts very quickly in the mash tun, and its diastatic power is well maintained during fermentation. Rye is best malted in conjunction with a little barley or oats, as it otherwise tends to superheat and to grow together in a tangled mass.

Mashing and Fermentation.—The details of this stage of the process are, in the case of the malting, designed to produce the highest possible yield of alcohol consistent with the commercial requirements, such as flavour and aroma, of the particular trade in which the distiller is engaged. In order to accomplish this the mashing takes place at a low temperature, the wort thus remaining unsterilized and the diastatic action continuing during the fermentation period. The problem for the distiller is to raise the mash to a temperature as high as possible in order to restrict the bacterial fermentation to which the wort is liable, whilst keeping it sufficiently low to prevent the destruction of the diastase. The method employed varies according to the nature of the mash and the quality of the spirit desired, but in general principle is governed by the requirements indicated. The micro-organisms most to be feared are those belonging to the class of fission fungi (*schizomycetes*) such as the butyric, lactic, mannitic and mucic ferments. In order to avoid bacterial fermentation it is necessary either to let the wort "sour" naturally (lactic acid being chiefly formed) or to add a small quantity of acid (formerly sulphuric acid was frequently employed) to it before pitching the yeast. Such a condition is favourable to the free development of the desirable types of distillery yeasts but restrictive to the growth of brewery yeasts and especially of bacteria.

In order to facilitate the proper control of the formation of the acid the souring process is usually carried out in a small separate mash so that when sufficient acid has been produced the temperature of the liquid is increased and the acidifying process stopped. The souring mash is often inoculated with a special variety of lactic acid bacteria—a pure culture of B *acidificans longissimus*. The optimum developing temperature of this organism is about 104° F but it is better to keep the wort at 122° F, for at that temperature practically no other bacteria is capable of development. When lactification is complete the temperature is raised to 165° F and after cooling the mass it is pitched with yeast and added to the main wort. Sometimes lactic acid is added instead of being produced naturally. Hydrofluoric acid and its salts are also sometimes used with very satisfactory results.

Much of the yeast used in British and Irish pot still and in some patent still distilleries is obtained from breweries. In order to obtain a more rapid and complete fermentation a special type of "German yeast" is often used. It is usual to "pitch" at about 80° F and then to cool slowly to 60° F. As fermentation develops the temperature again rises naturally to about 85° F. In malt whisky distilleries the original gravity of the wort is usually about 1·050 to 1·060, but in grain and potato distilleries it is often higher, being sometimes as high as 1·11 in Germany. In the production of industrial alcohol other methods, involving the use of a pure culture of a micro organism in a sterilized wort and then a pure culture of yeast, are adopted. For details of these *see* ALCOHOL IN INDUSTRY.

Distillation.—This may be described as a process by which, on the application of heat, one substance can be volatilized from another and recovered by subsequent condensation. Thus, a solvent, such as water, can be separated from solid matter which it holds in solution, or two liquids, boiling at different temperatures, can be freed one from the other. In the case of spirituous liquors the primary object of distillation is the separation, as far as possible, of the alcohol from the non-volatile constituents of the wash. Incidentally other volatile substances, such as water and products of fermentation other than ethyl alcohol are distilled off, but the proportion of these is reduced by further distillation and by various elaborations of the apparatus in which the process takes place. The modifications thus introduced vary according to the materials used and the type of spirit it is desired to produce. The essential parts of a still are the vessel in which the mixture can be heated, a tube or still head to carry off the vapour, a condenser for cooling and thus reducing the vapour once more to the liquid state, and a vessel for receiving the liquid.

Pot Still.—This apparatus embodies these features with the minimum of elaboration. Experience has demonstrated that, for wines producing the finest brandies, the most simple form of still is the best. For the distillation of wines which do not produce brandy of the finest quality more complicated apparatus is employed in order to facilitate higher rectification. In Scotland the pot stills are somewhat larger and are adapted more particularly to the requirements of the whisky industry. They vary in size from about 3,000 to 8,000 gal., the usual capacity being 5,000 to 6,000 gallons.

The pot stills used in Ireland differ materially from the Scotch stills. They are very large, ranging up to 20,000 gallons. A characteristic feature is the great length and height of the "lyne arm," *i.e.*, the pipe connecting the still with the condensing coil. This lyne arm generally runs up vertically from the still for a distance of 10 to 20 ft., then horizontally for another 30 to 40 ft., again vertically for 10 to 20 ft., and is then connected to the condenser. The horizontal portion of the lyne arm lies in a shallow trough fitted with a water supply, and the temperature of the spirit vapours prior to their passing to the condenser may thus be regulated at will. According to the length and height of the lyne arm and the temperature of the water jacket, more or less of the vapours condense and are carried back to the still by means of a pipe. This return pipe is fitted with a cock which enables the distiller to regulate the flow. Occasionally there is a further return pipe for the condensing coil, but this is not usual. The advantage of this form of plant is that it is possible to work up far greater quantities of wash and to obtain a much higher rectification in a single operation than is possible in the case of the pot still. It will be noticed that in this case there is no return pipe from the lyne arm.

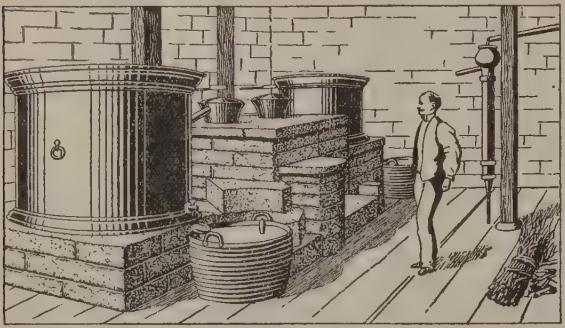

FIG. 3.—OLD COGNAC POT-STILL

Patent Still.—This was designed by Aeneas Coffey in the early part of the 19th century with a view to accomplishing in one process that which necessitates several operations in the pot still, of economizing time, fuel and material, and also of obtaining at will a spirit of higher purity than that which can be produced by the older and more simple form of apparatus. It is the still usually employed for the production of Scotch and Irish grain whiskies. It can, however, be adapted for the distillation of a spirit intended for methylation, or for the production of spirit having a high degree of strength and purity. In the preparation of spirit approximating closely to absolute alcohol, however, the product of the patent still must undergo further treatment and rectification. In certain details the Coffey still since first devised has undergone certain modifications, but in general principle it remains unchanged.

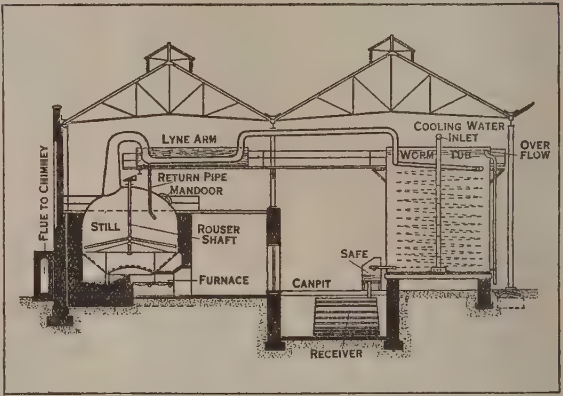

FIG. 4.—DIAGRAM OF SINGLE TYPE OF IRISH POT-STILL PLANT. (JOHN JAMESON'S DISTILLERY, DUBLIN)

The still shown in the accompanying illustration (fig. 5) is a type designed by Messrs. Robert Willison of Alloa for Scotch grain whisky distilleries. This Coffey still is a double still consisting of two adjacent columns, termed respectively rectifier and analyser. Both columns are subdivided into a number of chambers by perforated copper plates. The main structure is of wood firmly braced with iron. Each compartment communicates with the next by means of a drop pipe standing slightly above the level of the plate and passing downwards into a cup, which forms a water seal or joint. Each compartment is also fitted with a safety valve in case of the plates choking or of the pressure rising unduly. At the beginning of the operation both columns are filled with steam at a pressure of about 5 pounds. The steam at the base of the analyser passes upwards through it, thence to the bottom of the rectifier by means of the pipe B (termed the low wines vapour pipe), and then up through the rectifier. When both columns are filled with steam the wash is pumped up from the wash charger through the copper pipe A nearly to the top of the rectifier, which it enters at the point A. The pipe A runs from the top to the bottom of the rectifier, forming a double bend in each compartment, and the wash (contained in the pipe) travels down in a zig-zag course until it reaches the base of the rectifier at the point C. From here (still remaining in pipe A) it is pumped to the top of the analyser, where it emerges from the pipe and covers the plate of the top compartment. As there is an upward pressure of steam the wash is not able to pass through the perforations of the copper plate forming the base of the compartment, but collects until its level reaches the top of the first drop pipe. Through this it passes into the cup on the plate below and so out on to the next plate. The drop pipes being trapped by the cups, the steam cannot pass upwards through the former. In this way the wash passes through compartment to compartment on the analyser until it reaches the bottom, and then passes out by means of the spent wash siphon. The steam, on its passage up through the analyser, carries with it the alcoholic vapours and other volatile matters contained in the wash. The alcoholic vapours pass from the top of the analyser to the bottom of the rectifier, and then upwards through the latter from compartment to compartment. In so doing they are gradually cooled by the wash flowing down through the pipe A. This gradual cooling causes the less volatile constituents to condense and so to flow downwards through the column until they reach the base of the rectifier. At a certain point in the upper part of the rectifier (marked S in the illustration) the bottom of the compartment in question is formed not of a perforated plate, but of a stout copper sheet, pierced by a fairly wide pipe, which stands up about 2 in. above the level of the former. This is termed the spirit plate. It is so placed that the alcoholic vapours condense either on or immediately above it. The alcohol passes out from the spirit plate chamber from one of the two pipes shown in the illustration (either to the spirits or to the feints receiver as the case may be), and is then further cooled, in order to complete the condensation, by being run through coils immersed in flowing cold water.

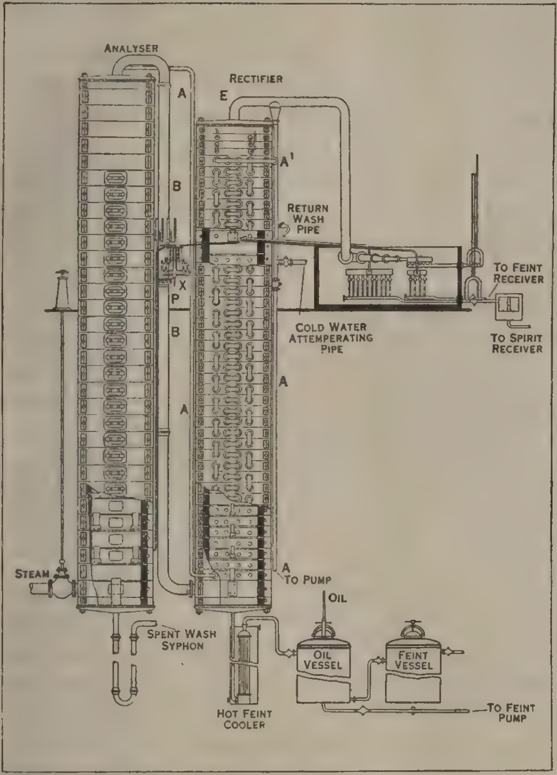

FIG. 5.—DIAGRAM OF COFFEY STILL (R. WILLISON AND CO., ALLOA)

In order to render the condensation still more perfect the upper chambers of the rectifier are fitted with coils through which cold water is passed. The vapours condensed by this fall upon the spirit plate. The vapours which have an appreciably lower boiling point than ethylic alcohol, such as the aldehydes, together with a large volume of carbonic acid gas derived from the wash, pass out of the top of the rectifier by means of the "incondensible gas" pipe E, and thence to a separate condensing coil. The spirit retained is of high strength, generally about 64 over proof. The less volatile constituents of the wash, generally termed "fusel oil," which pass out of the base of the rectifier, are cooled and then passed to the oil vessel. After the apparatus has been worked for some time the fusel oil which floats in a layer on the top of the contents of the oil vessel is skimmed off. The watery layer from the oil vessel, which still contains a little alcohol, is again passed through the apparatus to remove all of the latter.

The distillation is controlled by an operator standing on the platform P. The operator is able by means of the sampling apparatus X to determine the quality and strength of the spirit and of the wash. He is able, by regulating the quantity of steam admitted to the apparatus, by modifying the rate of pumping, and by running the spirit either to the spirit or to the feints receiver, as the case may be, to control the strength and quality of the product in much the same manner as does the pot still distiller.

By-products of Fermentation and Distillation.—Although the principal ingredient of all spirits is, of course, ethyl alcohol diluted with different proportions of water, there are present in varying quantities, other substances which impart to each type its individual characteristics and afford a means of determining its origin. These by-products are formed mainly during fermentation, but are also to a certain extent pre-existent in the raw materials or may be generated during the operations preceding and succeeding fermentation. Their nature is complex and varies sensibly according to the raw materials and the methods of malting, mashing, fermentation and distillation. The by-products or secondary ingredients may be classified as follows: (a) higher alcohols, (b) esters, (c) fatty acids, (d) fatty aldehydes and acetals, (e) furfural, (f) terpene, terpene hydrate and ethereal oils, (g) volatile bases.

The higher alcohols—commonly known as fusel oil—consist of mixtures of fatty alcohols ($C_nH_{2n+1}\cdot OH$) containing three or more atoms of carbon. The fusel oil in British pot still spirits is chiefly composed of amyl, butyl and propyl alcohols, their relative proportion being in that order, but in the preparation of British spirits in the patent still the amyl and butyl ingredients are to a great extent removed and the propyl is the predominating higher alcohol in the finished product. The butyl in the grain spirits, as also in brandy, is chiefly the normal, whilst that contained in spirit produced from potatoes is chiefly iso-butyl. The esters, formed by the interaction of alcohols and acids, chiefly during the fermenting and distilling operations, consist almost entirely of fatty acid radicles in combination with ethyl and to a minor extent amyl alcohol. Ethyl acetate (acetic ester) is the chief of these, others being ethyl valerate, butyrate and propionate. Oenanthic ether (ethyl pelargonate) although only representing a small proportion—about one per cent—of the total secondary ingredients present in brandy, is one of that spirit's most pronounced characteristics. The acid present is chiefly acetic—formed by the oxidation of the ethyl alcohol—but small quantities of other acids are also found. Furfural, which is probably formed chiefly from the pentoses contained in the wort, occurs to a greater or less extent in most spirits, but it is particularly characteristic of pot still products.

Effect of Maturing.—It is a fact which has been recognized for centuries that alcoholic beverages improve with age. There is little doubt that this improvement is due to changes in the character and relative proportion of the secondary ingredients, although the exact nature of the changes is not fully understood. They are undoubtedly dependent in some manner upon the ventilation of the containing vessel, as no perceptible alteration takes place when the liquid is stored in glass bottles. The degree and rate of maturation depend upon the character of the original spirit, the type of cask and the conditions existing in the place of storage. Generally all the secondary ingredients except furfural tend to increase with age, although, as their proportions are usually expressed in relation to the ethyl alcohol present, the loss of some of the latter by evaporation may result in an apparent increase which is relative rather than actual. Thus in a very damp cellar the spirit will lose very little in volume, but such loss as occurs will be almost completely confined to the alcohol. In a dry cellar the volume decreases more rapidly, and the loss of water as compared with alcohol is relatively greater. Change in the character of the spirit is also caused by extraction of materials from the wood of the cask. There is a limit of time to the beneficial effect of the ageing of the spirit, and when that has been reached the contents of a cask should be immediately bottled, otherwise deterioration will take place.

Physiological Effects.—The nature of the physiological effects produced by the ingestion of spirits varies considerably not only according to the class of spirit (*i.e.*, whether whisky, brandy, rum, etc.) consumed but also with its age and general condition, and there is no doubt that the causation of these phenomena is intimately connected with the nature and quantity of the secondary ingredients. Commenting on a statement in Bailey's *Book of Sports* to the effect that wine and brandy had a tendency to make a man fall on his side, whisky to make him fall forward, and cider and perry to make him fall on his back, Sir T. Lauder Brunton in giving evidence before the Spirits Committee in 1891 suggested that these statements, if correct, might indicate definite injury to various parts of the cerebellum. He was inclined to believe that the varying effect of different spirits might be due to the specific action of the different products on the separate nerve centres.

Numerous investigations have been conducted to determine the effects of the various by-products. Thus Dujardin-Beaumetz and Audige found that the pig, whose digestive organs are very similar to those of man, when fed for 30 months with pure alcohol, suffered no ill effects, whereas when similarly treated with imperfectly purified spirit (whether derived from beet, potato or grain) suffered considerably. The same investigators, experimenting on dogs, found that the lethal dose of various alcohols was: ethyl 5 to 6 grammes, per kilo body weight, propyl 3·75 grammes, butyl 1·8 grammes and n-amyl 1·5 grammes. Brunton and F. W. Tunnicliffe demonstrated a poisonous action of furfural upon man and, comparing the after effects upon animals of spirits containing, and freed from, aldehydes, found certain important physiological differences between them.

It is important therefore that the spirit manufacturer should adopt all possible precautions to obtain a product which, whilst satisfying commercial requirements, will ensure the minimum possibility of harm to the consumer. The ordinary precautions which at all times should be followed include clean stills and apparatus, a good water supply, high-class and appropriate materials, and careful control of all operations during mashing, fermentation and distillation. The removal of acids can be effected by neutralization with an alkali in the still, whilst for the elimination of fusel oil treatment with charcoal is the common method.

Many processes have been suggested for the artificial maturing of spirits. The most practical are those embodying the passage of hot or cold air, oxygen or ozone through the liquid. Miels and Barr suggest the maturation of new whisky by the addition of a little sherry and a minute trace of sulphuric acid (subsequently neutralized by lime). Hermite suggests a method which consists essentially of adding an electrolysed solution of common salt to the spirit and subsequently redistilling. R. P. Pictet, by cooling a new brandy to −80° C, is said to have obtained a liquid which had apparently acquired the properties of a 12 year old spirit. None of these methods, however, appears to have been devised with a view to removing those substances which render the new spirit objectionable as compared with the old. A patent taken out by J. P. Hewitt is of interest, however, as by distillation with phenyl-hydrazine sulphonate of soda he effects the actual removal of furfural and aldehydes from the crude spirit.

(F. G. H. T.)

SPIRITUALISM, a name used by some philosophers, instead of "Idealism," to signify a philosophic attitude or point of view about the universe opposed to materialistic philosophy, and to imply that the ultimate reality is more fundamentally on the mental or ideal side of things rather than on that which appeals most directly to the senses as the behaviour and modifications of matter. But the name "Spiritualism," or "Spiritism," is more usually employed to signify a growing persuasion on the part of certain people that the activity of human beings is not entirely limited to the use they make of their bodily or material organisms on this planet. It is held that those organisms were constructed by an animating principle which having entered into relation with matter for the purpose of developing an individuality can continue long after the temporary material body is worn out or otherwise resolved into its elements; and, further, that the personalities thus brought into existence shall carry with them their memory, character, tastes and affection, which they had developed here while in association with matter, and shall be able under certain limitations to guide and influence terrestrial affairs in co-operation with those still living on the earth. This may be taken roughly as the spiritualistic interpretation or explanation of certain obscure phenomena which have occurred sporadically from time immemorial, and which may be said to constitute the phenomena of spiritualism.

General Principles.—There is however a group of investigators who, while they accept the phenomena on the grounds of experience, are not prepared to accept the explanation in terms of human survival, and who therefore dislike the term "spiritualism," preferring to employ some non-committal term such as "metapsychics" or "parapsychology"; meaning thereby a study of those obscure phenomena which lie outside the region generally accepted as orthodox psychology, and which suggest a possible extension of human faculty in directions not as yet understood. The object of these investigators is first to verify and then to study the facts, so as to disentangle the laws which regulate them, and seek to bring them within the recognized domain of organized human knowledge, or else to expand that domain so as to include them. This is called psychical research.

A third group of scientific men not only discard the spiritistic hypothesis, but feel a doubt about the facts, regarding them rather as the outcome of savage superstition and folk-lore, and therefore unworthy of scientific attention.

The whole subject therefore at the present time is a debatable one, on which there are many more or less legitimate differences of opinion. On the whole however there is a general consensus of agreement among those who have devoted time and attention to the subject that some of the phenomena are genuine; so that in time they must be accepted and gradually incorporated into the main body of science. They admit however that the investigation is conducted under difficulties, inasmuch as the phenomena cannot be produced at will, and because the facts are largely dependent on the good faith and careful testimony of those who experience them, or who are allowed to witness them under sufficiently strict conditions. In so far as the phenomena appear to be dependent upon the activity of agents whose existence is not generally recognized, and who have the spontaneity and it may be the capriciousness characteristic of live creatures, the phenomena differ in many respects from the purely mechanical behaviour of atomic groupings and material bodies, such as form the customary stock-in-trade of astronomers, physicists and chemists. They appear likely to belong more to the domain of biology, or even of anthropology, when those sciences are sufficiently enlarged to include them. Meanwhile there is a great body of testimony as to their actual occurrences, which cannot properly be ignored.

But, again, this testimony depends on the utilisation of people endowed with exceptional faculties; and these faculties are occasionally imitated by those who do not really possess them—a procedure which must be stigmatized in the strongest terms as fraudulent. There are others who, while possessing the faculties in a small degree, are tempted to enlarge and extend the results by normal supplement: a tendency which has to be constantly guarded against, for, if unchecked, it tends to bring the whole subject into disrepute.

Meanwhile, however, a body of careful investigators, notably those who founded in London the Society for Psychical Research, and others who have joined them or formed similar Societies, have accumulated a great mass of evidence in favour of the phenomena; and the enquiry is still proceeding.

Assuming, on the strength of the evidence, that human faculties are not so limited as was at one time thought, and that these obscure phenomena actually occur, they may be classified into two great groups:—(1) the mental, or purely psychical branch, concerned with the reception of ideas and information,—information which could not have been normally acquired by the operator and therefore has to be styled supernormal; and (2) the physical branch, which concerns the production of effects in ordinary matter by apparently a supernormal extension of physiological processes.

To the first group belong such subjects as may be summarized under the heads telepathy, clairvoyance (*qq.v.*), lucidity, trance utterance, automatic writing, premonition, xenoglossy, psychometry, and other apparent extensions of receptive faculty occasionally summarized under the rather question-begging term of "cryptesthesia." It is chiefly on the strength of these mental phenomena that the hypothesis about the continued activity of the discarnate has grown up. For most of the communications so received purport to come, and certainly have the superficial appearance of coming, from intelligences no longer in the flesh, who desire to send messages of condolence, sympathy, and assurance to surviving relatives, and to furnish proof of their continued activity. To this group must also probably be added the visual and auditory hallucinations (if that term can be properly used) which many people have experienced in the form of apparitions, or other apparently sensory manifestations, of the people concerned. It has been found that these appearances, or voices, are not limited to those of dead people, as they can be traced sometimes to the unconscious influence of living people, when they are either asleep, or in some danger, or subject to some strong emotion. And these are called phantasms of the living.

The discovery of telepathy, that is to say the transference of thought or of ideas or emotions from one person to another without the use of any of the normal means of communication—a power which has been established by direct experiment as possessed by some people—tends to throw light upon these apparitions, and indeed upon the whole spiritistic hypothesis. For if it is possible for one mind to influence another without the use of the material mechanism commonly employed, it tends to demonstrate an independence between mind and body which cannot fail to have important implications. Though neither the vocal cords nor any other muscles are used for transmission; although neither the eye nor the ear, nor any of the other senses, are used for reception; yet, since some brain process must at least indirectly be involved, it is just possible that telepathy may be due to some unknown method of transmission between brain and brain. But no evidence has ever been adduced, at least none of any trustworthy character, for the existence of what have been called "brain waves." And many circumstances connected with telepathy seem to render it unlikely that a physical method of transmission, even of an etheric kind, could be utilised for the purpose of transmitting information, even though something analogous to brain waves existed. The great distance over which thought-transference occurs, and its apparent independence of obstacles are against such a hypothesis. For although the analogy of wireless telegraphy is often adduced, it must be remembered that we have no means of apprehending etheric waves except by the use of definite instruments (a) for producing such waves in conscious and prearranged manner at one end, and (b) of detecting and transmuting them into sound or other mechanical movements at the other. Telepathy occurs without such instruments (assuming that it occurs at all), and nothing that has been detected in a screened organ like the brain makes it able to act as either a receiving or a transmitting instrument except through the agency of the nerves and muscles. Consequently the most natural hypothesis is that telepathy is a purely mental phenomenon, an action of mind on mind apart from the bodily organs; though the ultimate realization and demonstration of the occurrence must of course depend on the normal methods of testimony and record.

Now mental activity apart from the body is of the essence of the spiritistic hypothesis: and there would be no reason to object to the idea that deceased people can communicate information provided the great and fundamental step is taken of assuming that they still continue to exist. Conversely, the fact, so frequently testified to, that such communications are actually received, whether in the form of apparition or audition, or of automatic writing, or trance speech, or any other way, would, when established, also strongly support or even demonstrate the continued activity of the apparently operating personality. Hence it may be held that the discovery of telepathy rationalises and renders more acceptable many of the asserted occurrences which otherwise would seem absurd and incredible. If an apparition were regarded as an objective reality, all manner of difficulties would arise about the details. But if it is only a mental impression, perhaps roughly analogous to an image in a looking-glass, although produced in some obscure and not in a simply optical manner, difficulties tend to disappear. The image can then be thought of as something not "seen" at all, but mentally reconstructed in accordance with a telepathic impulse which, indirectly through the mind, influences that part of the brain which is accustomed to receive an optical, or it may be an auditory, impression through the nerves. For, on any hypothesis, the brain and mind are closely interrelated; and a mental impression cannot be testified to or realised without the operation of the brain-nerve-muscle system.

PHYSICAL PHENOMENA

On the spiritistic view—that is to say granted the working hypothesis that individuals once generated and isolated from a cosmic reservoir of life and mind, by means of their association with matter, shall continue to function as mental or psychic entities—it is fairly easy to suppose that they may be able to influence other minds, especially now that telepathy is fairly established as a *vera causa,* and can thus presumably cause inspiration, and convey ideas or information. For it may reasonably be assumed that they have a wider outlook than when limited by the flesh; and, being also less restricted in time, that they may be in occasional touch with greater and higher intelligences on their side. Thus not only could ordinary lucidity and clairvoyance and even premonition be accounted for, but also the more valuable inspirations of genius.

It is not difficult to suppose that the organisms of people thus acted upon could be stimulated to produce such muscular movements as speaking and writing, or any other familiar bodily activity. The influence exerted on such people might still be considered purely mental, and might be thought likely to operate most freely on the recipient organism when the medium or possessor of that organism is normally in a state of unconsciousness or partially suspended mental activity; but it would hardly be expected that the influence would be such as to produce physical phenomena beyond the capacity of the ordinary unstimulated organism. Nevertheless there is a large and growing body of evidence for the occurrence of even physically supernormal phenomena. Undoubtedly this evidence must be scrutinised with extreme care because of its unusual character; so that the further question whether in some cases these phenomena are produced by the latent power of the normal individual, or whether it is dependent on a stimulus received from some other intelligence, may remain an open one, to be considered and classified later when the facts are thoroughly established.

The physical phenomena which have thus been seriously vouched for are such as the following. First, movement of objects without apparent contact; in other words, the displacement of matter at some distance from the boundary of the normal organism, with no perceptible link, and therefore out of the normal reach of the muscles. This is known as telekinesis or locomotion of objects at a distance. A modification of this phenomenon is the moulding or rearrangement of matter so as to produce an imitation of known objects, after the manner of a sculptor or a painter, so as to produce simulacra of hands and faces and other parts of the human organism out of any material available. Another fact which is testified to is the rearrangement of the particles on a photographic plate, so that when the plate is developed in the ordinary way a supernormal image of some kind appears upon it, whether it be writing or a human or animal figure. It is further asserted that if no suitable material is provided, or cannot be collected, some organized material can be drawn, either from the medium or from any of those present, of apparently a living or protoplasmic nature, remaining still associated or connected with the organism from which it is drawn; and that this externalised protoplasm is then independently manipulated so as to display a likeness of some departed person, more or less unsatisfactory and incomplete, but far beyond the normal power of the medium from which the material is drawn. Such exteriorised protoplasm is now generally known as ectoplasm. It only lasts a short time, and has to be returned to the body whence it came. But meanwhile it is said that it can achieve many odd results, among others that it is able to produce "direct voice," to move about, and also to exert considerable muscular force, thus effecting the locomotion of objects already spoken of as telekinesis.

The testimony of investigators suggests the idea that this extraneous material is worked by an intelligent mind, much in the same fashion as our own bodily organisms are normally worked by our own minds, and that its activities show will and intention analogous to the will and intention of our own movements. We know too little about the relation between mind and matter to stigmatise such an hypothesis as intrinsically absurd: we must be guided by the facts. But the asserted facts are so extraordinary, and physiologically so incredible, that the evidence will have to be of a strong and cumulative character before such an idea can be accepted. Nevertheless it is mainly by physiologists well acquainted with the difficulties of such an hypothesis that it has been most responsibly put forward. And there is considerable testimony from some physiologists in Europe that, however odd they may be, phenomena which suggest this kind of activity are definitely found to occur. The ectoplasm appears to have varying consistency, sometimes being visible only, sometimes tangible only, sometimes neither, and occasionally both. Ectoplasmic formations have been photographed, though it is said that they can sometimes only be photographed in ultra violet light, and with the use of a quartz lens.

One special difficulty surrounding this investigation is that the ectoplasmic material seems to be manipulated or controlled through an etheric connecting link, and that a tremor or vibration in the ether, of the kind which normally excites the retina of the eye, is detrimental to its activity; so that in most ordinary cases operations of this kind have to be conducted, or seem to be easier, in the dark—a circumstance which makes investigation specially difficult and unsatisfactory. It seems to have been found however that red light is not so deleterious as the brighter illumination of higher frequency, and that with due preparation the ectoplasmic formations can be photographed by a flashlight before they are thereby disintegrated. Moreover it is asserted that in the case of some exceptionally strong mediums, some of the effects have been produced in full daylight.

The force exerted by the ectoplasm can be quite considerable. For instance a table can be raised completely off the ground; and the weight of a man clambering on the table need not be sufficient to bring it down. The forces have sometimes been measured by spring-balances: and an attempt has been made to weigh the medium from whom ectoplasm has hypothetically been removed, with the result that the normal organism is said to have lost weight corresponding to that of the material which has been extruded and accumulated on another balance.

In quoting such assertions it is not to be supposed that they are as yet fully accepted; but they indicate the lines on which investigation should proceed. The hypothesis gives a link on which the phenomena can be threaded together, so as to give them a sort of coherence, which further experience may either substantiate or discard.

Still More Obscure Phenomena.—All the movements and mouldings hitherto spoken of are within the power of normal individuals, if they are allowed free use of their limbs. There is no difficulty in levitating objects or people, or in moulding images and simulacra. Hence the evidence for the occurrence of these things in a supernormal manner must depend on whether the medium and all those concerned are under complete control. Much of the experimentation is complicated by this necessity.

But there are certain other phenomena asserted which are not of a normal character, and could not be produced normally if the operator were free,—phenomena which might be spoken of as miracles. The one most commonly attested to is the immunity to damage or destruction by extreme heat. It is said that certain people can hold flaming or red-hot coals in their hands without feeling pain and without being singed; that this power can be conveyed to other people under certain conditions; and that even fabrics, such as hair or cambric, can be rendered temporarily immune to fire. Travellers tell us of native races who can walk through fire, or over hot coals, without injury, when in a state of exaltation. Heat is known to be a rapid vibration or tremor among the particles of a body, and it is difficult to see how the molecular or chemical changes normally associated with such tremor can be suspended. But again, when there is sufficient confirmation, we must be prepared to accept the facts, whether we feel able to understand them or not.

Another phenomenon of what is popularly called a miraculous character, has been often asserted to occur, namely the passage of a solid body into or out of a closed cavity; as, for instance, the introduction of an object into a closed room, such object having been previously known to be outside; a phenomenon known as an "apport." Verification of such a fact as that is singularly difficult, especially when the enclosure is, like a room, such as can readily be normally opened; and, like all the rest of the phenomena, it must depend with excessive cogency on the good faith of all concerned. Indeed good faith alone might not be sufficient. Before accepting a thing like that, one would have to allow for hypnotic or other influence.

A modification of this "passage of matter through matter," as it has been called, is the linking of two entire rings together, or the tying of knots on an endless string. These things have been testified to, but are hardly as yet even tentatively accepted. The disintegration and reconstitution of matter has been contemplated as a working hypothesis by the few who do accept them; while others have taken refuge in a fourth dimension of space, in which a globe is no more a complete enclosure than a circle is in three dimensions. A quadruped is fully confined when enclosed in a village pound, but a bird is not. The parable is obvious.

It is however hardly worth while to seek for some mode of conceiving or formulating an explanation until the facts are established. The object of this article has been, first, to show the kind of assertions which are made, and then to indicate the kind of lines on which a rational explanation may be looked for; at least in connection with those for which a prima facie case has been established; and, next, to suggest that an enlarged psychology, and possibly an enlarged physiology,—possibly even an enlarged physics—will have to take into account and rationalize a number of phenomena which so far have been mainly disbelieved or ignored.

Historical Summary.—Although spiritualistic phenomena have been testified to by all nations and peoples, although they are spread over the historical documents collected in the Old Testament, and have continued down to the time of John Wesley and later, it is usual to attribute the rise of what is called Modern Spiritualism to occurrences which took place in America about the middle of last century, when they began to attract rational attention; passing through a time of much scepticism and contumely, until they have emerged in the moderate and cautiously sceptical atmosphere of today.

Examples of mediumistic and prophetical incidents are common from the time of the Hebrew Patriarchs downwards. David and the other Kings did not hesitate to consult seers, and, sometimes unwisely, regulated their conduct accordingly. The episode of the infant Samuel is a good example of the phenomenon called the direct voice. In the Graeco-Roman period monitions were experienced, and oracles consulted, as everyone knows. Coming down to recent times, the phenomenon, now fairly common, of intelligent raps, seems to have begun in a family at Hydesville near Rochester, N.Y., about 1848. Stainton Moses, himself a powerful medium, helped to establish the London Spiritualist Alliance, which was joined by the naturalist Alfred Russel Wallace, while the physicist and chemist Sir William Crookes began a series of investigations into a variety of physical phenomena, with the help of the exceptional medium D. D. Home, through whom startling results had been obtained in good light, as narrated by the late Lord Dunraven (*see* "Experiences with D. D. Home" printed by Maclehose for the S.P.R.).

In the seventies of last century Sir William Barrett made preliminary experiments in thought transference; and Cambridge men of letters began to study the various phenomena seriously. In 1882 a special Society was founded by F. W. H. Myers and Edmund Gurney under the Presidency of Henry Sidgwick. This Society for Psychical Research has accumulated a mass of information, critically examined, recorded and discussed in their *Proceedings,* and the work continues to this day.

On the Continent the subject has been taken up by Charles Richet in France, Von Schrenck Notzing in Germany, Morselli, Lombroso and Schiapparelli in Italy, and has been carried on under Dr. Geley and his successors in the Institut Metapsychique of Paris and other organizations; while the American Society for Psychical Research has published an extensive collection of records. In recent times Professor Charles Richet has written what is virtually a text book of the subject under the title *Traité de Metapsychique,* translated into English as *Thirty Years of Psychical Research.* And Dr. Geley has discussed the subject from the medical, biological and philosophic points of view in *From the Unconscious to the Conscious.* Books containing what purport to be records of communications received through mediums in the trance state are too numerous to mention; but the eloquent work of F. W. H. Myers entitled *Human Personality and its Survival of Bodily Death* not only fairly covers the subject up to 1900, but bids fair to become a classic. Selection from other books is difficult. A history of the subject in two volumes by Podmore eschews the spiritistic hypothesis in order to emphasize telepathy. Another history of the subject emphasizing its religious bearings is by Conan Doyle. Older treatises are Hare's *Experimental Investigations of the Spirit Manifestations* (New York 1856), De Morgan's *From Matter to Spirit* (1863), Alfred Russel Wallace's *Miracles and Modern Spiritualism* (1876), Stainton Moses' *Spirit Teachings,* Zöllner's work translated by Massey as *Transcendental Physics.* Also *Reports* of the Dialectical Society in London, and of the Seybert Commission in America, and the *Proceedings* of the Society for Psychical Research in 36 volumes.

BIBLIOGRAPHY.—Books aiming at a philosophical or biological discussion of the subject, in addition to those already mentioned, are:—*Supernormal Faculties in Man* by Osty, *Dissociation of Personality* by Morton Prince, *Body and Mind* by McDougall, *Mind and Personality* by William Brown, *Telepathy and Clairvoyance* by Tischner, *Ectoplasm and Clairvoyance* by Geley, *Occultism and Modern Science* by Oesterreich, *The Facts of Psychic Science and Philosophy* by Campbell Holms is an uncritical summary of a large number of asserted observations.

Books containing detailed evidence are such as the following:—*Phantasms of the Living* (two volumes) by Myers and Gurney (1886), *Evidence for the Supernormal,* by Lloyd Tuckey, *Evidence for a Future Life,* by Delanne, *Psychical and Supernormal Phenomena,* by Joire, *After Death* etc., 3 volumes by Flammarion, *On the Threshold of the Unseen,* by Barrett, and many books by J. Arthur Hill, H. A. Dallas, Drayton Thomas and others. (O. J. L.)

SPITALFIELDS, a district of London, England, in the western part of the metropolitan borough of Stepney. The name is derived from the fact that the land belonged to a priory of St. Mary Spital, founded in 1197.

SPITHEAD, a strait of the English Channel, between the mainland (the coast of Hampshire, England) and the north-eastern coast of the Isle of Wight, forming the eastern entrance to Southampton Water, the Solent being the western. It is 12 m. long, 4 m. wide but between Ryde and Gilkicker Point is almost exactly three miles. The Spit Sand, extending south-east from this promontory, gives name to the strait. On the north side opens the narrow entry to Portsmouth Harbour, with the towns of Portsmouth and Gosport east and west of it. On the south the coast of Wight rises sharply, well wooded, and studded with country residences, and here is the watering-place of Ryde. Spithead shares in the fortifications of Portsmouth Harbour, the principal station of the British navy. The strait has been the scene of many naval pageants.

SPITSBERGEN (Norwegian SVALBARD), an Arctic archipelago between Greenland and Novaya Zemlya in 76° 25′ to 80° 50′ N. and 10° 20′ to 35° E., has a total area of 25,000 sq.m. and comprises West Spitsbergen (15,200 sq.m.) North-East Land (about 6,000 sq.m.), Edge island (2,500 sq.m.), Barents island (580 sq.m.), Prince Charles Foreland, the Wiche islands, Hope island and many smaller islands, including Bear island in about 74° 30′ N. 19° E. The archipelago was officially taken possession of by Norway in 1925.

Geography.—The chief island is in the main a much dissected plateau with many deep fjords penetrating far inland. Small plains are found in the north and west. The sharp peaks that gave Spitsbergen its name rise to 4,960 ft. in Horn Sund Tind in the south, 3,450 ft. in Mt. Monaco on Prince Charles Foreland and 4,770 ft. in Mt. Eidsvoll in the north-west. In the middle and east the mountains are flat-topped and seldom over 2,000 ft., but Mt. Newton (5,445 ft.) in New Friesland is the loftiest peak in Spitsbergen. Rocks skirt many stretches of the open coasts but with accurate charting a number of safe harbours have been found. Glaciers fill the valleys except in the southern interior where they have receded. They generally reach the sea, often along broad fronts, but give rise to no large icebergs. Many are in a state of decrepitude, but a few seem to be advancing. An ice covering over New Friesland is the nearest approach to an ice sheet in West Spitsbergen. Barents and Edge islands have glaciers only on the east. The Wiche islands have no large glaciers, but North-East Land and Giles (Gillis) Land are each covered with a dome of ice that almost envelops the island. Prince Charles Foreland has numerous glaciers. Bear Island with an area of 73 sq.m. rises to 1,630 ft. in Mt. Misery. The northern part is a plain at an elevation of about 150 feet. There are no glaciers. Harbours are small and poor. Hope island lies 125 m. east of South Cape, Spitsbergen, is 20 m. long and not more than one mile wide. It rises to 1,200 feet. There is no harbour.

Structure and Geology.—The principal features of the geology are known. Most formations from early Palaeozoic, and perhaps Archaean, to recent occur. The oldest rocks appear chiefly on the west and north, including Prince Charles Foreland and North-East Land. They are the Hecla Hook series of Cambrian and Ordovician dolomites, limestones, shales and quartzites which form the Caledonian folds and overthrusts of the west. The folds can be traced as far east as the west of North-East Land. Granite and gneiss formerly believed to be Archaean probably belong to the same formation and were involved in the Caledonian foldings. Some of these crystalline rocks, however, may prove to be pre-Cambrian. Outside the area of these old rocks Spitsbergen is mainly a plateau of relatively undisturbed strata lying unconformably on a platform of pre-Devonian crystalline rocks. In the north-west there are Devonian rocks. These are unconformably overlain by lower Carboniferous or Culm sandstones and shales with some coal. Middle Carboniferous is rare and the Culm is generally succeeded by upper Carboniferous limestones, Permo-Carboniferous cherts, and Permian sandstones and shales. Next come Triassic, Jurassic and Cretaceous sandstones, limestones and shales. In the Cretaceous beds there is coal. Unconformably there follow Tertiary sandstones and shales with several coal seams. Tertiary folding is obvious in the west against the Hecla Hook beds in places and in the east, but in central Spitsbergen is noticeable only in gentle undulations. Heavy faulting occurred in Tertiary times. Intrusions of dolerites and basalt were probably of Cretaceous (Neocomian) date. An extinct volcano and several hot springs (temp. 82° F) in Bock bay are Quaternary. The strand flat is well developed at 30–60 ft. and post-glacial raised beaches are marked. Glacial and post-glacial débris on low ground generally mask the solid rock and loose screes form fans on the lower slopes. Bear island is built of Hecla Hook, Devonian and Carboniferous beds. The two latter series contain some coal.

Climate and Ice Conditions.—The sea around Spitsbergen is shallow, and the ice readily accumulates round the shores. Pack-ice prevents access to most shores except for a few months in the year. However, the warm North Atlantic drift sends a branch to the western shores of Spitsbergen, moderating its climate, and leaving an open passage which permits vessels to approach the western coast during most months of the year. The fjords are frozen from October or November to April or May.

Owing to the warm drift the climate of Spitsbergen is less severe than in the corresponding latitudes of Greenland. January and February means range from 0° to −8° F, and July means from 38° to 40° F. Even in the coldest months of the winter a thaw may set in for a few days; but, on the other hand, snow sometimes falls in July and August. Spring comes in June; the snow becomes saturated with water and disappears in places, and scurvy grass and willow open their buds. By the end of June the thermometer has ceased to sink below the freezing-point at night; July, August and September are the best months. In September, however, autumn sets in. The annual precipitation at Green Harbour is 11.6 in. and less in the interior. Winds are generally light except on the west coast and local winds in the fjords. There is mist on the west and around Bear island in summer.

Fauna.—The Greenland whale has disappeared in consequence of the great havoc made by the early whalers. According to Scoresby, no fewer than 57,590 whales were killed between 1669 and 1775. Reckless extermination of seals also took place. Walruses are now rarely seen in the waters of West Spitsbergen. Birds, also, have rapidly diminished in numbers. The fulmar petrel meets ships approaching Spitsbergen far away from the coasts. It makes colonies on the cliffs, as also do the glaucous gull or the "burgomaster." Rotches, black guillemots, ivory gulls, auks, looms and kittiwake gulls breed on the cliffs, while geese, loons and snipe frequent the lagoons and small fresh-water ponds. The eider duck breeds on the islands, but its numbers have become noticeably reduced. These birds, however, are only guests in Spitsbergen, the snowy owl and ptarmigan being the only species which stay permanently. Some 60 species have been recorded from Spitsbergen and Bear island; about half of them breed there. Of land mammals, besides the polar bear, the reindeer and arctic fox have been greatly reduced: Norway has prohibited the slaughter of any reindeer until 1934; before 1868 from 1,500 to 2,000 were killed by hunters in a few weeks of summer.

Vegetation.—The only trees are the polar willow, which does not exceed 2 in. in height and the rare dwarf birch; and the only bushes are the crowberry and cloudberry. But at the foot of the bird cliffs some loam has been formed notwithstanding the slowness of putrefaction, and there, in contrast with the brownish lichens that cover the rocks, grows a carpet of mosses of the brightest green, variegated with the golden-yellow flowers of the ranunculus, the large-leaved scurvy grass, the cuckoo flower, many saxifrages, fox-tail grass, etc.; while on the driest spots yellow poppies, whitlow grasses, and rock roses are found. Even on the higher slopes, 2,500 ft. or more above the sea, the poppy is occasionally met with. In all about 130 species of flowering plants have been found. Although very limited in number, the flora is suggestive in its distribution. Most of the species of flowering plants are found in the flora of Europe while 117 are circumpolar in distribution. Many flowering plants which are common in West Spitsbergen are absent from the east coast, where the cold climate is inimical to both flora and fauna.

Mining.—Coal has been known since the 17th century but was not mined commercially until the 20th century when work began in Advent bay, and progressed slowly there and elsewhere until the development of the coalfields was greatly stimulated during the World War by the scarcity and high price of coal in Scandinavia. The coalmine in Longyear valley, Advent bay, which was under American ownership since 1905, was sold in 1916 to Norwegians. Several other Norwegian mines have started, notably in King's bay and Hjorth Haven in Advent bay and on Bear island (since closed). Swedish mines were worked in Lowe Sound (Braganza bay) from 1917–25. There are Dutch mines in Green Harbour. British enterprise, hampered by war conditions, revived in 1919 in the coal-bearing areas in Klaas Billen bay, Temple bay and Coles bay. By 1920 practically all the coal-bearing areas were annexed by one or other company. In 1927 five mines were exporting coal. The total amount of coal exported in 1925 was 413,000 tons, nearly all of which went to Norwegian ports, including some to Narvik for the Swedish railways. A few thousand tons went to Archangel. The coal exported so far is of Tertiary and Cretaceous ages and proves to be good steam coal. Bituminous coal of Carboniferous age is available but not yet mined. Mining continues throughout the year but the export season at present is from late April to September.

Communications.—There are no regular sailings to and from Spitsbergen but tourist vessels make occasional calls in July and August and many colliers go to and from Norway during summer. There has been a Norwegian radio-station at Green Harbour since 1911 and there are also stations as well as post offices at the chief mines.

Bibliography.—The literature is voluminous. Sir W. Martin Conway in *No Man's Land* (Cambridge, 1906) details the history of Spitsbergen to 1840, tabulates the principal voyages thereafter until 1900, and gives a full bibliography from the earliest time down to 1902. The observations of the Swedish expedition for the measurement of an arc of the meridian were brought together (in French) in *Missions scientifiques pour la mesure d'un arc de méridien au Spitzberg* . . . (Stockholm, 1903–06), and those of the Russian expedition under the same title in 1904, *seq.* (St. Petersburg [Leningrad]). Other important sources of scientific value are the publication of the Swedish *Vetenskaps Akademie; Ymer* (Stockholm); *Videnskaps Akademi* (Oslo), especially the series of papers on *Resultater av de Norske Statsun. Spits. Ekspeditioner* (1922–); Albert I., Prince of Monaco's *Résultats des campagnes scientifiques,* 40, 41 and 45 (1889, etc.); and *Spitsbergen Papers* (Oxford, 1925). Two general works are R. N. Rudmose Brown, *Spitsbergen: its exploration, hunting and mineral riches* (1919) and F. Nansen, *En ferd til Spitsbergen* (1920) or *Spitzbergen* (Leipzig, 1921). G. Isachsen, "Fra Ishavet" in *Det Norske Geografiske Selskabs Aarbok* (1916–19) gives much information about Norwegian hunters. H. M. Cadell, "Coal Mining in Spitsbergen," *Trans. Inst. Min. Eng.,* vol. 60 (1920) and A. Hoel, "The Coal Deposits and Coal Mining of Svalbard" (Oslo, 1925) describe the coal-bearing areas. F. C. Wieder, *The Dutch Discovery and Mapping of Spitsbergen 1596–1829* (Amsterdam, 1919) has many reproductions of early maps. The meteorological observations at Green Harbour are published annually in *Jahrbuch des Norwegischen Meteorologischen Instituts* (Oslo). A. Miethe and H. Hergesell, *Mit Zeppelin nach Spitsbergen* (1911) is noteworthy for the excellence of its illustrations, including colour plates. G. Binney, *With Seaplane and Sledge in the Arctic* (1925), describes recent work in North-East Land. Some of the results of the Norwegian surveys are collected in *Expedition Isachsen au Spitsberg, 1909–10, Resultats scientifiques* (Oslo, 1916). The geomorphology and geology are explained by G. de Geer "On the physiographical evolution of Spitsbergen" *Georg. Annaler,* vol. I. (Stockholm, 1919) and by O. Nordenskjold in *Handbuch der Regionalen Geologie* IV., 2b. (Heidelberg, 1921) with bibliography. *Spitzbergen-Handbuch* (Berlin, 1916) gives full sailing directions. The Spitsbergen Treaty is published in Treaty Series No. 18, Cmd. 2,092 (1924). (R. N. R. B.)

Exploration.—It is probable that Svalbard, discovered by the Vikings in 1194, according to the *Landnamabok,* was Spitsbergen, but the discovery was forgotten. Modern knowledge dates from the discovery by William Barents and Jacob Heemskerk, on June 17, 1596. Barents saw parts of the west and north coasts, and he gave the name of Spitsbergen. In 1607 H. Hudson, after visiting Greenland, reached Spitsbergen and reported whales. Bear island, midway between Spitsbergen and the North cape, had been discovered by Barents, and became important as a hunting-ground (for walrus, etc.), after Stephen Bennet's visit in 1603. In 1609 Thomas Marmaduke reached Spitsbergen, and in the following year the first hunting expedition was despatched thither by the Muscovy company under Jonas Poole, on whose report of the abundance of whales on the coast the Spitsbergen whaling industry was established in 1611. Very shortly the Dutch began to take a share in this, and there were frequent collisions between the whalers of the two nationalities, while in 1615 the Danes attempted to claim this part of "Greenland," as Spitsbergen was for a long time considered. England attempted to annex the archipelago, but at length the Dutch became predominant in the whaling industry, and in 1623 founded the busy summer settlement of Smeerenburg. This began to decline in about 20 years, as the whales were slowly driven from the bays. Marmaduke discovered Hope island and North-East Land in 1613; Edge saw the Wiche islands in 1617; and C. Gillis found Gillis (Giles) Land in 1707. At what period Russians from the White sea district first came to Spitsbergen to hunt walruses, seals, bears, foxes, etc., cannot be known, but the industry had importance before 1740. The Russians called the archipelago Grümant, a corruption of Greenland.

Many expeditions have made Spitsbergen their base for polar exploration. The expedition in the "Racehorse" and "Carcass" sent from England in 1773 under C. J. Phipps, was the first having a purely geographical purpose. Phipps mapped the north of Spitsbergen and reached 80° 48′ N. In 1818 D. Buchan and J. Franklin reached 80° 34′ to the north of the archipelago. Captain D. C. Clavering and Sir Edward Sabine in 1823 explored the islands, and Sabine made his remarkable magnetic observations, while Clavering reached 80° 20′ N. Sir William Parry in 1827 reached 82° 40′ N. of Spitsbergen on sledges. In the same year the Norwegian geologist, B. M. Keilhau, visited the group. The Swede, Sven Loven, was the first to undertake, in 1837, dredging in Spitsbergen waters. In 1858 Otto Torell, accompanied by A. E. Nordenskiöld and A. Quennerstadt made important observations and brought home rich geological collections. In 1861 a larger expedition led by Torell, Nordenskiöld, A. J. Malmgren, and K. Chydenius investigated the possibility of measuring an arc of meridian in Spitsbergen. The work of the measurement of the arc was completed in 1864 by an expedition led by Nordenskiöld, assisted by Malmgren and N. Dunér. This expedition was followed in 1868 by that of the "Sofia," under Nordenskiöld to the north coast. In the same year the German expedition under K. Koldewey circumnavigated west Spitsbergen. In 1870 two young Swedes, Drs. A. G. Nathorst and H. Wilander, examined the phosphoric deposits at Cape Thordsen, and two years later a colony was formed and a small tramway constructed to work the beds. The attempt, however, did not prove successful. Leigh Smith and the Norwegian, Captain E. Ulve, visited and mapped parts of east Spitsbergen in 1871, and reached 81° 24′ N. In the same year the first tourist steamer visited the archipelago. In 1872 an expedition under Nordenskiöld wintered in Mossel bay, hoping to set out for the Pole in spring. This project had to be abandoned, and Nordenskiöld explored North-East Land and crossed the vast ice-sheet which covers it. The expedition returned in 1873. In 1882 the Swedish geologists, A. G. Nathorst and G. de Geer, made a journey in Ice Fjord which furnished interesting data about the geology and flora of the islands. In the same year a Swedish meteorological station was established at Cape Thordsen for carrying on the observations desired by the international polar committee. The expeditions of Gustaf Nordenskiöld in 1890 and the circumnavigation by Nathorst in 1898, during which the Wiche islands and Giles Land were explored, confined their attentions almost entirely to the coasts. In 1892 C. Rabot made the first serious attempt to penetrate the interior from the head of Ice fjord, exploring a part of the Sassendal; and in 1896 Sir Martin Conway led an expedition which crossed the island for the first time and surveyed the region between Ice Fjord and Bell Sound. In 1897 Conway and E. J. Garwood surveyed the glaciated area north of Ice Fjord, and climbed Horn Sund Tind. In the same year S. A. Andrée made his fatal balloon ascent from Danes island with the intention of floating over the Pole. In 1896 a weekly service of Norwegian tourist steamers was established in summer, with an inn at Advent bay. In 1898, 1899 and 1906 the prince of Monaco made scientific investigations in the archipelago, and in 1898–1902 Swedish and Russian expeditions undertook the measurement of an arc of the meridian. W. S. Bruce, in 1906–07–09, made a complete survey and scientific investigations of Prince Charles Foreland, and in 1920 J. M. Wordie scaled some of its highest peaks, Monaco, Rudmose and Barents. In 1910 W. Filchner surveyed the glaciated region between Temple and Mohn bays. Every summer since 1906 Norwegian State expeditions, under G. Isachsen, A. Staxrud and A. Hoel, have surveyed in the western side of the mainland, and conducted hydrographic research. King's bay was used by R. Amundsen in his unsuccessful flight to the Pole in 1925, and by him and R. E. Byrd in their successful flights in 1926. G. Wilkins alighted in the Fjord in April 1928 after his flight from Alaska. (*See* also ARCTIC REGIONS, *Exploration.*)

Political History.—The question of political control had been discussed since about 1870, mainly by Norway, Sweden and Russia, without any solution being found. Spitsbergen therefore occupied the curious position of being *terra nullius*. In 1907, however, Norway again opened negotiations for an international conference to decide the question of sovereignty, and one was held at Oslo (Christiania) in July–Aug. 1910, followed by another in 1912, without definite result. In July 1914 a conference which included also representatives of Britain, France, Belgium, the United States, Holland and Germany tried to devise a form of administration consistent with the country remaining a *terra nullius*, but the outbreak of the World War put an end to the discussions. In 1919 the Supreme Council conferred on Norway the sovereignty of Spitsbergen, including Bear I. and all islands between 10° and 35° E. and between 74° and 81° N. The signatories of the treaty were Great Britain and the British Dominions, France, Italy, the United States, Japan, Holland, Denmark, Norway and Sweden. Ratifications were delayed and Norwegian sovereignty did not become effective until Aug. 1925. Russia has since adhered to the treaty. Svalbard is the new name for all islands in the Norwegian sphere in the Arctic, but the names of individual islands are unchanged. Svalbard is deemed a part of the kingdom of Norway and is administered by a governor (*sysselmann*) and a small staff. Game laws have been made. (X.; R. N. R. B.)

SPITTA, JULIUS AUGUST PHILLIP (1841–1894), German writer on music, was born at Wechold, Hanover, on Dec. 27, 1841. He was one of the founders of the Bachverein at Leipzig in 1874. In 1875 he became professor of musical history at the university of Berlin, and at the conservatoire, of which in 1882, he became a director. His *J. S. Bach* (2 vols. Leipzig, 1873–80, Eng. trans., 3 vols., 1884–5), is one of the great classic musical biographies. Spitta, who was one of the editors of the *Vierteljahrsschrift für Musikwissenschaft* from 1885 onwards, died in Berlin on April 13, 1894. His other works include editions of the organ works of Buxtehude (2 vols., Leipzig, 1874–6), and of the works of Heinrich Schütz.

SPITTELER, CARL (1845–1924), Swiss poet and novelist, was born at Liestal, near Basle, April 24, 1845, and died at Lucerne Dec. 28, 1924. In youth he studied theology, but did not pursue a clerical career. After many years of teaching (eight of them in Russia), he published his first important work, *Prometheus and Epimetheus,* in 1880–81, under the pseudonym of "Felix Tandem." This was an epic, written in a rhythmical, quasi-biblical, hieratic prose. A little later appeared *Extramundana* (1883), a volume of apologues in verse. From 1885 to 1892 he engaged in journalism, but published *Schmetterlinge* (1889), a series of short poems. After 1892, when he settled in Lucerne, he was able to devote himself wholly to literature. Three other volumes of short poems were produced between 1892 and 1906—*Literarische Gleichnisse, Balladen* and *Glockenlieder.* In 1900–05 appeared his long epic, *Olympischer Frühling,* which was cited as the main ground for the award of the Nobel Prize for literature in 1919. His prose writings include *Imago* (1906) and three other romances; *Lachende Wahrheiten,* a volume of essays (1898; Eng. trans. 1927); *Die Mädchenfeinde* (1907; Eng. trans., 1922), a story founded on a reminiscence of his boyhood; and *Meine frühesten Erlebnisse* (1914), a charming account of his childhood. His last work, published in 1924, shortly before his death, was *Prometheus der Dulder,* a metrical, compacter and maturer treatment of the theme of *Prometheus and Epimetheus.*

BIBLIOGRAPHY.—*See* short lives and studies by Felix Weingartner (1904), Carl Meissner (1912), O. Kluth (1918; in French), and Rudolf Gottschalk (1928). The most complete English notices of him are in *Studies of Ten Literatures* by Ernest Boyd (1923) and in an article by Prof. J. G. Robertson in the *Contemporary Review* (Jan. 1921). *See* also the introductions to the translations of *Lachende Wahrheiten* (Laughing Truths; 1927) and *Selected Poems* (1928). (J. F. M.)

SPLEEN, a vascular organ situated on the left side of the abdomen (*see* DUCTLESS GLANDS).

SPLIT or **SPLJET** the capital of Dalmatia, Yugoslavia (Ital. *Spalato*), has the finest harbour on the Adriatic coast, with a broad bay affording deep, safe anchorage. This, combined with its central position, and good communication with other parts by road, rail and steamer, has made it of great commercial importance, with an extensive trade in wine and oil. Pop. (1921) 25,042, almost entirely Serbo-Croatian. Spalato arose from the palace of Diocletian, who renounced the imperial crown in A.D. 303 and lived here until his death. The palace was then allowed to fall into ruin, but when the incursion of the Avars was over (639) the inhabitants of the ruined city of Salona, near by, took refuge here, and built up homes within the 9½ acres covered by the palace, incorporating its walls and pillars. Its ground plan is like a Roman camp, *i.e.*, almost a square with four quadrangular towers and four gates, with four streets meeting in the middle. The eastern gate, or Porta Aenea, is destroyed, but the western gate, or Porta Ferrea, and the main entrance to the building, the beautiful Porta Aurea, are still in fairly good preservation. The streets are lined with massive arcades. The vestibule now forms the Piazza del Duomo or cathedral square; to the north-east of this lies the temple of Jupiter, or perhaps the mausoleum. Since the 9th century this has been the cathedral of St. Doimo or Domnius, noteworthy for its finely carved choir stalls. To the south-east is the temple of Aesculapius, long transformed into a baptistery, a beautiful Romanesque campanile having been added in the 14th and 15th centuries.

Excavations have been carried on intermittently at the ruins of Salona, 4 m. north-east, since 1818, and many interesting architectural remains have been discovered together with many smaller relics, now housed in the Split Museum. These include prehistoric objects. Salona was made a Roman colony in 78 B.C. and was one of the chief ports of the Adriatic. Soon after 313 the city became an episcopal see with St. Doimo as its first bishop. The palace was transformed into an imperial cloth factory. The town was captured several times by the Goths and Huns and in 639 was destroyed by the Avars, but was not entirely deserted until the end of the 12th century. In 659 John of Ravenna, the papal legate, was created bishop of Spalato, as the new city was called, the origin of the name being uncertain. A little later it became an archbishopric, and its holders were metropolitans of all Dalmatia until 1033. In 1105 Spalato became a vassal state of Hungary; in 1327 it revolted to Venice, but in 1367 returned to Hungary. It was ruled by the Bosnian king Tvrtko from 1390 to 1391, and in 1402 by the famous Bosnian prince Hrvoje. A large octagonal tower is still known as *Torre d'Harvoye.* In 1420 Spalato fell to Venice and ceased to have an independent history. The castle and walls were erected by the Venetians between 1645 and 1670 and dismantled during the French occupation of Dalmatia (1805–13) in which latter year the province returned to Austria, who still held it at the outbreak of the World War (1914–18). Owing to this fact, the Croatian inhabitants suffered greatly, their intelligentsia being deported in chains as hostages, while the occupation of the town by the Italians in 1918, led to still further hardships.

See T. G. Jackson, *Dalmatia, the Quarnero and Istria* (Oxford, 1887); E. A. Freeman, *Subject and Neighbour Lands of Venice* (London, 1881); R. Munro, *Bosnia, Hercegovina and Dalmatia* (London, 1900); for researches at Salona, R. Adams, *Ruins of the Palace of the Emperor Diocletian at Spalato, in Dalmatia* (London, 1764) with engravings by Bartolozzi; L. J. Cassas and J. Lavallée, *Voyage pittoresque et Historique de l'Istrie* (Paris, 1802) illustrated; and G. Lucio, *De Regno Dalmatiae et Croatiae* (Amsterdam, 1666) for chronicles relating to Spalato and Salona.

SPLÜGEN PASS, one of the passes across the main chain of the Alps from Switzerland to Italy. The route from Thusis passes first through the celebrated gorge of the Via Mala, then through the Schams basin and past Andeer, beyond which the Rofna gorge gives access to the village of Splügen in the upper reach of the main or Hinter branch of the Rhine (*q.v.*). Leaving to the west the road over the San Bernardino Pass, 6,769 ft., the Splügen road (constructed in 1823) mounts south to the pass (6,946 ft.), which forms the political frontier. On the other side the road avoids the old path through the dreaded Cardinello gorge (here passed Macdonald's army in December, 1800) in order to descend by zigzags to Pianazzo. Thence past Campo Dolcino and Gallivaggio the descent is made to the ancient town of Chiavenna at the junction of the road from the upper Engadine over the Maloja Pass, and 17 m. by rail above Colico, at the northern end of the lake of Como. The distance by road from Splügen village (16 m. above Andeer) to Chiavenna is 25 m.

SPODUMENE, a lithium-aluminium silicate ($LiAl[SiO_3]_2$) belonging to the pyroxene group (*see* PYROXENE), named in 1800 from Gr. *σπόδιος* (ash-coloured), in allusion to its colour, and soon afterwards termed by J. R. Haüy *triphane* (*τριφανής*, appearing three-fold), because it exhibited certain characteristics equally in three directions. Spodumene crystallizes in the monoclinic system, the crystals having generally a prismatic habit and being often striated longitudinally. It has perfect prismatic cleavage, and imperfect cleavage parallel to the clinopinacoid, whilst a lamellar structure may be developed by parting along the orthopinacoid. The hardness is 6·5 to 7, and the sp.gr. about 3·16. Though generally a dull mineral, some varieties of spodumene are so brightly coloured and transparent as to be valued as gem-stones, *e.g.*, the emerald-green hiddenite (*q.v.*) and the lilac-coloured kunzite (*q.v.*), whilst a yellow or yellowish-green spodumene found as pebbles in the state of Minas Geraes, Brazil, resembles, when cut, some kinds of chrysoberyl. Common spodumene is used as a source of lithium in chemical preparations.

Spodumene occurs in granite and crystalline schists. The original specimens came from the isle of Utö, Sweden, but the finest examples are found in the United States, especially in Massachusetts, fine specimens having also been obtained from the Black Hills of S. Dakota. Some remarkable deposits containing spodumene were discovered many years ago at Branchville, Connecticut, and were exhaustively studied by G. J. Brush and E. S. Dana. The spodumene occurred in large quantity, in a vein of albite-granite, associated with apatite, garnet, columbite, pitchblende and other uranium minerals, with several manganese phosphates.

SPOFFORTH, FREDERICK ROBERT, "The Demon" (1853–1926), Australian cricketer, was born at Sydney, N.S.W., on Sept. 9, 1853, and died at Surbiton, Surrey, on June 4, 1926. He was educated at Eglington college, Sydney, and played in Australia up till 1888, when he came to England, and played occasionally in England until 1896. He visited England in the five tours from 1878 to 1886, and in his two great years, 1882 and 1884, took 188 and 218 wickets. Little interest was taken in England in the first Australian tour of 1878 up to his appearance, at Lord's, to play the M.C.C. on May 27. By the end of the day the match was over; the M.C.C. were put out for 33 and 19, and Spofforth had taken 6 wickets for 4 runs and 4 for 16. This one day established Australia as a first-class cricketing power. His other great triumph was during the historic tour of 1882. In the test match at the Oval, England, with 84 to make to win, he lost by 7 runs. In the match Spofforth took 14 wickets for 90 runs. He was badly hurt early in the 1886 tour, and was never the same bowler again.

Of Spofforth's actual pace there are differing opinions. It is perhaps, safe to say that when he first came to England he was really fast, but it is certain that he learnt at once to modify his pace on English wickets, and relied on disguised change of pace, with perhaps one really fast one in an over. Of his supremacy there is no doubt whatever. It may suffice to quote Lord Harris: "Spofforth was the most difficult of them all." Spofforth was above all a man who "bowled with his head"; he got his wickets by variation of pace and flight, combined with a sharp off-break, and maintained an ascendancy by an unquenchable spirit of aggression, displayed in his terrifying run up to the wicket, with his long arms whirling, finishing in a beautifully graceful delivery which made the most of his great height.

Spofforth's bowling is fully illustrated in Beldam and Fry's *Great Bowlers and Fielders* (1907). *See* also *Scores and Biographies* (vol. xiv.); Reminiscences in Wisden's *Cricketers' Almanack* for 1927; H. S. Altham, *History of Cricket* (1925).

SPOHR, LUDWIG (1784–1859), German composer and violinist, was born at Brunswick on April 24, 1784. He spent his childhood at Seesen, where in 1789 he began to study the violin, and at six years old was able to take part in chamber-music. He had a few lessons in composition, but, as he himself tells us, he learnt more from studying the scores of Mozart. After playing a concerto of his own at a school concert with marked success, he was placed under Maucourt, the leader of the duke's band; and in 1798 he started on an artistic tour. He made his way to Hamburg, but had to return on foot. The duke then gave him an appointment in his band, and provided for his future education under Franz Eck, with whom he visited St. Petersburg and other European capitals. His first violin concerto was printed in 1803. In 1805 he became violinist to the duke of Gotha. Soon after this he married, his first wife being Dorette Scheidler, a celebrated harpist.

At Gotha Spohr composed his first opera, *Die Prüfung*, but did not succeed in producing it. *Alruna* was equally unfortunate, though Goethe approved of it at a trial rehearsal at Weimar in 1808. In this year Spohr, hearing that Talma was performing at Erfurt before Napoleon's Congress of Princes, and failing to obtain admission to the theatre, bribed a horn-player to send him as his deputy; and, though he had never touched a horn in his life, he learned in a single day to play it well enough to pass muster in the evening and to get a good view of Napoleon and the princes in a pocket mirror on his desk. Spohr's third opera, *Der Zweikampf mit der Geliebten*, written in 1809, was successfully performed at Hamburg next year. In 1811 he produced his (first) *Symphony in E flat*, and in 1812 composed his first oratorio, *Das jüngste Gericht*[1].

In 1812 Spohr became leader of the orchestra at the Theater an der Wien, Vienna. He then began his dramatic masterpiece, *Faust*, which he completed in 1813, though it was not performed until five years later. He resigned his appointment at Vienna in 1815, and made a tour in Italy, where he performed his eighth and finest violin concerto, the *Scena cantante nello stilo drammatico*. The leading Italian critics called him "the finest singer on the violin that had ever been heard." On Spohr's return to Germany in 1817 he was appointed conductor of the opera at Frankfort; and there in 1818 he first produced his *Faust*. It was followed by *Zemire und Azor*, which, though by no means as fine as *Faust*, soon attained a much greater popularity. *Faust* suffered from its libretto, which is on quite a different plot from Goethe's poem.

Spohr first visited England in 1820, and on the 6th of March played his *Scena cantante* with great success in London at the first Philharmonic concert. At the third he produced a new symphony (*No. 2 in D minor*) and, instead of having it led by the first violinist and a *maestro al cembalo*, conducted it himself with a bâton; a great innovation in London at the time. After a visit to Paris, and a short sojourn in Dresden, Weber recommended him strongly to the elector of Hesse-Cassel as Kapellmeister. Spohr began his duties at Cassel on Jan. 1, 1822, and produced his sixth opera, *Jessonda*, in 1823.

In 1822 Mendelssohn, then a boy of thirteen, visited Cassel; a firm friendship sprang up between the two, which ceased only with Mendelssohn's death in 1847. Spohr's next three operas, *Der Berggeist* (1825), *Pietro von Abano* (1827) and *Der Alchymist* (1830), attained only temporary success. At the Rhenish musical festival held at Düsseldorf in 1826, his oratorio *Die letzten Dinge* (*The Last Judgment*), the most famous of his sacred compositions, was produced. In 1831 Spohr published his admirable *Violin School*. The year 1834 was saddened by his wife's death. Two years later he married a pianist, Marianne Pfeiffer. During 1833 he had been working at an oratorio—*Des Heilands letzte Stunden* (*Calvary* or *The Crucifixion*), which was performed at Cassel on Good Friday 1835, and sung in English at the Norwich Festival of 1839 under Spohr's own direction, with an effect which he afterwards always spoke of as the greatest triumph of his life. For the Norwich Festival of 1842 he composed *The Fall of Babylon*, which also was a perfect success, though the elector of Hesse-Cassel refused Spohr leave of absence to conduct it. His last opera, *Die Kreuzfahrer*, was produced at Cassel in 1845. Of his nine symphonies the finest, *Die Weihe der Töne*, was produced in 1832.

Spohr's compositions for the violin include concertos, quartets, duets and other concerted pieces and solos, and among these a high place is taken by four double quartets (*i.e.*, octets for two antiphonal string-quartet groups), an art-form of his own invention. He was, indeed, keenly interested in experiments, notwithstanding his attachment to classical form; and the care with which he produced Wagner's *Fliegender Holländer* and *Tannhäuser* at Cassel in 1842 and 1853, in spite of the elector's opposition, shows that his failure to understand Beethoven lay deeper than pedantry. He died at Cassel on Oct. 16, 1859.

See his *Selbstbiographie* (Eng. trans., 1865); and *Letters of a Leipzig Cantor*, ed. A. D. Coleridge (1892).

SPOKANE (spō-kăn′), a city of eastern Washington, U.S.A., at the falls of the Spokane river, 50 m. from its mouth in the Columbia river; a port of entry and the county seat of Spokane county. It has a municipal airport; is on Federal highways 10, 95, 195 and 395; and is served by the Chicago, Milwaukee, St. Paul and Pacific, the Great Northern, the Northern Pacific, the Spokane International, the Spokane, Portland and Seattle and the Union Pacific railways, and by numerous electric trolley and motor-coach lines. Pop. (1920) was 104,437 (83% native white); (1928 local estimate) 126,000. Spokane is the metropolis of the "Inland Empire" of 200,000 sq.m., lying between the Rocky mountains on the east and the Cascade or Coast range on the west, and embracing eastern Washington, north-eastern Oregon, northern Idaho, western Montana and southern British Columbia. The city has an area of 40·37 sq.m. and an altitude of 1,891 ft., and is surrounded by pine-clad mountains, rivers, cascades, waterfalls, lakes (76 within 50 m.), orchards and fertile fields of grain. It is protected by the mountain ranges from extremes of heat and cold and from the fogs of the coast. The average year has 208 days of sunshine, 16·5 in. of rainfall, and a "growing season" of 183 days between killing frosts. Through the city, in the heart of the business section, flows the Spokane river, tumbling over cataracts, from which 25,000 h.p. of electric energy is generated. The city is clean and well built, with substantial business buildings and commodious hotels; well paved, well lighted, and well kept streets; and delightful views in every direction. Since 1911 it has been under a commission form of government. The park system includes in all 2,200 acres. Mount Spokane (5,808 ft. high), 35 m. N.E., is maintained by the State as a public recreation ground. Three miles west of the city is Ft. George Wright, an important post of the U.S. army, in a reservation of 1,022 ac., presented to the Government by the city in 1894. The assessed valuation of property in 1926 was $85,981,102.

Schools.—The investment in public-school buildings and equipment amounts to over $7,000,000, and the teaching staff in 1928 numbered 760. Gonzaga University (Roman Catholic; opened 1887), Whitworth college (Presbyterian; founded in Tacoma in 1890) and Spokane college (Lutheran) are in the city.

Resources and Commerce.—The Inland Empire is rich in natural resources (lumber, minerals, fertile soil and water power) and Spokane is its principal market, supply point, manufacturing and distributing centre and financial capital. The wholesale and jobbing business of the city is estimated at $225,000,000 annually. Spokane is fairly entitled to the sobriquet "the power city," for by 1928 the hydro-electric plants of the district developed 278,943 h.p., of which 187,300 h.p. was generated by the seven plants on the Spokane river in and near the city. This electric power operates mines, maintains extensive irrigation projects, runs transcontinental trains over the Rockies and the Cascades, and supplies current for industrial plants, street-cars and suburban trains, street lamps, domestic lighting and the household appliances which are widely used. Spokane has a branch of the Federal Reserve Bank at San Francisco and of the Federal Land Bank.

History.—The first permanent settlement on the site of Spokane was made in 1874 by James N. Glover, who bought a tract of land from two trappers. The town was incorporated in 1881, as Spokane Falls, received a city charter later in the year, and became the county seat in 1882. In 1890 "Falls" was dropped from the name. Spokan (said to mean "children of the sun") was the name of an Indian tribe of Salishan stock which had formerly occupied the river valley. The Northern Pacific railroad reached the city in 1883, the Union Pacific in 1889, and the Great Northern in 1892. In 1889 (Aug. 4–6) a fire destroyed 30 blocks in the heart of the city, practically the entire business section, at a loss estimated at $5,000,000, but within two years the district was rebuilt, with great improvements. The population was 19,922 in 1890, 36,848 in 1900 and 104,402 in 1910. The pioneer who laid out the town site lived to see a city of over 100,000.

SPOLETO (anc. *Spoletium*), a town and archiepiscopal see of the province of Perugia, Italy, 18 m. N.N.E. of Terni, and 88 m.

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[1] Not to be confused with *The Last Judgment*.

N. by E. of Rome by rail. Pop. (1921) 17,678 (town); 28,289 (commune). It is situated on a hill, so that the lowest part is about 1,000, the highest 1,485 ft. above sea-level, at the south end of the open valley of the Topino, a tributary of the Tiber, which it joins near Assisi. The principal industries are the collection and preparation of truffles and preserved foods, also tanning and the manufacture of earthenware, cotton and wool spinning. Spoleto is also the centre of an agricultural district, and contains a government experimental olive oil factory. There are few towns of Italy which possess so many Roman remains in good preservation under the medieval buildings, and few medieval towns with so picturesque an appearance. There are considerable remains of pre-Roman polygonal walls. There are remains of a Roman theatre, over 370 ft. in diameter, and an amphitheatre 390 by 295 ft. A Roman bridge of three arches, 80 ft. long and 26 ft. high, exists at the lower (north) entrance to the town.

The rock above the town was included within the polygonal walls: but Totila fortified, not this rock, but the amphitheatre, which remained the citadel until 1364, when Cardinal Albornoz destroyed it and erected the present Rocca, which was enlarged by Pope Nicholas V.; it is now a prison. The Porta Fuga (the name alludes to the repulse of Hannibal) occupies the site of a Roman gate, but is itself medieval: while the medieval enceinte encloses a somewhat wider area than the ancient. The Piazza del Mercato represents the Roman forum; close by is a triumphal arch of Drusus and Germanicus (A.D. 21), and a temple (?) over which is built the church of S. Ansano. A Roman house in the upper part of the town, with mosaic pavements, probably belonged to Vespasia Polla, the mother of the emperor Vespasian. The Palazzo Municipale, above it, contains the archives and picture gallery. The cathedral of S. Maria Assunta, much modernized in 1634 by Bernini, occupies the site of a church of the Lombard dukes erected about 602. The present church was consecrated in 1198; the façade with eight rose windows belongs to the middle of the 12th century. Over the main entrance is a large mosaic of Christ enthroned, with the Virgin and St. John, by the artist Solsernus (1207). The Early Renaissance vestibule (after 1491) is fine. In the choir and on the half dome of the apse, are the finest frescoes of Fra Filippo Lippi (scenes from the life of the Virgin) completed after his death by Fra Diamante: his tomb, erected by Lorenzo de' Medici, with the epitaph by Politian, is on the left of the choir. The fine stalls and panelling in the winter choir date from 1548–54. The Campanile is beautiful.

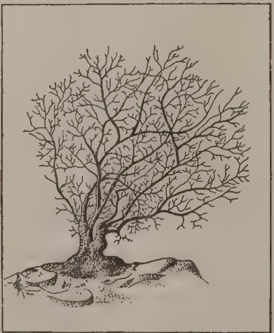
The church of S. Pietro, outside the town, has a façade richly sculptured with grotesque figures and beasts, of two different dates, about 1000 and about 1200. The little church of SS. Giovanni e Paolo (12th century) contains frescoes of the 12th–14th centuries notably an early representation of the martyrdom of S. Thomas à Becket and a portrait of S. Francis of Assisi. S. Domenico is a fine example of later Italian Gothic with bands of different coloured stone. Both the church and its crypt contain 14th century frescoes. The triple-apsed crypt of S. Gregorio probably dates from the 9th century; the upper church was consecrated in 1146 and the Romanesque work covered with stucco in the restoration of 1744. S. Nicolò is a beautiful example of Pointed Gothic. The basilica of S. Salvatore (*il Crocefisso*) at the cemetery belongs to the 4th century A.D. The fine sculptures of the façade, with its beautiful windows, as also the octagonal dome, all belong to this period. It was restored in 1815. S. Ponziano, not far off, belongs to the 13th century. The city is still supplied with water by an aqueduct, to which belongs the huge bridge called the Ponte delle Torri, crossing the ravine which divides the town from the Monte Luco (2,723 ft.). The bridge is 253 ft. high and 755 ft. long and has ten arches: it was erected in 1364.

After the battle of Trasimenus (217 B.C.) Spoletium was attacked by Hannibal, who was repulsed. It suffered greatly during the civil wars. Sulla, after his victory over Crassus, confiscated the territory of Spoletium (82 B.C.). Under the empire it again became a flourishing town. It was situated on a branch of the Via Flaminia, which left the main road at Narnia and rejoined it at Forum Flaminii. An ancient road also ran hence to Nursia. Martial speaks of its wine. Aemilianus, who had been proclaimed emperor by his soldiers in Moesia, was slain by them here on his way to Rome (A.D. 253), after a reign of three or four months. The foundation of the episcopal see dates from the 4th century. Owing to its elevated position it was an important stronghold during the Vandal and Gothic wars. It was beautified by Theodoric (493) and fortified by Belisarius (536) but its walls were dismantled by Totila (546). Under the Lombards Spoleto became the capital of an independent duchy (from 570), and its dukes ruled a considerable part of central Italy. Together with other fiefs, it was bequeathed to Pope Gregory VII. by the empress Matilda, but for some time struggled to maintain its independence. In 1155 it was destroyed by Frederick Barbarossa. In 1213 it was definitely occupied by Gregory IX. During the absence of the papal court in Avignon it was a prey to the struggles between Guelphs and Ghibellines, until in 1354 Cardinal Albornoz brought it once more under the authority of the Church. In 1809 it became capital of the French department of Trasimene. In 1860 it was taken by the Italian troops after a gallant defence.

At Monteleone di Spoleto a circular tumulus was found in 1902, with a rectangular chamber in the centre, and in it was the famous *biga* (two horse chariot), the only ancient one found in a complete state, which is now in the Metropolitan Museum at New York. (T. A.)

SPONGES. Mediterranean civilisation has used sponges from the earliest times. Homer describes Hephaestus as washing off the grime of the smithy with a sponge (Iliad, xviii., 414), while the household servants of Penelope and Odysseus used sponges to swab down the tables in the dining-hall (Odyssey i., 111; xxii., 22, 439). Aristotle calls the kind of sponge used for padding helmets and greaves *Achilleion,* and says it was "very fine, very dense, and very strong"; this was probably the "Elephant's Ear" sponge. The Romans made paint-brushes of "Achilleum" (Pliny), and used sponges on wooden handles for mops. The Gospels (Mark xv., 36) show that a sponge was a common article in Roman Jerusalem.

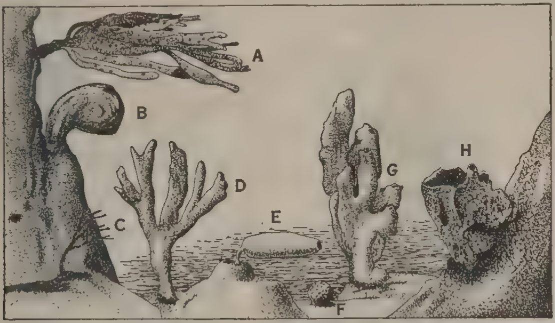
Commercial Sponges.—Modern trade recognises five principal kinds of sponges from the Mediterranean—(1) The Fine Turkey Cup (*Euspongia officinalis mollissima*), is softest and most delicate, but little more so than (2) the Fine Turkey Solid (*E. officinalis adriatica*), the soft bath-sponge, cushion-shaped and larger than the cup-sponge. (3) The Zimocca, Brown Turkey or Hard Greek sponge—"fine dure" of the French—(*Euspongia zimocca*) is a hard sponge, usually a cup-shape flattened almost to a disc; its harsh surface makes it useful for scrubbing. (4) The Elephant's Ear (*Euspongia officinalis lamella*) is a thin-walled shallow cup whose shape and elasticity gives it special value for stuffing, its texture and flatness for polishing. (5) The Honeycomb (*Hippospongia equina*) is the well-known Mediterranean bath-sponge (French "Venise"); its large size, uniform fibre, and many wide cavities distinguish it from the Turkey Solid, while the comparatively continuous skin between the round holes on the upper surface distinguishes it from the bath-sponges now obtained from the west Atlantic.



FROM LENDENFELD, "HORNY SPONGES," BY COURTESY OF COUNCIL OF ROYAL SOCIETY

FIG. 1.—SKELETON OF BUSH HORNY SPONGE (DENDRILLA ROSEA)

In sponges from the shallow seas near the Bahamas and Florida the round holes are usually each bordered by a pronounced circular ridge or fringe; often each is on the top of a "tower" or finger (noticeably in the Reef Sponge or (6) Glove Sponge, *Euspongia tubulifera*); possibly this protection of the vent-hole is because there is more sediment in the water. It may be for the same reason that we find in this American sea no cup-sponges or toadstool shapes. The fibre is more brittle than in sponges from Levantine waters, possibly because of suspended lime in the water; but it must also be remembered that the water-temperature at the Bahamas is about 27° C. against 17° C. in the Mediterranean. Compared with the Mediterranean, the Caribbean sponges show more numerous tassels and brushes on the upper surface, especially in (7) the Wool Sponge (*Hippospongia gossypina*), with surface resembling a lamb's fleece, the staple "bath-sponge" of these fisheries. The surface is characterized by grooves and deep channels between the tufts, because the skin in life has less, or less resistant, skeleton than in the Mediterranean; consequently water-passages which were in life roofed with skin are open in the cleaned skeleton, the tufts being the columns which supported the skin. (8) The Velvet Sponge (*Hippospongia maeandriformis*) shows these grooves very markedly; it comes nearest in softness to the Turkey Sponges. (9) The Hard-head or Honeycomb Reef Sponge (*Euspongia agaricina*) and (10) the hairy Yellow Sponge (*Euspongia corlosia*) are hard when squeezed, approaching the character of the Zimocca. (11) The Grass Sponges (*Hippospongia graminea* and *H. cerebriformis*) are the least valuable commercially; they have the form of a truncated cone fluted with deep furrows. Roughly, one third of a pound's weight of Turkey Cup sells for about as much as a pound of Mediterranean Honeycomb or Wool Sponge, as three pounds of Velvet or Yellow Sponge, or as ten pounds of Grass or Glove. The lagoons of Bermuda grow a hard sponge (*Hippospongia lapidescens turrita*) with kiln-like towers, which is only suitable for rough purposes.



AFTER BIDDER IN PROCEEDINGS OF THE S.W. NATURALISTS' UNION

FIG. 2.—COMMON SPONGES OF TEMPERATE SEAS

A. Branched Finger Sponge (*Chalina oculata*); B. Sea Fig (*Suberites ficus*); C. Tow Sponge (*Vibulinus stuposus*); D. *Axinella dissimilis*; E. Common Sponge (*Leucandra fistulosa*); F. Sea Sponge (*Donatia lyncurium*); G. Mermaid's Glove (*Desmacidon fruticosum*); H. Brittle Horny Sponge (*Spongelia fragilis*)

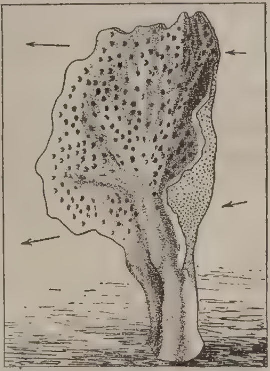
Australian waters have a number of undoubtedly valuable sponges; fine bath-sponges occur in Torres Straits, on the west coast, and near Port Phillip. In the South Caroline Islands they fish and use (12) a fine soft sponge (*Coscinoderma lanuginosum*) much resembling the Turkey Sponge in character; the same sponge occurs near Port Phillip. The Great Barrier Reef Expedition is at present (October, 1928) re-investigating the Australian toilet sponges and the results seem promising (June 1929).

In all these cases the "sponge" is the cleaned skeleton of a creature that lives attached to the sea bottom. The skeleton is formed of *spongin*—a substance resembling silk (*q.v.*) in chemical character and composition, and, like silk, belonging to the "scleroproteins" (of which horn is another familiar example), a group of highly insoluble nitrogenous substances, apparently easily formed as waste-products from the life of protoplasm.

Sponges with a skeleton of spongin are known as Horny Sponges (*Ceratosa*), and include many other species besides the dozen used by man. There are two main groups: those with latticed or netted skeletons (*Dictyoceratida*) like the market-sponges, and those with tree-like skeletons (*Dendroceratida*). The tree-like skeletons grow up from the basal spongin plate; the netted skeletons grow in from any part of the semi-solidified, sticky spongin cuticle (fig. 1).

Of other sponges—wholly useless to man—there are many thousands of species. The skeleton usually contains crystalline spicules; these are of cubic opal (silicic acid with cubic symmetry) in the Glass Sponges, of cubic opal, cemented by varying quantities of spongin, the Needle-sponges, of tetrahedral opal in the Four-ray Sponges, and of carbonate of lime, in the form of calcite (Iceland spar), in the Chalky Sponges. Siliceous spicules of fossil sponges have formed our flints.

Characteristics and Relationships.—Spicules or spongin-fibres are in the living sponge all surrounded by the living substance which has formed them, except that often some spicules are pushed outwards by their own growth until they bristle the surface. Sometimes they are pushed out by their growth—to form a stalk for the sponge (*Hyalonema*—Glass-rope sponge) or a beard rooting it in the mud (*Euplectella*, fig. 9).

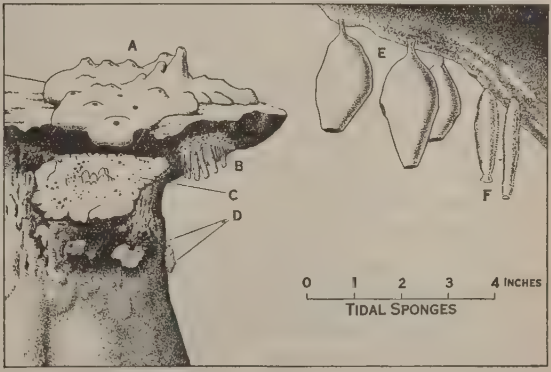


AFTER BIDDER IN QUAR. JOUR. MICROSCOP. SC.

FIG. 3.—FAN SPONGE (PHAKELLIA CONULOSA) IN UNCHANGING OCEAN CURRENT, WATER ENTERING BY PORES ON ONE SIDE AND LEAVING BY VENTS ON THE OTHER

A microscopic examination shows that the living substance is composed of protoplasmic cells, which, in all groups except the Glass Sponges, surround and penetrate a clear glutinous semi-fluid *intercellular jelly*. Throughout the many forms there are always some tubes or cavities in the sponge lined with *flagellate cells* each bearing a fine whip (Latin *flagellum*) with which they lash on the water so that it keeps moving through the cavities and bringing fresh food for the sponge. These are also called *collar-cells*, because there is a little collar (fig. 6) surrounding the butt of the flagellum and so preventing its side-to-side movements from knocking away particles of food from the cell; it also acts as a valve to prevent water flowing the wrong way.

Precisely similar collar-cells are to be seen in the Collar-flagellates or *Choanoflagellata* (a group of Protozoa, *q.v.*), and it seems certain that the Horny Sponges and their relations have originated from protozoan Collar-flagellates which have taken to sticking together into colonies, and then to secreting so much adhesive substance that it forms a jelly continuous under the bases of the cells (fig. 7) from which rations can be drawn by cells who are not themselves catching any food. Socialism and class-distinction are thus alike established, and sponges have therefore passed out of the grade of Protozoa, where cells are typically separate, similar and individualist. The title of Metazoa has been given to the further-developed animals with stomachs (*Enterozoa*); W. J. Sollas has therefore called the sponges *Parazoa*.



AFTER BIDDER IN PROCEEDINGS OF THE S.W. NATURALISTS' UNION

FIG. 4.—COMMON SPONGES OF TEMPERATE SHORES

A. Colony of Bead Sponge (*Halichondria*); B. Chimney Sponge (*Leucosolenia variabilis*); C. Cockscomb (*Hymeniacidon*); D. Lace Sponge (*Clathrina coriacea*); E. Sack Sponge (*Grantia compressa*); F. Coronet Sponge (*Sycon ciliatum*)

The Glass Sponges have probably emerged to the rank of Parazoa by another route from other Collar-flagellates. Their cells rarely form any intercellular jelly, but for the most part lie naked in the water as a branching network or cobweb (fig. 9). Opposed to the "True" gelatinous sponges, we may call these "Naked sponges."

CLASSIFICATION

Sub-kingdom PARAZOA Sollas—*Porifera* Grant. Sponges.

Colonial Collar-flagellates consisting of cells of more than one kind.

Phylum 1. NUDA. Naked Sponges. Originating from branching colonies of naked cells.

Class 1 and Order 1. *Hexactinellida.* Glass Sponges.

Phylum 2. GELATINOSA. True sponges. Originating from adhesive colonies of cells bedded in secreted jelly.

Class 2 and Order 2. *Monaxonellida.* Needle-sponges[1].

Families: Clavulidae (Pin-cushions); Desmacidonidae (Claw-sponges); Axinellidae (Fans); Renieridae (Spindle-sponges).

Class 3. *Ceratosa.* Horny Sponges.

Order 3. Dendroceratida (Horny Bushes).

4. Dictyoceratida (Horny Nets).

Class 4. *Calcarea.* Chalky Sponges.

Order 5. Calcaronea (Banana-chalks).

6. Calcinea (Lace-chalks).

Class 5. *Tetraxonida* (s.s.) Four-ray Sponges.

Order 7. Plakinida (Flat Four-rays).

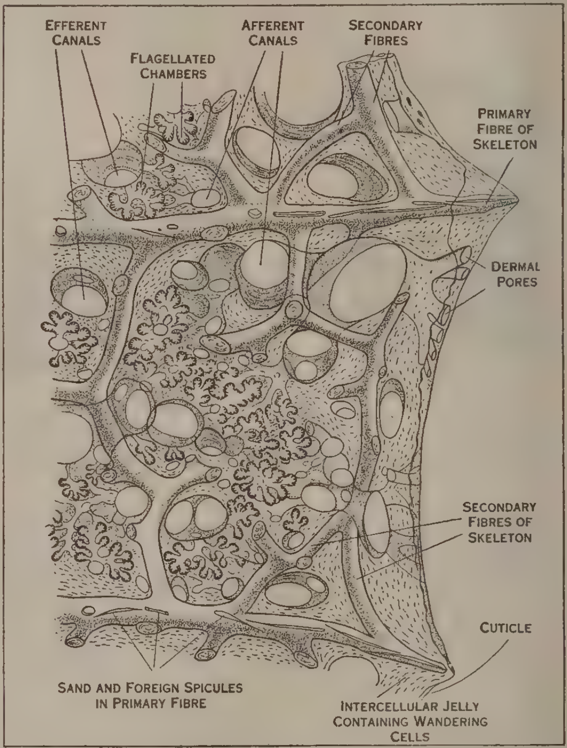
8. Tetractinellida (Grapnel-sponges).

9. Donatiida (Plane-fruits).

[10. Lithistida (Stony Sponges). Not a true group.]

This classification represents the opinions of the writer; others will be found in the text-books. Vosmaer (13), Sollas (2), Delage (5) and Dendy separated *Calcarea* from all other sponges. Dendy included all Needle-sponges in *Tetraxonida.* Hentschel (4) in the Phylum and Class *Porifera* recognises five equal Orders; Pin-cushions are placed in *Tetraxonida,* the other Needle-sponges are united with Horny Nets in *Cornacuspongida* and the Horny Bushes form the 5th Order, *Dendroceratida.* Emile Topsent in 1928 (17) divides the *Porifera* into three Classes: *Calcaria* (=Chalks), *Triaxonia* (=Glass-sponges), and *Demospongiaria* to include the rest. *Demospongiaria* contain the Sub-classes *Tetractinellida, Monaxonellida,* and *Ceratellida* (=Horny Sponges). *Tetraxonellida* are the Four-rays without the Plane-fruits and Gristly sponges: these are included in *Monaxonellida* (Needle-sponges), and united with Pin-cushions to form the Order *Hadromerina. Monaxonellida* have four Orders: *Hadromerina; Halichondrina* (=Fans); *Poecilosclerina* (=Claw-sponges); *Haplosclerina* (=Spindle-sponges). The figures (except dates) in parentheses following authors' names in the foregoing and subsequent paragraphs refer to works so numbered in the *Bibliography* at the end of this article.

The "Glass Sponges" are exclusively deep-sea sponges, with large spicules, often extended into long threads like delicately spun glass (fig. 9), but typically four-rayed or six-rayed rectangular crosses with one or more rays often exaggerated or suppressed. The "Needle-sponges," with spicules generally like needles, rods, or spindles, $\frac{1}{20}$ to 2 mm. long, comprise the majority of sponges met on the shore. "Pin-cushions" show also some fine "pinheaded" spicules generally really trefoil—or cross-headed; sponges mostly massive and corky, often bun-shaped. "Claw-sponges" usually show with a good microscope minute C-shaped or G-shaped spicules (often only 3 c. long), the *chelae* or "claws," with commonly a 3-fluked anchor or claw at each end of the C or G; the large spicules being needles, bodkins, or rods (fig. 8) (rarely spindles), and a stout bodkin with prickles on it (*acantho-style*) very characteristic; sponges often hand-shaped, with many fingers or clustered turrets but others form flat crusts. "Fans" are typically shaped like antler-ferns with their branches in one plane (fig. 3) sometimes coalescing into a fan, supported by branching feathery fibres of spicules; needles, with or without spindles, are the commonest spicules, never prickly bodkins or claws, which Dendy considered were possessed ancestrally and lost (1921, "Sealark," p. 111). In "Spindle-sponges" (including fresh-water sponges, "Witches' butter" of our ancestors) all the numerous spicules have equal symmetrical ends; ends of neighbouring spindles or rods are generally cemented together by spongin into a network or scaffolding, often rectangular (fig. 11). "Horny Sponges," the marketable kinds, grow in warm seas at 2–20 fathoms depth; in most others the spongin is too hard and brittle to be commercially useful. Inside the fibre of many "Nets" is much sand. The "Chalky Sponges," mostly small, frequent temperate shores; the microscope shows 3-ray and other spicules (fig. 12) soluble in acid. "Banana-chalks" are characterised by tall chimneys, in shape like bananas (Minchin); they are all white to whitish-brown, with many Y-shaped, or more accurately ϒ-shaped or T-shaped spicules (fig. 12).


EFFERENT CANALS
FLAGELLATED CHAMBERS
AFFERENT CANALS
SECONDARY FIBRES
PRIMARY FIBRE OF SKELETON
DERMAL PORES
SECONDARY FIBRES OF SKELETON
CUTICLE
SAND AND FOREIGN SPICULES IN PRIMARY FIBRE
INTERCELLULAR JELLY CONTAINING WANDERING CELLS

AFTER SCHULZE IN ZEITSCHRIFT FUR WISSENSCHAFLICHE ZOOLOGIE (ENGELMANN)

FIG. 5.—TURKEY BATH-SPONGE (EUSPONGIA OFFICINALIS), WITH MAGNIFIED SECTION VERTICAL TO SURFACE

The "Lace-chalks" are coral-red, sulphur-yellow, snow-white and fawn colour, usually making a little crust or cushion of lace-work on the rock with occasional short chimneys (fig. 7); their equiangular spicules have 3 rays about $\frac{1}{10}$ mm. long (fig. 12). "Four-ray Sponges" are characterised by spicules corresponding to the name. They may be symmetrical resembling the calthrops of mediaeval warfare, but usually the ray pointing inwards is of different thickness and length from the other three rays. Of the "Flat Four-rays" *Plakina* has minute, scattered spicules; *Oscarella* has no spicules. The "Grapnel-sponges" show slender spicules with one long arm pointing to the centre of the sponge and three prongs, often curved; they include, however, the "Starry-sponges" (Stellettidae); among which often no four-ray spicule can be found, and which lead us on to the "Gristly-sponges" (*Chondvilla,* Sea-kidney, stars only; *Chondrosia,* Gristle-sponge, no skeleton) and to the "Plane-fruit Sponges," which have a crust of stars, with needles and spindles arranged in a radiating skeleton (*Donatia*, fig. 2, the Common "Sea Orange," is like a small, yellow, hard golf-ball). The deep sea "Stony Sponges" have shapeless silica laid down on their spicules, mortising them together like the sutures of the skull; their relationships are uncertain; probably they really belong to several groups, some descended from Needle-sponges.

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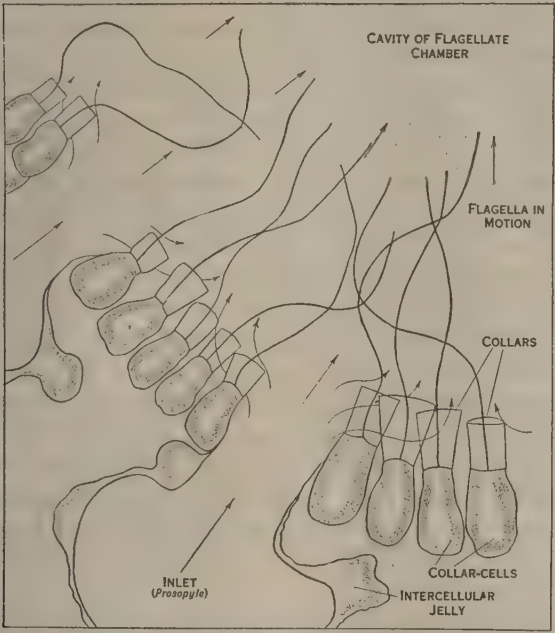
[1] Outside marketable Horny Sponges only about half-a-dozen species have popular names, and the groups are known to zoologists by Latin and Greek names, usually of six syllables. For this article the writer has ventured to coin names in English.



AFTER BIDDER IN QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE

FIG. 6.—WALL OF FLAGELLATE CHAMBER OF THICK WALLED BANANA-CHALK (LEUCANDRA ASPERA); ARROWS SHOW DIRECTION OF CURRENTS

The neat round holes on the upper surface of a bath-sponge, into which a man's smallest finger will just go, have a very definite size for a good mechanical reason. They are known to zoologists as the "vents" or "oscula," and in healthy life water issues from them continuously so long as they are open. The large tube or cavity from which a vent opens (fig. 8) is the "cloaca," or main drain. The water issues from the cloacae through numerous round holes (fig. 8), and water enters to replace it by minute holes all over the surface, in most sponges invisible except with a lens; the name of "pores" is technically confined to them, giving sponges their scientific name of *Porifera*. Except for its million pores, a sponge has no mouth.

From the pores the water enters a system of spaces and tubes branching repeatedly, and from them arise millions of delicate capillaries only some 8μ ($\frac{1}{3000}$ of an inch) in diameter. Each of these opens into a tiny cup-shaped chamber (fig. 6) known as a "flagellate chamber," because its walls are composed of 100 or 200 of the flagellate collar-cells about 6μ high. These wave their flagella, 10μ long, like so many eels fixed with their gills in a net and their tails downstream, and suck the water in through the fine hole or holes in the dome, driving it out into another fine tube, an *efferent* canal, which leads the water away. The efferent canals unite together into tubes which unite again into larger tubes, and these into a few main canals which open into the *cloaca*, and so to the *vent* (fig. 8). In the cleaned skeleton the canals cannot be traced to their smaller branches, but if a living sponge be killed in strong spirit its whole *canal-system* can be traced out.

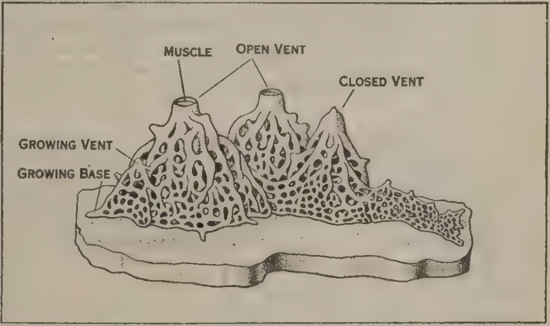
Certainly in the Glass Sponges, and probably in some other sponges, cells in the cavities under the skin and elsewhere also feed, but it has been proved by experiment that the collar-cells feed, and in calcareous sponges only the collar-cells feed. There is a good reason for the flagellate chambers being the region in which food is taken in: because from their enormous number the aggregate size of the channel through which the water is passing is largest there, and consequently its motion is slowest, and there is least difficulty in arresting the food. Similarly in a sewage-farm the water enters and leaves the field by a quick stream, but moves through the many little ditches so slowly that the land can absorb the manure.

Each flagellum with each stroke draws and pushes a little water forward into the chamber, and as the chamber was already full. its walls are stretched and the water inside it is under pressure, which is communicated, with some loss from friction, through the slowly moving water of the efferent canals to that of the cloaca. The water inside the sponge is nowhere moving at so high a speed as in the current escaping from the vent, but the flagellate chambers, efferent canals and cloaca form a *pressure-chamber*, from which a jet escapes through the vent. The pressure in the sponge's cloaca is kept up by the continuous work of the flagella, the force-pumps of the sponge's hydraulic engine, sucking the water in through the pores and delivering it in a continuous jet from the vent.

We know that, when watering a garden with a hose-pipe without any nozzle a wide jet of water will fall to the ground only three feet away, but that diminishing the opening with the finger will result in a ten- or a twenty-foot jet. A smaller volume escapes, but therefore the water inside the hose moves more slowly, there is less loss of head by friction inside the hose, and the jet issues at a higher velocity. We thus understand why the sponge's vent is so small in comparison with the total width of channel of its many millions of flagellate chambers. If the vent were double the size, the current in all the canals and chambers would be speeded up, and the head maintained by the flagella would consequently be lost in friction: the jet would be larger but much slower and would not travel so far.

It is most important for a sponge in still water that its vent jet should go far. The sponge lives by filtering its food from the water, and filters it completely, so that it can get no nourishment by taking in the same water again. It lives, also, by taking in oxygen and throwing out carbonic acid and the nitrogenous waste products of its food: so that the water which it has used is not only deprived of food, but poor in life-giving oxygen and loaded with deleterious carbonic acid and excreta. This valueless and poisonous water must be thrown far away from the entering stream.

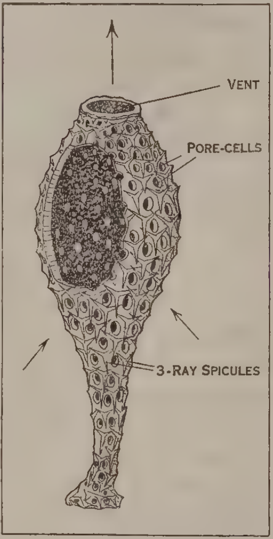
Sponges are organisms which live on minute particles filtered from the water, and are shaped so as to separate the used water from their new supply. The history of sponges is the history of their adaptation to separate efficiently used outgoing water from the incoming water on which they feed.



AFTER MINCHIN IN LANKESTER'S "TREATISE ON ZOOLOGY" (A. & C. BLACK)

FIG. 7.—LACE-CHALK (CLATHRINA CLATHRUS) SHOWING VENTS CLOSED COMPLETELY BY THE CIRCULAR MUSCLE SEEN INSIDE THE TWO OPEN VENTS
Left, the sponge is growing actively, right, the water is too stagnant and the sponge has contracted

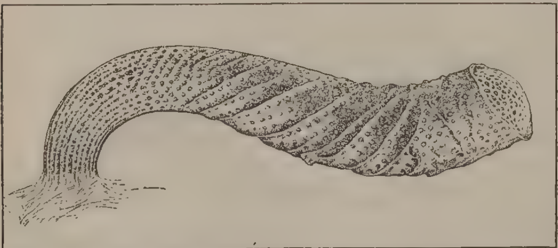
Let us examine the arithmetical facts which make it advantageous for unicellular collar-flagellates to unite into a sponge and for elementary thimble-shaped sponges such as the *Olynthus* to unite into a second-grade sponge like *Sycon* (fig. 4) in the Chalky Sponges, or like the "Rhagon"; the name given to very young Four-ray Sponges. Assume that in fig. 8, which illustrates a young Lace-chalk, that the size of the opening of the vent has been drawn exactly equal to the aggregate size of the vents of one hundred thimble-shaped flagellate chambers represented as making up the sponge. There is therefore no advantage from increased speed through a narrow vent, the speed of the water as it leaves the whole sponge being that with which it leaves the component thimbles, but the figure shows the immense advantage which has nevertheless been gained to each component or thimble by combination with its neighbour. Whereas the hundred independent thimbles would have a hundred independent streams, each with its own surface rubbing against the surrounding stationary water and so bringing the jet speedily to a standstill, it will be seen that of the component streams issuing from the common vent only 36 are external, and of these only half the surface is exposed to friction. The jet from the vent has the same velocity as the hundred streams, with their full aggregate weight, but is exposed to less than one-fifth of the total resistance to which the hundred separate streams were exposed. Experimentally the combined jet goes to about ten times the distance to which the individual jet travelled, and for each thimble the water which it sucks in will have, say, $\frac{1}{10}$ the pollution from used water which it would have had if isolated. The principle is akin to the reduction of overhead expenses when small businesses unite.



AFTER HAECKEL'S "DER KALSCHWAMME" (DE GRUYTER & CO.)

FIG. 8.—YOUNG LACE-CHALK (LEUCOSOLENIA PRIMORDALIS) IN "OLYNTHUS" STAGE, MAGNIFIED

Consider the action of the currents around a live bath-sponge at the bottom of a still sea. When the jet from the sponge throws water from the bottom layer of the sea to the layer four feet above it, an equal quantity of water must be pushed out of the four-foot layer to go somewhere; and an equal quantity must come into the bottom layer. If the water be still, these two requirements will be satisfied at once by the formation of a closed eddy like a smoke-ring, which will supply the water which is sucked into the pores by bringing down the water which has been ejected by the vent, so that the work of the flagella will be wasted and will bring to the sponge neither food nor oxygen.



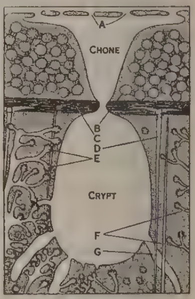
AFTER THOMSON IN THE REPORTS OF THE CHALLENGER EXPEDITION (H.M. STATIONERY OFFICE)

FIG. 9.—VENUS'S FLOWER BASKET (EUPLECTELLA ASPERGILLUM) FROM THE PHILIPPINE ISLANDS, 100 FATHOMS, SHOWING THE LARGE VENT WITH THE CONVEX SIEVE-PLATE PRESUMABLY FACING DOWN STREAM

Water in the sea is rarely absolutely still, even at the bottom on a windless day. Even in the Levant end of the Mediterranean there must be a slight tidal drag for half the day and a shoreward drift when the sun is hot and a seaward drift at night. Such currents, however slow, will bear the outgoing jet to one side: if the jet be only six inches high, the foul water will still come down to pollute three-quarters of the intake; if it be four feet high the whole return will come to the ground free of the sponge, and the purity of the intake will be absolute. *The longer the jet from the vent, the purer will be the water of the intake.* It has been shown for certain sponges by calculation (7) that the diameter of the vent is that which will carry the water to the greatest possible distance for that make of sponge.

Yet in a fine Turkey cup-sponge, however, we find there is no narrow vent at all, but all the efferent cloacae open into a cup-shaped false cloaca, which widens as it goes upwards to a lip several inches across. This is a second method of those arrived at during the 1,400 million years that sponges have existed; by it the angle between the outgoing and incoming streams is increased from the right angle of the bath-sponge, and becomes exceedingly wide; so that, however slow the outgoing stream, the diameter of the circular eddy is so large that the slightest drift of the surrounding water must take the polluted effluent away from the intake. In the fan sponge (fig. 3), where the vents and pores are on opposite sides of an upright plate, the angle between intake and effluent is 180°, so that the used water *never* returns. This, however, is only advantageous where the drift of the sea is unchanging in direction. Such a condition exists at the bottom of the great oceans, where there is a slow current from pole to equator, and in some of the deeps around Scotland; but in a tidal run the sponge for a third of its life would have the tide pressing the water into the vents and out of the pores. In the tidal English Channel the peculiar Cannon-sponge accomplishes the advantageous result in a wholly different manner. It points its wide vent horizontally, looking like an 18th century cannon; but its round base is carried on a thin stalk like a pig's tail, so that as the tide sweeps round it, swivels with it, and always points down stream. A deep-sea Claw-sponge, known as the Umbrella-sponge has also a flexible stalk so that the convex side of the umbrella must be down stream.

Appreciating the advantages of completely separating outflow from intake, it is possible to conceive how sponges arose, and such very similar forms have been evolved along so many different lines of descent. Glass Sponges appear as the offspring of branching colonies of unicellular collar-flagellates which learned to secrete a substance crystallising into rectangular scaffoldings, on which they can set themselves like a salmon-net across the slow currents of the deep ocean and so obtain an endless supply of the suspended organic particles. They have existed since the earliest fossiliferous rocks, and probably twice as long; but with no hydraulic system to form a forcible jet from the vent, they have been unable to live except in oceanic currents. The True Sponges are the offspring of multicellular gelatinous colonies of collar-flagellates (such as *Proterospongia*); they have learned to shape their gelatinous aggregate so as to unite the currents made by individual collar-cells, and on various plans to direct the streams of used water away from the approaching drift of purer water; thus they can support existence in still caves and tide-pools.



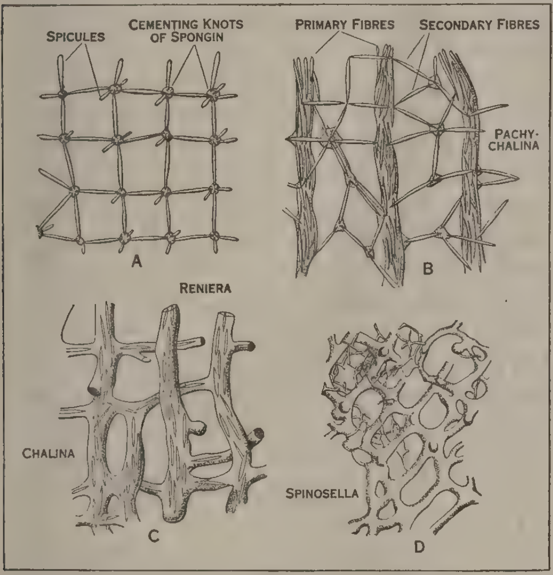
AFTER SOLLAS

FIG. 10.—"CHONE" WHICH REGULATES THE AFFERENT STREAM IN CYDONIUM EOSASTER, A GRAPNEL-SPONGE

(A) Dermal pores; (B) Solid-stars; (C) Contractile cells; (D) Grapnel spirule; (E) Flagellate chambers; (F) Efferent canals; (G) Afferent canal

G. H. Parker found that the pressure in the chambers of *Stylotella* (a Claw-sponge) supports a column of water $3\frac{1}{2}$ to 4 mm. above the surrounding surface (6). The velocity of the jet from the vent in *Leucandra aspera* is about 8 cm. a second, throwing 5 gallons a day to a distance of nine inches. The velocity at the same moment past the collar-cells (fig. 6) was 2 to 4 cm. an hour (7) taking 1 or 2 seconds to pass the cell 12μ high.

Spongin.—Chalky Sponges have no spongin, though the red and yellow pigments may be of an allied substance; Four-ray Sponges have little or none. Needle-sponges have commonly a basal spongin-plate, and their spicules are cemented by more or less spongin into bundles and networks, the claw-sponges showing so much spongin that some (as *Ectyon* and *Ophlitospongia*) may easily be mistaken for Horny Sponges; among the Chalinine Spindle-sponges, the spicules are sometimes reduced to a few spindles or rods inside horny fibres. In Horny Sponges the spongin of the fibres is secreted by flask-shaped cells which are known as spongoblasts. An examination of the unmarketable sponge called *Hircinia,* shows that similar cells are forming the horny cuticle of the outer surface, and that the horny fibre is secreted by a tube of spongoblasts, pouched in from the sticky surface and carrying with it the adherent sand. (Projection of the fibre is not the condition in healthy life, but is due to the shrinkage as water drains from the sponge.)



A-C AFTER MINCHIN AND DENDY IN LANKESTER'S TREATISE ON ZOOLOGY (A. & C. BLACK) D, BY COURTESY OF THE ZOOLOGICAL SOCIETY OF LONDON

FIG. 11.—SKELETONS OF SPINDLE-SPONGES

The knots of spongin uniting single spicules in A are found in the secondary network of B, where the primary fibre has several rows of spicules wholly embedded in spongin. In C the single spicules of secondary fibre are also embedded, while in D, much spongin fibre is apparently free from spicules

Spicules.—Sponge-spicules are formed by cells. In the calcite three-ray spicules the Chalky Sponges (*Calcarea*) each ray is formed by two cells, the first rudiment being apparently non-crystalline, with the three rays separate (Minchin, 1898); then the rays become crystalline and unite, the three-ray spicule being optically one crystal (Sollas, 1885). The optic axis of the crystal is perpendicular to the plane of the rays in the symmetrical spicules of the Lace-chalks, and inclined to it in the upsilon-shaped "alate" spicules (fig. 12) of the Banana-chalks. The spindles and club spicules of Banana-chalks are each formed by two cells (Bidder, 1898, Woodland, 1905, Minchin, 1908). In Grapnel-sponges Dendy (Quart., *Micr. Soc.* 1926) found a slender non-siliceous rudiment, the "proto-rhabd," either laid down by cells of unusual appearance called "formative cells," or, as he afterwards supposed, reproduced like a bacterium from a parent proto-rhabd; several sponge-cells (silico-blasts) gather round this rudiment and pour opal over it and the formative nuclei. In Glass Sponges Ijimi describes a large number of cells as taking part in the formation of each spicule: the massed cells so engaged are the only cells of Hexactinellids, except the gemmule-cells, which show a gelatinous agglomeration such as is common in the True sponges.

Collar-cells.—The "collar" is not homogeneous, but a tubular tassel of sticky parallel rods—in *Grantia* 20–30, in *Clathrina* or *Halichondria* fewer. The rods can contract, thickening as they do so (Julian Huxley, 1911); they are not proved prehensile. The cell contains food-reserve granules, transparent after starvation, and (Gatenby—*see* "Cytology") a Golgi body. In Chimney-chalks the nucleus is near the top of the cell and connected with the flagellum (8, p. 21; Bidder 1898), in Lace-chalks it is connected in young cells (Robertson & Minchin, 1910), but separates and passes to the base.

Movement.—In many sponges especial fusiform cells form muscular bands and sphincters (fig. 10) whose contraction either closes a channel for water or alters its width. No sponge has any nervous mechanism. The flagellate cells wave their flagella without correlation, in different periods and at different phases. The contractile cells contract to direct stimulus, or are restrained from contraction by direct stimulus (b). There are no sensory cells and no nerve fibres.

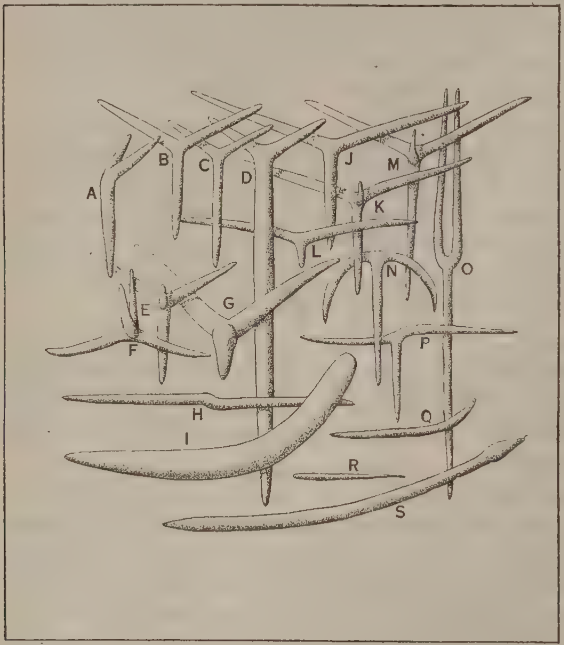
Within the jelly of the sponge-body, ova and other cells wander about with amoeboid movements, sucking from the bases of the collar-cells their food-resources and eating any intrusive foreign particle or organism encountered in the jelly. In the fresh-water *Spongilla* (9) the collar-cells are described as throwing carmine into the jelly and the amoeboid cells as devouring it; the green unicellular alga which colours *Spongilla* grows uninjured while *Spongilla* is well fed, but forms a reserve, being eaten by the amoeboid cells when other supplies fail.

In the young fixed larva the cells next the rock necessarily move over it to form a good disc of adhesion. Such movements may result in the whole young sponge changing its place; a gemmule of *Spongilla* allowed to fix at the bottom of the glass side of the aquarium will crawl some little way up the side, until light and other reactions are less different on the upper and lower sides of its base.

The most remarkable change of form and position in cells is that which gives rise to the pores in Lace-chalks. The small afferent holes through which water enters the flagellate chambers consist in Calcareous sponges each of a single perforate cell (Bidder, 1891). In the Lace-chalks any one of the external cells can stretch down through the sponge-wall to the flagellate surface, push in between the collar-cells and perforate itself to make a pore (Minchin, 1892). These "porocytes" in unhealthy conditions crawl over and completely cover the collar-cells. The occasional vertical ray, which in certain species of Lace-chalks converts some of the three-rayed spicules into four-rayed spicules, is always added by a porocyte (Minchin).

Nutrition.—In Banana-chalk (*Leucandra aspera,* fig. 6) 20 minutes after feeding with carmine the interstitial jelly between the collar-cells (fig. 5) is loaded with carmine particles and every collar-cell has several adhering to it or in vacuoles, generally near its base. After 4 hours the collar-cells are crowded with carmine, after 18 hours there are a few fine particles, but after a few hours more it has all disappeared. Food seems to be taken in at the sides of the collar-cell (9) (as in collar flagellates), but probably also inside the collar, and passes into vacuoles with an acid reaction. After about 6 hours the vacuole has become a faecal bolus of transparent mucilaginous substance (Cotte [1903, p. 459] observed the reaction to be alkaline) containing refringent granules, probably calcareous. This moves about in the upper part of the living collar-cell, from which it is presently cast out inside the collar and so into the efferent current. If a sponge, gathered from exposed rock at low-tide, be placed in fresh sea-water, the stream from the vent, so soon as the current resumes, is seen to bear a number of white specks and clots, heavier than water, which are the aggregated faeces that have accumulated during the period of quiescence.

Reproduction and Growth.—Increase of sponges is mainly by vegetative growth. *Leucosolenia variabilis* (fig. 4) sends out stolons along the rock from which tubular chimneys grow up in apparently endless succession. *Clathrina coriacea* (fig. 4), though complete in all its parts as a cushion a quarter-of-an-inch wide, will weave its lace over the rock till it covers many inches; the crusting Needle-sponges such as *Halichondria* (fig. 4) or the fresh-water *Ephydatia* can extend their crusts indefinitely. Rate of growth varies enormously with conditions: a calcareous sponge hanging from a boat in harbour may add 40% a day to its weight (7, p. 315), while the same species on a tidal rock may only increase 2% a day. The tidal sponges shown in fig. 4 are all annual, and in the most favourable situation *Sycon* or *Grantia* may grow to 10 inches instead of 2 inches long. Vosmaer's observation on the gemmule of the "Sea-orange" (13, p. 440) gives an increase of about 17% a day, but Rathbun's artificial sponge-cuttings of Horny sponges in Florida from $2\frac{1}{2}$ cubic inches grew to $12\frac{1}{2}$ cubic inches in two months (*see* Bidder, 1896, p. 201), which is only 3% a day. Mr. L. R. Crawshay has told the writer that his sponge-cuttings in the Bahamas increase more slowly than this, growing in a year to 2 or $2\frac{1}{2}$ times their volume, and that the large Wool sponges increase in volume annually from 0% to 80% (say, 50% a year); he considers the largest ($2\frac{1}{2}$ feet across) to attain an age of at least 25 years. The Wool sponges, Velvet sponges and Mediterranean Honeycomb sponges are probably the largest of all sponges. Cresswell (15) describes a circular specimen of the last species 36 inches across and 12 inches high. The Needle-sponge "Neptune's Cup" (*Cliona*) forms in the East Indies a rigid stalked goblet a yard high and more than a foot across the rim; it is one of the Pin-cushion sponges, and when young bores in soft limestone or sea shells, producing the worm-eaten appearance often seen in oyster-shells; in temperate seas its adult form is a yellowish corky sponge several inches in diameter, formerly known as *Raphyrus*.



AFTER MINCHIN IN LANKESTER'S "TREATISE ON ZOOLOGY" (A. & C. BLACK)

FIG. 12.—CALCITE SPICULES OF CHALKY SPONGES

(A. B. E. F. G.) *Ascaltis cerbrum lacunosa;* (C) *Clathrina blanca;* (D. H.) *Clathrina lacunosa;* (I) Lace-chalks: *Ascandra falcata;* (J. K.) Y-shaped (alate) spicules of *Leucosolenia variabilis;* (L) alate and (O) tuning-fork spicule of *Lelapia australis;* (P) T-spicule and (Q) lance-spicule of *Leucosolenia variabilis;* (R) needle and (S) lance-spicule from *Leucosolenia complicata*

Depleted fisheries can be restored by fixing to tiles cut pieces of sponge, each of which grows into a new sponge. Some sponges detach portions of themselves as *buds. Leucosolenia* (Vasseur, 1880) breaks off the end of a branch, which falls blind-end down and grows into a complete sponge. In *Oscarella lobularis* the tip of a lobe will become thin-walled and then be nipped off; having no skeleton it does not sink, but may exist for a fortnight as a free-swimming sponge before it fixes on the bottom and grows into a flat lobed sponge like its parent (F. E. Schulze, 1879 [β]).

The form of reproduction especially characteristic of sponges is *gemmulation,* found in Glass Sponges, Four-rays, Needle-sponges, Horny Sponges and Lace-chalks, but never recorded in Banana-chalks, among which sex is highly developed. A sponge-gemmule arises by a number of undifferentiated cells coming together and enveloping themselves in some sort of membrane or epithelium. In the Sea-orange the growth of a radial bundle of spicules in the parent forces the gemmule to the exterior, where it drops off; in Grapnel-sponges the gemmules appear to be thrown out in the cloacal current; in Glass Sponges and in Claw-sponges the exterior cells of the gemmule become flagellate and it swims away like a "planula" larva; in the Sea fig (fig. 2) the gemmules remain during healthy life sealed in envelopes of spongin just above the sponginous base of attachment, ready to reproduce the sponge if it be destroyed. Gemmules of Fresh-water Sponges are similarly protected by chitinous shells, reinforced by various rods or spindles (*Spongilla*) or amphidiscs (*Ephydatia*). After years of desiccation they grow new *Spongilla* when water returns. Fresh-water Sponges of temperate climate die in winter, and the gemmules show like seed-pearls among the remnants of the skeletons, which they reclothe in spring. Young sponges of the same species, growing near each other, generally fuse together if their growth brings them into contact (not in the case of bath sponges); when this happens to two grown from gemmules of different parents, the resulting sponge will contain cells of two heredities and in its gemmule both strains may be present.

There is also, at least in some groups of sponges, true sexual reproduction. The development of ova into larvae may be observed readily in Chalky or Horny Sponges, in *Halisarca* (a slime-covered purple crust, without skeleton, probably closely allied to Bush Horny Sponges) in *Oscarella,* Spindle-sponges and Claw Sponges. It has only recently (Burton, 1928) been recorded in a Sea-orange, though this species has been observed constantly for 150 years. It has never been recorded in Grapnel-sponges or Fan-sponges, it is rare among Pin-cushions and Ijima was unable to find it among Glass Sponges.

Many descriptions of spermatogenesis in sponges appear to the descriptions of parasitic flagellates (*Syncrypta spongiarum,* see *Linnean Soc. Journ.* Z. xxxiv.) and when spermatozoa are figured there is rarely evidence that they are not alien. In *Grantia compressa* Gatenby (1920, ibid.) has shown both the spermatogenesis and the fertilisation of the ovum by the spermatozoon through the intermediary of a collar-cell, in *Sycon raphanus;* Bidder (ibid.) has shown the direct fertilisation of the ovum under the cloacal surface by the spermatozoon. The spermatozoon was stiff-tailed when seen alive; it is possible that the tail only comes into play when the ovum is near.

Segmentation of the ovum in the Calcaronea produces a ring of eight similar cells (recalling the colonial Flagellates *Stephanosphaera* and *Cyclonexis*), each of which then divides horizontally into a smaller and a larger cell; from the eight smaller cells is produced a hemisphere of flagellate cells and from the eight larger a hemisphere of rounded cells. This "amphiblastula" larva swims for a day or two, then the flagellate hemisphere is sucked inside the other and becomes concave, the two-layered cup so formed fixing by its lip to a rock. The rounded cells secrete the spicules and form the dermal layer, a vent bursts through both layers, pores are formed, and the young sponge is a two layered cylinder whose lower end is closed by the rock, the perforate walls and flagellate lining giving a resemblance to the *Olynthus* stage of *Clathrina* (fig. 8). Spicules sometimes appear while the larva is still free-swimming, and (Bidder, *Brit. Assoc.,* 1928) the early division into two classes of cells occurs from the necessity of separating the spicule-forming cells from the locomotor cells, so that the activity of the flagellate cells shall not be hindered by the deposit of calcite or opal in their substance. There is no such division in *Oscarella,* which has no skeleton, but in most sponges the larva is egg-shaped with a surface of flagellate cells covering a solid interior of spicule-forming cells.

The fixed "Olynthus" larva of *Sycon* is subsequently metamorphosed into a Sycon by the flagellate cells retreating into radial tubes; this may be considered to repeat a change which took place in racial history.

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SPONSOR, one who stands surety for another (from Lat. *spondere*, to promise), especially in the rite of Christian baptism, a godfather or godmother. The practice originated not in infant baptism, but in the custom of requiring an adult pagan who offered himself for the rite to be accompanied by a Christian known to the bishop, who could vouch for the applicant and undertake his supervision, thus fulfilling the function performed in the Eleusinian mysteries by the *mystagogus*. The Greek word for the person undertaking this function is ἀνάδοχος, to which the Latin *susceptor* is equivalent. The word "sponsor" in this ecclesiastical sense occurs for the first time, but incidentally only, and as if it were already long familiar, in Tertullian's treatise *De baptismo* (ch. 18), where, arguing that in certain circumstances baptism may conveniently be postponed, especially in the case of little children, he asks, "For why is it necessary that the sponsors likewise should be thrust into danger, who both themselves by reason of mortality may fail to fulfil their promises, and may also be disappointed by the development of an evil disposition [in those for whom they become sponsors]?"

The sponsors here alluded to may have been in many cases the actual parents, and even in the 5th century it was not felt to be inappropriate that they should be so; Augustine, indeed, in one passage appears to speak of it as a matter of course that parents should bring their children and answer for them "tanquam fidejussores" (*Epist. . . . ad Bonif.* 98), and the oldest Egyptian ritual bears similar testimony. Elsewhere Augustine contemplates the bringing of the children of slaves by their masters, and of course orphans and foundlings were brought by other benevolent persons.

The comparatively early appearance, however, of such names as *compatres, commatres, propatres, promatres, patrini, matrinae*, is of itself sufficient evidence, not only that the sponsorial relationship had come to be regarded as a very close one, but also that it was not usually assumed by the natural parents. How very close it was held to be is shown by the Justinian prohibition of marriage between godparents and godchildren. On the other hand, the anciently allowable practice of parents becoming sponsors for their own children, though gradually becoming obsolete, seems to have lingered until the 9th century, when it was at last formally prohibited by the council of Mainz (813). For a long time there was no fixed rule as to the necessary or allowable number of sponsors and sometimes the number actually assumed was large. By the council of Trent, however, it was decided that one only, or at most two, these not being of the same sex, should be permitted.

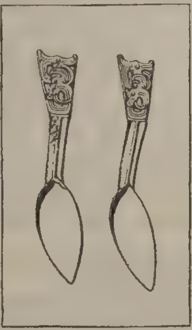
The rubric of the Church of England, that "there shall be for every male child to be baptized two godfathers and one godmother, and for every female one godfather and two godmothers," is not older than 1661; the sponsors are charged with the duty of instructing the child, and in due time presenting it for confirmation. In the Roman Catholic Church the spiritual relationship established between the sponsor and the baptized, and the sponsors and the parents of the baptized, constitutes an impediment to marriage. (*See* MARRIAGE; CANON LAW.)

SPONTINI, GASPARO LUIGI PACIFICO (1774–1851), Italian composer, was born on Nov. 14, 1774, at Majolati (Ancona) in Italy. He was the son of a poor cobbler and was intended for the priesthood. But he obtained lessons from Kapellmeister Quintiliani, and in 1791 went to the Conservatorio de' Turchini at Naples, where he studied under Paisiello, Cimarosa and Fiorivanti. By 1799 he had already written and produced eight operas. After becoming court composer to King Ferdinand of Naples in this year an intrigue with a princess of the court compelled Spontini to leave Naples in 1800. In 1803 he settled in Paris, where he had no success until the production of *Milton*, a one-act opera, in 1804. Thereafter his powers and ambitions steadily developed, being manifested to the full for the first time in *La Vestale*, produced on Dec. 15, 1807. *Ferdinand Cortez* was received with equal enthusiasm in 1809; but *Olympia* (1819) had less success.

Spontini had been appointed director of the Italian opera in 1810; but his quarrelsome and grasping disposition led to his summary dismissal two years later, and, though reinstated in 1814, he voluntarily resigned his post soon afterwards. In 1820 he settled in Berlin by invitation of Frederick William III., commissioned to superintend all music performed at the Prussian court and compose two new grand operas, or three smaller ones, every three years. But he began by at once embroiling himself with the intendant, Count Brühl. *La Vestale, Ferdinand Cortez* and *Olympia*—the last two entirely remodelled—were produced with great success in 1821. But Spontini's fame was entirely eclipsed by the appearance of Weber's *Der Freischütz*. A new opera, *Nourmahal*, founded on Moore's *Lalla Rookh*, was performed in 1822, and another, entitled *Alcidor*, in 1825; and in 1826 Spontini began the composition of *Agnes von Hohenstaufen*, (produced in 1829), which undoubtedly will rank permanently as his greatest work.

Dismissed from his court position in 1841, he settled in Paris. In 1850 he retired to his birthplace, Majolati, and died there on Jan. 14, 1851.

SPOON, a table implement, bowl-shaped at the end, with a handle varying in length and size. From the derivation of the word the earliest northern European spoon would seem to have been a chip or splinter of wood; the Greek κοχλιάριον (Lat. *cochleare*) points to the early and natural use of shells, such as are still used by primitive peoples. Examples are preserved of the various forms of spoons of ivory, flint, slate and wood, many of them carved with the symbols of their religion, used by the ancient Egyptians. The spoons of the Greeks and Romans were chiefly made of bronze and silver, and the handle usually takes the form of a spike or pointed stem. Mediaeval spoons for domestic use were commonly made of horn or wood, but brass, pewter and "latten" spoons appear to have been common about the 15th century. The full descriptions and entries relating to silver spoons in the inventories of the royal and other households point to their special value and rarity. The earliest English reference appears to be in a will of 1259. In the wardrobe accounts of Edward I. for the year 1300 some gold and silver spoons marked with the fleur-de-lis, the Paris mark, are mentioned. One of the most interesting mediaeval spoons is the coronation spoon used in the anointing of the sovereign. The sets of spoons popular as christening presents in Tudor times, the handles of which terminate in heads or busts of the apostles, are a special form to which antiquarian interest attaches. (*See* APOSTLE SPOONS.) The earlier English spoon-handles terminate in an acorn, plain knob or a dia-

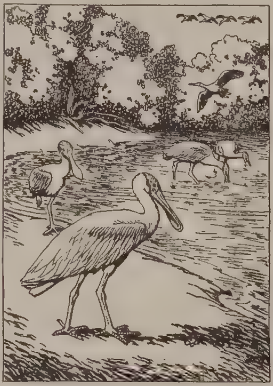


BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

CHINESE BRONZE SPOONS OF THE CHOU DYNASTY mond; at the end of the 16th century the baluster and seal ending becomes common, the bowl being "fig-shaped." At the Restoration the handle becomes broad and flat, the bowl is broad and oval and the termination is cut into the shape known as the *pied de biche,* or hind's foot. In the first quarter of the 18th century the bowl becomes narrow and elliptical, with a tongue or "rat's tail" down the back, and the handle is turned up at the end. The modern form, with the tip of the bowl narrower than the base and the rounded end of the handle turned down, appeared about 1760.

See C. J. Jackson, "The Spoon and its History," in *Archaeologia* (1892), vol. liii.; also Cripps, *Old English Plate.*

SPOONBILL, a bird, once called shoveller (*q.v.*), *Platalea leucorodia,* related to the stork. The spoonbill became extinct as a British breeding bird about 1660, though there is reason to hope it may again nest in Norfolk in the near future. It breeds in Holland, Spain, the Danube basin, and thence across Asia to India, as well as in North Africa. The plumage is white in both sexes, with a broad flat bill with which it sifts small animals from the mud of ponds, etc. Allied species replace it in South Africa and Australia. The pretty roseate spoonbill (*Ajaja ajaja*) of America is tropical and sub-tropical, and is found as far north as the Gulf States, where, however, it has been nearly exterminated. It has a deep pink plumage, deepening in places to crimson.



BY COURTESY OF THE NATIONAL ASSOCIATION OF AUDUBON SOCIETIES

THE ROSEATE SPOONBILL (AJAJA AJAJA), FOUND ONLY IN TROPICAL AND SUBTROPICAL AMERICA

Spoonbills breed in companies, often with herons, in trees or reed-beds, laying four white eggs, sparingly blotched with light red.

SPORADES, the scattered islands of the Greek Archipelago, distinguished from the Cyclades, which are grouped round Delos, and from the coastal islands of Europe and Asia. Ancient and modern writers differ as to the list. The Doric Sporades—Melos, Pholegandros, Sikinos, Thera, Anaphe, Astypalaea and Cos—were by some considered a southern cluster of the Cyclades. In modern times the name Sporades is applied to two groups: *The northern Sporades* lie north-east of Negropont (Euboea), Skiathos, Skopelos and Ikos being included in the department of Magnesia, and Scyros (*q.v.*) in that of Euboea. Scyros has a fine harbour. Skiathos is beautifully wooded; the town overlooks an excellent harbour. Skopelos is also well wooded. Almost every householder in both islands is the owner, joint owner or skipper of a sailing ship. *The southern Sporades,* lying off the south-west of Asia Minor, formerly included in the Turkish vilayet of the "Islands of the White Sea," are as follows: Icaria, Patmos (*q.v.*), Leros, Calymnos, Astypalaea (Astropalia or Stampalia), Cos (Turk. *Stanko, q.v.*), Nisyros, Tilos or Episcopi, Syme, Khalki, Rhodes (*q.v.*) and many smaller isles.

See C. Bursian, *Geographie von Griechenland* (Leipzig, 1862–71), ii. 348 ff.; L. Ross, *Reisen auf den Griechischen Inseln* (1840–45).

SPOROZOA, a group of parasitic Protozoa which produce unicellular spores within a tough envelope or cyst. Since formerly various Protozoa, which had only this character in common and were not truly related to one another, were classed with the Sporozoa, some protozoologists have split up the class Sporozoa into two classes, Amoebosporidia and the true Sporozoa. For further particulars *see* PROTOZOA.

SPORTS, ARTICLES ON. Almost all varieties of indoor and outdoor sport have separate articles in this *Encyclopædia.*

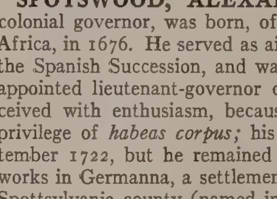
Among the chief are: ATHLETIC SPORTS; ANGLING; BASEBALL; BILLIARDS; BOWLS; BOXING; BRIDGE; BULL-FIGHTING; CAMPING OUT; CHARADE; CHESS; CONJURING; COURSING; CRICKET; CYCLING; DRIVING; FALCONRY; FOOTBALL; GAME; GAMES, CLASSICAL; GOLF; GYMKHANA; GYMNASTICS AND GYMNASIUM; HOCKEY; HORSE RACING; HUNTING; HURDLE RACING; JUMPING; LACROSSE; LAWN TENNIS; MODEL YACHTING; MOUNTAINEERING; PATIENCE; PIGEON-FLYING; PIG-STICKING; PINOCHLE; POKER; POLO; PUGILISM; RACQUETS; RIDING; ROLLER-SKATING; ROWING; RUNNING; SHOOTING; SKATING; SKI; SPORT; STEEPLECHASE; SWIMMING; TENNIS; TOBOGGANING; TOREADOR; TOURNAMENT; TUG-OF-WAR; VENTRILOQUISM; WALKING RACES; WATER-POLO; WEIGHT-THROWING; WHIST; WRESTLING and YACHTING.

SPORTS, THE BOOK OF, or more properly the DECLARATION OF SPORTS, an order issued by James I. in 1617 on the recommendation of Thomas Morton, bishop of Chester, for use in Lancashire, where the king on his return from Scotland found a conflict on the subject of Sunday amusements between the Puritans and the gentry, many of whom were Roman Catholics. Permission was given for dancing, archery, leaping, vaulting and other harmless recreations, and of "having of May games, Whitsun ales and morris dances, and the setting up of May-poles and other sports, therewith used, so as the same may be had in due and convenient time without impediment or neglect of divine service, and that women shall have leave to carry rushes to church for the decorating of it." On the other hand, "bear and bull-baiting, interludes, and (at all times in the meane sort of people by law prohibited) bowling" were not to be permitted on Sunday (Wilkins, *Concilia,* iv. 483).

In 1618 James transmitted orders to the clergy of the whole of England to read the declaration from the pulpit; but so strong was the opposition that he prudently withdrew his command (Wilson, in Kennet, ii. 709; Fuller, *Church History,* v. 452). In 1633 Charles I. not only directed the republication of his father's declaration (Rushworth, ii. 193), but insisted upon the reading of it by the clergy. Many of the clergy were punished for refusing to obey the injunction. With the fall of Laud all attempts to enforce it necessarily came to an end.

SPOTSWOOD, ALEXANDER (1676–1740), American colonial governor, was born, of an old Scots family, in Tangier, Africa, in 1676. He served as aide to Marlborough in the War of the Spanish Succession, and was wounded at Blenheim. He was appointed lieutenant-governor of Virginia in 1710, and was received with enthusiasm, because he brought to the colony the privilege of *habeas corpus;* his term as governor closed in September 1722, but he remained in Virginia, living near his iron-works in Germanna, a settlement of Germans, on the Rapidan in Spottsylvania county (named in his honour); and he was deputy postmaster-general of the colonies from 1730 to 1739. He was the first representative of the British government in America who fully appreciated the value of the western territory. As governor he recommended the establishment of a Virginia company to carry on trade with the Indians, he urged upon the provincial government and also upon the British authorities the wisdom of constructing forts along the frontier, and he personally organized and conducted in 1716 an exploring expedition into the Shenandoah Valley. He developed the iron industry of Virginia, promoted the religious education of the Indians, and tried to advance the interests of education, especially the College of William and Mary. He died at Annapolis, Md., June 7, 1740.

See R. A. Brock (ed.), "The Official Letters of Alexander Spotswood" (with a memoir), in *The Collections of the Virginia Historical Society* (1882–85).



BY COURTESY OF THE N.Y. ZOOLOGICAL SOCIETY

THE SPOTTED JEW-FISH (PROMICROPS GITAIARA)

SPOTTED JEW-FISH (*Promicrops gitaiara*), an immense marine bass (fam. *Serranidae*) found on the coasts of tropical America, which sometimes attains a length of 8 ft. and a weight of about 700 pounds. The adult is dull olive-brown in colour, with faint spots and bands; the young are yellowish-green, with dark cross-bars and spots about the head. The South Pacific jew-fish reaches 12 ft.

SPOTTISWOODE (SPOTTISWOOD, SPOTISWOOD or SPOTSWOOD), **JOHN** (1565–1639), archbishop of St. Andrews and historian of Scotland, eldest son of John Spottiswood, minister of Calder and "superintendent" of Lothian, was born in 1565. He was educated at Glasgow University (M.A. 1581), and succeeded his father in the parish of Calder in 1583. In 1601 he attended Ludowick, duke of Lennox, as his chaplain, in an embassy to the court of France, returning in 1603. He followed James to England on his accession, but was the same year nominated to the see of Glasgow, his consecration in London, however, not taking place until October 1610. On May 30, 1605 he became a member of the Scottish privy council. In 1610 he presided as moderator over the assembly in which presbytery was abolished, in 1615 he was made archbishop of St. Andrews and primate of Scotland, and in 1618 procured the sanction of the privy council to the Five Articles of Perth with their ratification by parliament in 1621. In 1633 he crowned Charles I. at Holyrood. In 1635 he was appointed lord chancellor of Scotland, an office which he retained till 1638. He was a spectator at the riot of St. Giles's, Edinburgh, on July 23, 1637, endeavoured in vain to avoid disaster by concessions, and on the taking of the Covenant perceived that "now all that we have been doing these thirty years past is thrown down at once." He escaped to Newcastle, was deposed by the assembly on December 4, on trivial charges, and died in London on November 26, 1639, receiving burial in Westminster Abbey. His most considerable work was *The History of the Church and State of Scotland* (London, 1655, *seq.*).

See the accounts prefixed to the first edition of Spottiswoode's *History of Scotland* and to that published by the Spottiswoode Society in 1851; also David Calderwood's *Hist. of the Kirk of Scotland* (1842–1849).

SPOTTISWOODE, WILLIAM (1825–1883), English mathematician and physicist, was born in London on Jan. 11, 1825. He was educated at Laleham, Eton, Harrow, and Balliol college, Oxford, where he obtained a first-class in mathematics in 1845, and then took his father's place as partner in the firm of Eyre and Spottiswoode, printers, in which business he was engaged until his death on June 27, 1883. His first mathematical publication was *Meditationes Analytical* in 1847. He was chiefly interested in determinants. His elementary treatise on this subject (1851) was the first published work on determinants. His researches are also concerned with the contact of curves and surfaces, the polarization of light, and electrical discharge in gases.

A list of his papers is given in *Nature*, vol. xxvii.

SPOTTSYLVANIA, a county of Virginia, U.S.A., so called after Alexander Spotswood (*q.v.*), lieutenant governor of Virginia in 1710–22, who owned extensive estates and mines therein. It is bounded on the north by the Rapidan and Rappahannock rivers and on the south by the North Anna. It is celebrated as containing several of the most famous battle-fields of the Civil War—Fredericksburg, Chancellorsville, the Wilderness and particularly that of Spottsylvania Court House, where the armies of Grant and Lee contended for nearly two weeks (May 8–21, 1864).

SPRAT, THOMAS (1635–1713), English divine, was born at Beaminster, Dorsetshire, and was educated at Wadham College, Oxford (1657–70). He became a prebendary of Lincoln in 1660. He wrote a poem *To the Happie Memory of the most Renowned Prince Oliver, Lord Protector* (1659); *Observations upon Monsieur de Sorbier's Voyage into England* (London, 1665); and a *History* of the Royal Society of London (London, 1667), which Sprat had helped to found. In 1684 he became bishop of Rochester. As dean of Westminster he directed Wren's restoration of the abbey. He died on May 20, 1713.

SPRAT, a marine fish (*Clupea sprattus*), one of the smallest species of the genus *Clupea* or herrings, rarely exceeds 5in. in length, and occurs in large shoals on the Atlantic coasts of Europe. The sprat spawns in the open sea from February to May. Its eggs are buoyant and pelagic and easily recognized. The sprat is one of the more important food-fishes on account of the immense numbers in its shoals. In Norway large quantities are tinned in oil, or are eaten fresh, pickled, smoked or prepared as anchovies.

SPRAYING MACHINERY. The discovery that certain substances in weak solutions or emulsions or in the form of powder could be used to combat many insect and fungus pests of farm, garden and orchard crops and also some weeds led to the development of mechanical devices for spraying the liquids or dusting the powders over the stems and foliage of plants and trees. The name sprayer is usually applied to the machines which distribute liquids and that of duster to those used for distributing powders, though the two types are also referred to as wet and dry sprayers respectively.

Sprayers utilize pressure to force the liquid through a specially constructed nozzle which splits it up into very fine particles or spray. These machines differ according to (*a*) the complexity of the mechanism; (*b*) the kind of power by which they are operated; (*c*) the method of transport adopted, and (*d*) the diversity of their accessories. Before dealing with the main types of sprayers it may be as well to describe the various accessories. Nozzles are of two principal types: one produces a jet in the form of a hollow cone and the other a fan-shaped jet—the latter is becoming obsolete. There are, however, many variations and each manufacturer has practically developed a distinct nozzle. The cone-shaped jet is produced by forcing the liquid into a small chamber at a tangent and then through a small hole. If the hole is very small a spring-loaded pin is provided for cleaning the outlet, should it become choked. In some sprayers apertures of different sizes may be fitted so that sprays of varying degrees of fineness may be used. The fan-shaped jet is produced by forcing the liquid against a lip, the fineness of the spray depending on the width of the exit aperture. Lances are hollow tubes or rods, to which the nozzles are attached and are used to bring the spray close to the plant or tree and usually have rubber connections so that they can be operated in any direction. Spray guns are used in place of lances on powerful machines. They enable the spray to be adjusted by turning a handle which alters the pressure. By using these devices it is possible to spray foliage on the ground and then by increasing the pressure to spray the tops of trees. Spray booms which consist of pipes carrying nozzles at intervals are attached to the machine (which is carried on wheels or a cart) and are used for spraying such field crops as potatoes, and such weeds as charlock. For hops the spray booms are arranged more or less vertically, and the machine is drawn between the rows. Mixers, stirrers or agitators are often fitted to sprayers in order to ensure the liquid being as uniform as possible; these devices usually operate automatically when the machine is in use. Stop-cocks or cut-offs are used for stopping the flow of liquid at the discretion of the operator.

Manual Sprayers.—The simplest form of sprayer consists of a hand pump with a suitable nozzle, attached to or used in conjunction with an ordinary bucket. Another simple type is the knapsack sprayer which, as its name implies, is carried on the back of the operator. This type may make use either of a direct pump or of an air-pump and compressed air chamber for the purpose of projecting the liquid. If the latter device is employed, a number of preliminary strokes of the air-pump are required before spraying in order to produce the necessary pressure. In either case the machine embodies a container for the liquid (usually 2 or 3 gallons) a lance and nozzle. Larger machines are carried on a wheeled framework or in a cart.

Power Sprayers.—There are two kinds of sprayers operated by power, namely, those which are driven from the transport wheels and those driven by engines mounted on the same framework. The first type are used mainly for agricultural crops for which they are very suitable, whilst the latter type are more suitable for spraying large orchards. In both cases it is usual to employ horses for hauling the machines, though sprayers which are both propelled and operated by internal combustion engines are being used in America, where large orchards or plantations have to be treated. The essential components of these machines do not differ in principle from those described above. For spraying tall trees a special type of nozzle is sometimes employed, which is so constructed that the liquid is carried in an unbroken stream to the requisite height before it dissolves into spray: high pressure and considerable power are required to operate machines when using these nozzles, the largest engines developing 60 h.p.

Stationary spray plants are used to some extent in the United

States, especially in the apple regions of the State of Washington. Such a plant consists of a spray tank, a pump, a gas engine or electric motor, and a pipe line equipped with faucets.

Dusting Machines.—These machines may be classified in a similar way to sprayers but very few accessories are necessary and generally speaking the machines are of simpler construction: an air blast, produced by means of a fan or bellows, is used to blow the dust into a discharge pipe which may be fitted with a mouthpiece shaped like a funnel or a special spreading device. Mechanical devices are also employed to ensure regular feeding of the powder to the air blast. Manual dusters are similar in size and capacity to the manual sprayers and have a restricted usefulness. For farm work power machines are commonly used, particularly in the cotton fields of America. Like sprayers, these machines may be operated from the travelling wheel or driven by an internal combustion engine varying in size from 1 to 5 h.p. or so. For dusting large areas, aeroplanes have been used, and where large, uniform areas of a single crop require to be treated and the climatic conditions are suitable, the method may be regarded as established. (B. J. O.; H. G. R.)

SPREE (sprā), a river of Prussia, 227 m. in length, rising in Saxony, close to the Bohemian frontier, and flowing north past Bautzen, Spremberg and Kottbus, dividing between the first two towns for a time into two arms. Below Kottbus the river splits into a network of channels in the peculiar marshy region known as the Spreewald, then passes Fürstenwalde and Köpenick, threads Berlin in several arms and joins the Havel at Spandau. Over 100 m. of it are navigable and it is connected with neighbouring rivers by canals.

SPREEWALD, a district of Germany, in the province of Brandenburg, a marshy depression of the middle Spree valley, 106 sq.m. in extent, 27 m. long and varying from 1 to 7 m. in width. The river Spree, above Lübben splits into over two hundred arms, and in seasons of flood generally overflows considerable portions of this region. Part of the region is cultivated, part used as pasture land and wooded like a park especially in the lower districts. Fishing, cattle-breeding and the growing of vegetables, more particularly small pickling cucumbers, are the chief occupations of the people. In summer Spreewald is a popular resort of the Berlin people, and also in winter the district is largely visited by people bent on skating, sleighing and other winter pastimes.

SPREMBERG, a town in the Prussian province of Brandenburg, situated partly on an island in the river Spree and partly on the west bank, 76 m. S.E. of Berlin by the railway to Görlitz. Pop. (1925) 12,674. There are a pilgrimage chapel, dating from 1100 and a ducal château, built about the end of the 16th century (now utilized as Government offices). It carries on considerable manufactures of woollen cloth, as well as of bicycles, bricks and cigars.

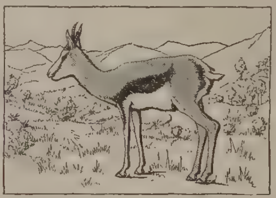
SPRENGEL, HERMANN JOHANN PHILIPP (1834–1906), German chemist, was born at Schillerslage, near Hanover, on Aug. 29, 1834, and educated in Hanover, and at the universities of Göttingen and Heidelberg. After three years as assistant in Oxford university chemical laboratory (1859–61), he engaged in research work at the Royal College of Chemistry in London. He was employed from 1865–1870 in Farmer's chemical works, and became a naturalized Englishman. For the rest of his life he was engaged on his own inventions and patents. His best known research, *On the Vacuum,* was published in 1865. In this paper he describes the vacuum pump known as the Sprengel pump. This pump opened up a large field for development in connection with the discharge tube, electric glow lamps, and numerous problems which required a vacuum for their elucidation. Sprengel devised the U-tube method of comparing densities of liquids. In 1873 Sprengel patented his device of introducing water in a fine spray instead of steam in sulphuric acid chambers. He was elected F.R.S. in 1878. He died in London on Jan. 14, 1906.

See obituary notice by Mesol in *Journal of the Chemical Society,* vol. 91 (1907).

SPRING, the act of springing, or leaping; hence applied in various senses: to the season of the year in which plant life begins to bud and shoot; to a source of water springing or welling up from below the surface of the earth (*see* WATER SUPPLY); or to an elastic or resilient body or contrivance for receiving and imparting mechanical power.

In architecture, the level of the plane at which an arch or vault begins to curve inward toward the centre; in an arch or vault whose curves are circular or segments of circles, the level of the centre points from which the circular curves are described.

SPRINGBUCK or **SPRINGBOK** (*Antidorcas euchore*), an aberrant South African gazelle inhabiting the country south of the Zambezi, but ranging northwestwards to Mossamedes. In the more settled parts of Cape Colony, the Transvaal, and the Orange Free State it now only exists within the enclosures of the large farms. Both sexes carry lyrate horns; the shoulder-height of an adult male is about 30in., and an average pair of horns measures 14in. along the curve; in the female the horns are more slender. The general colour above is reddish fawn, separated from the white of the underparts by a dark band on the flanks.



BY COURTESY OF THE N.Y. ZOOLOGICAL SOCIETY

SPRINGBUCK OR SPRINGBOK (ANTIDORCAS EUCHORE), THE SOUTH AFRICAN GAZELLE

SPRINGER, the term given in architecture to the stone from which an arch springs (*see* ARCH); in some cases this is the stone resting on the impost or capital, the upper surface of which is a plane directed to the centre of the arch.

SPRINGFIELD, the capital city of Illinois, U.S.A., and the county seat of Sangamon county, on the Sangamon river, 100 m. N.N.E. of Saint Louis. It has a municipal airport; is on Federal highways 36 and 66; and is served by the Baltimore and Ohio, the Chicago and Alton, the Chicago and Illinois Midland, the Chicago, Springfield and St. Louis, the Illinois Central, the Illinois Traction (electric) and the Wabash railways. Pop. (1920) 59,183 (85% native white); estimated locally at 70,000 in 1928. The city has a level site of 9·72 square miles. The State capitol (begun in 1868 and occupied since 1876) is in the form of a Greek cross, with granite porticoes and a dome 361 ft. high. Facing it, in the same grounds, is the beautiful Centennial Memorial building (erected 1918–22, to mark the 100th anniversary of the admission of Illinois into the Union), which houses the State museum and the library of the State Historical Society, with its unequalled collection of Lincolniana. Across the street in one direction is the supreme court building (1905); in another, the State arsenal (1902–03); and not far away is the executive mansion (first occupied in 1856). The old capitol (begun in 1837 and occupied 1840–76) is now used as the county court-house. Near the heart of the city is Lincoln's home, the only one he ever owned, which he bought two years after his marriage and occupied until after his election to the Presidency. It is owned and maintained by the State. The Lincoln tomb and monument (a granite obelisk 121 ft. high over a mausoleum) stands on an eminence in Oak Ridge cemetery, north of the city. Springfield is full of spots associated with Lincoln: sites of his law-offices, boarding-houses and friends' homes; court-rooms where he practised; the old State-house, where he sat as representative, where he had headquarters during the campaign of 1860, and where his body lay in state in 1865; the Wabash freight station, where he said good-bye to his old friends on leaving for the White House; and many others. The city's parks contain 600 ac., and 2 m. N.E. are the State Fair grounds of 376 acres. In 1924 a comprehensive city plan was officially adopted, which will make Springfield a city of unusual beauty and distinction. It provides (among many other improvements) for the development of a capitol group (around the existing State buildings) and of a municipal group (around the Lincoln home, and including an open-air forum) and for parkways connecting the two with each other, with the Lincoln monument, with the proposed Union Station and with the principal parks. Since 1911 the city has had a commission form of government. The assessed valuation of property for 1927 was $30,164,100.

Springfield is in the heart of vast coal-fields. Several seams lie under the city, one of which is worked, and about 5,000 miners make Springfield their home. The Illinois oil-fields are only 150 m. distant. Limestone, clay, oil shale, sand and gravel abound in the vicinity. The agricultural products within a 50 m. radius are valued at $190,000,000 annually. The city has a large wholesale and retail trade. Its manufacturing industries are numerous and diversified, with an output in 1925 valued at $26,587,661. Among the leading products are watches, agricultural implements, cast-iron pipe, tractors, road graders, electric meters, shoes and miners' lamps. Bank clearings in 1926 amounted to $147,300,000. The first settlement here was made in 1818. In 1821 the village was chosen to be the county seat, and was named Springfield. In 1823 it was platted, and for a brief period was called Calhoun. It was incorporated as a town in 1832 and chartered as a city in 1840. In 1837 it was made the State capital, in place of Vandalia, and the legislature met here in Dec. 1839. From Camp Yates (within the present city limits) Grant started on July 3, 1861, as colonel of a regiment of Illinois volunteers, for his service in the Civil War. Springfield was the birthplace of Nicholas Vachel Lindsay, and the early home of Edgar Lee Masters and Brand Whitlock.

SPRINGFIELD, a city of Massachusetts, U.S.A., at the intersection of Federal highways 5 and 20, on the east bank of the Connecticut river, 6 m. from the southern boundary of the State; a port of entry and the county seat of Hampden county. It is served by the Boston and Albany, the Boston and Maine and the New York, New Haven and Hartford railways. Pop. (1920) 129,614 (24% foreign-born white); 1928 local estimate 149,800, to which the contiguous cities and towns add over 75,000. Four bridges cross the river, including the Hampden county memorial bridge, a massive structure of steel and concrete, 80 ft. wide, built to commemorate the patriotic service of the county's citizens, and dedicated in 1923. The area of the city is 38·53 square miles. It has many buildings of architectural importance, and since 1921 its development has been guided by an official planning board. The new Union Railroad station, opened in 1926, is one of the most commodious and complete in New England. The court-house, two churches and other buildings were designed by H. H. Richardson. Facing a public park is the fine "Municipal Group" (designed by Pell and Corbett) which was dedicated in 1913, replacing the city hall erected in 1854 and completely destroyed by fire in 1905. It consists of twin buildings (one an auditorium and the other an administration building; each 115 ft. wide, with a portico formed by ten Corinthian columns 41 ft. high) on either side of a campanile 300 ft. high, which contains a carillon of 12 bells. The city's parks cover 1,268 acres. Forest park has an area of 757 ac., and includes a zoological garden and fine collections of lotus plants. The Art museum (1894–96) contains the valuable collections of George Walter Vincent Smith. Near it is the Science museum (organized 1859); the city library, which has 325,000 volumes and an annual circulation of 10 volumes per caput of the entire population; and the William Pynchon memorial building (dedicated 1927), the home of the Connecticut Valley Historical Society. In Merrick park, adjoining the library, stands St. Gaudens's statue of "The Puritan." The public-school system includes commercial, technical and classical high schools, a kindergarten training school, vocational and continuation schools. The American International college (1885) and the International Young Men's Christian Association college (1886) are in Springfield. There are 77 churches in the city, and it is the see of a Roman Catholic and a Protestant Episcopal bishop. The *Springfield Republican* (Independent), a morning newspaper established in 1824 by Samuel Bowles, is still owned by the Bowles family. The city operates under a bicameral form of government. The assessed valuation for 1927 was $314,151,780.

There has been a U.S. arsenal in Springfield since the Revolution, when it was established by the Continental Congress; and an armory since 1794, when Congress authorized the building of the Government's first gun factory on a hill near the present railroad station which had been selected by Washington for the purpose in 1789. Here 800,000 of the famous Springfield muskets were made during the Civil War, and it is still the principal manufactory of small arms for the U.S. army. The Smith and Wesson revolver factory, the Rolls-Royce automobile works, and a plant of the Westinghouse Electric and Manufacturing Company, are among the commercial manufacturing establishments of special interest. Springfield is noted for the diversity of its industries, which make nearly 1,500 different products, and employ chiefly skilled mechanics. The aggregate output in 1926 (exclusive of the Government arsenal) was $113,990,400. The largest groups were electrical machinery, apparatus and supplies ($20,022,499); motor vehicles, bodies and parts ($12,168,826); foundry and machine shop products ($10,538,683); printing and publishing ($5,930,766). Springfield is the transportation centre, both by rail and by highway, of western Massachusetts, and a fine airport is under construction. The railroad terminal post-office at the Union station (one of the three maintained in New England) sorts and forwards over 1,200 carloads of mail each month. A mail-order house sends some 500 tons of catalogues to Springfield by freight, to be mailed on to individual addresses. The city's trade area has a population of 700,000. Two of the largest insurance companies of America have their home offices in Springfield. Bank clearings in 1927 amounted to $283,174,997.

Springfield was founded in 1636 by a dozen families from Roxbury, under the leadership of William Pynchon (1590–1662), one of the original patentees of the Massachusetts Bay Colony, who left Roxbury because he was dissatisfied with its government, hoping to put his own theories into effect in a new colony. The town was incorporated in 1641, and named after Pynchon's birthplace in Essex, England. For several years he ruled it with the power of an autocrat, but in 1652 he was removed from the magistracy in consequence of a tract in which he attacked the Calvinistic doctrine of the Atonement, and returned to England. In King Phillip's War Springfield was a centre of hostilities. After the establishment of the arsenal in 1777 it was an important military supply depot of the Continental army. During Shays's Rebellion there was a riot here in Sept. 1786, and on Jan. 25, 1787, the insurgents, led by Shays, attacked the arsenal, but were dispersed by the militia. Industrial development began with the establishment of the Government armory (1794), which brought in skilled workmen and attracted other enterprises. In nine years the population increased 50%. A second impetus was given by the completion of the Boston and Albany railroad in 1839. By 1850 the town had a population of 11,766, and in 1852 it was chartered as a city.

SPRINGFIELD, a city of south-western Missouri, U.S.A., 200 m. S.E. of Kansas City; the county seat of Greene county. It is on Federal highways 60, 65 and 66; has a municipal airport; and is served by the Frisco and the Missouri Pacific railways. Pop. 39,631 in 1920, 93% native white; estimated locally at 60,000 in 1928. The city has a beautiful location on the crest of the Ozark plateau, 1,300 ft. above sea-level, and is surrounded by charming scenery frequently likened to Kent. The region is rich in timber, and is famous for its poultry, dairy products, live stock, apples, strawberries, grapes, peaches and other fruits. There are stone quarries and lead and zinc mines in the vicinity. The city's manufacturing industries, which had an output valued at $19,071,888 in 1925, include extensive shops of the Frisco lines, the largest wagon factory west of the Mississippi, and a great variety of smaller plants. Its jobbers and manufacturers do a combined business estimated at 25 to 30 million dollars annually. Bank clearings amounted to $90,000,000 in 1926, and the city's assessed valuation for 1927 was $43,412,072. Springfield is the seat of Drury college (1873) and the South-west Missouri State Teachers college (1905). Adjoining each other are a National and a Confederate cemetery. Springfield was founded about 1829; laid out in 1833; incorporated as a town in 1838 and again in 1846; and chartered as a city in 1847. It has a commission form of government. At the opening of the Civil War Springfield was an important strategic point. It was occupied alternately by Confederate and Union forces until the spring of 1862, after which the Unionists retained control. The battle of Wilson's Creek (Aug. 10, 1861), 10 m. S. of the city, was one of the bloodiest engagements of the war. The first railroad reached the city in 1870.

SPRINGFIELD, a city of Ohio, U.S.A., the county seat of Clark county; 45 m. W.S.W. of Columbus, on Lagonda creek, near the Mad river. It is on Federal highway 40; has a municipal airport; and is served by the Big Four, the Detroit, Toledo and Ironton, the Erie, the Pennsylvania and electric railways, and by motor-bus and truck lines in all directions. Pop. (1920) 60,840 (12% negroes); 1928 estimate 73,000. The city occupies 11·7 sq.m. of undulating land, reaching an altitude of 980 feet. On hills north of the creek are Wittenberg college (Lutheran; founded 1845), and the State homes of three fraternal orders: the Knights of Pythias (opened 1894), the Masons (1895), and the Odd Fellows (1898). Immediately west of the college campus is beautiful Ferncliff cemetery, in which stands a Soldiers' monument on top of a prehistoric mound. The city's parks cover 250 acres. Springfield is an important manufacturing, publishing and horticultural centre. Its 33 greenhouses have 1,500,000 sq.ft. of glass and produce 4,800,000 rose-plants in a year. There is a peony farm of 70 ac., and nurseries for ornamental shrubbery. The aggregate output of the city's factories, 1927, was valued at $85,000,000. Among the leading products are agricultural implements, metallic caskets, motor trucks, water wheels, playground equipment, piano plates, gas and steam engines and small motors. Bank debits in 1927 aggregated $287,232,000, and the city's assessed valuation was $119,472,220. Since 1914 it has operated under a commission-manager form of government. In 1799 Simon Kenton and a small party from Kentucky built a fort and 14 cabins 3 or 4 m. W. of Springfield's present limits. Later in the year James Demint settled on a hill overlooking Lagonda creek. In 1801 he engaged a surveyor to plat a town here, and soon after this Kenton's settlement was abandoned. Trouble from the Indians threatened the new town until 1807, when peace was more firmly established at a council held on a neighbouring hill, where Tecumseh was the principal speaker. In 1818, when Clark county was erected, Springfield was made the county seat. It was incorporated as a town in 1827, and in 1850, when the population was 5,108, was chartered as a city.

SPRINGFIELD, a town of Windsor county, Vermont, U.S.A., and a village of the same name, 40 m. S.E. of Rutland, on the Black river, near the Connecticut; served by the Boston and Maine and the Springfield Terminal railways. Pop. (1920) 7,202. It is a manufacturing town, in a region of great natural beauty, with the falls of the Black river in the centre of the village. Springfield was settled about 1761. It was the first town in Vermont to adopt a manager form of government, which has been in operation since 1920.

SPRING-GUN, a device formerly in use against poachers and trespassers. Since 1827 spring-guns and all man-traps are illegal in England, except as a protection against burglars.

SPRING-RICE, SIR CECIL ARTHUR (1859–1918), British diplomatist, was born in London on Feb. 27, 1859, the second son of the Hon. Charles Spring-Rice (1819–70), and grandson of the 1st Baron Monteagle. Educated at Eton and Balliol college, Oxford, he entered the Foreign Office in 1882, becoming private secretary to Lord Granville in 1884 and précis writer to Lord Rosebery in 1885. He went to Washington as third secretary in 1886, and in 1895 proceeded to Berlin. In 1898 he become secretary at Teheran, and in 1901 British commissioner on the Caisse de la Dette in Cairo. In 1903 he went to St. Petersburg (Leningrad), first as secretary and later as councillor of embassy, remaining in Russia till the end of 1905. In 1906 he was sent to Persia as minister, having lately been created K.C.M.G. In 1908 he was created G.C.V.O. and went to Sweden as minister, and in 1912 was appointed ambassador to the United States. He died at Ottawa on his way home to England, Feb. 14, 1918.

See Sir V. Chirol, *Cecil Spring-Rice: In Memoriam* (1919).

SPRINGS are, in almost all cases, the natural overflow or point of escape from some underground reservoir of water. Their classification may be either according to the geological conditions governing the point of location, or according to the chemical composition of its waters. When an appreciable amount of chemical impurity is present they are usually termed "mineral springs."

The rocks which constitute the crust of the earth are either permeable or impermeable to water. During most seasons of the year, in temperate climates, a certain amount of rainfall soaks into any crust formed of permeable strata; the part absorbed may be the complete rainfall during winter months, when the air is saturated with moisture, or may fall to near zero during a dry summer, when all the rainfall is returned to the air as evaporation from the surface. That portion of the rainfall which soaks down below the level of plant-roots goes to replenish the underground reservoir. The shape of the reservoir varies indefinitely, according to the geological structure of the area; but it is only the shape of its water surface that concerns springs. This surface, known as the water-table, divides the fully saturated rocks from those which only hold moisture in their minute pores.

In an area of completely permeable rocks the springs issue at or near the valley bottoms; when, however, the district is made of alternating permeable and impermeable beds, each impermeable bed holds up water on its surface. If the strata are horizontal, small springs may be found all round the outcrops; but if they are tilted or folded the flow of the underground water will be towards the lowest point on the base of the permeable water-bearing bed. At this point the main spring for that local reservoir will be located.

In strata which are, in the main, impermeable, but somewhat brittle the presence of joints and cracks is of prime importance in determining the direction and amount of flow in the underground waters. In jointed rocks the rain-water may sink to great depths down one set of joints and rise again along a second, issuing at the surface as a warm or thermal spring; this is the probable cause of the hot springs at Bath. When a permeable bed and an impermeable one are brought into juxtaposition through faulting the flow of water in the permeable one is checked; but since faulting frequently shatters the rock it affords a plane of weakness along which the water will tend to flow. If the water is flowing under pressure due to an overlying impermeable cover, it may reach the surface as an "artesian spring." The water of artesian springs sometimes carries small particles of solid matter in suspension as well as salts in solution. The solid particles are dropped at the point of exit of the spring and may be cemented by the salts deposited from solution. When this takes place a mound is built up, from the summit of which the spring issues. Hence the "mound springs," such as are seen at their best in the great artesian basin of Australia.

Some of the largest springs issue from thick beds of massive limestone. This type of rock is usually well jointed and, being soluble in rain-water, the joints and marked bedding planes become enlarged by solution and the whole of the rainfall is absorbed in the mass of the rock and flows underground to issue as large springs. Frequently these springs yield a somewhat hard water of otherwise great purity.

Mineral Springs.—All springs containing noticeable quantities of salts in solution, other than the carbonate and sulphate of lime, are known by this name. The commonest minerals found are common salt, giving rise to "bitter springs"; and iron, sulphur, magnesia, etc., giving "medicinal" waters.

Thermal Springs.—The springs coming under this heading are derived from two sources. Firstly, meteoric waters which have penetrated down to considerable depths and rise again along well-defined fissures issuing as springs at the surface, but with the temperature of the rocks from which they have come; and, secondly, volcanic waters, either in the form of geysers or hot springs (*see* VOLCANO); in these the water may be either meteoric or in part, at any rate, juvenile—that is, water which is issuing at the surface for the first time. Most of these waters contain much mineral substance in solution, which is deposited on cooling and forms marked basins and terraces of sinter, such as the famous pink and white terraces of New Zealand.

(W. B. R. K.)

SPRINGTAIL, the common name of a group of small wingless insects forming the order Collembola, subclass *Apterygota* (*q.v.*). Many of them carry a pair of tail-like appendages near the extremity of the abdomen, which function as a springing organ, hence the name.

SPRING VALLEY, a city of Bureau county, Illinois, U.S.A., on the north bank of the Illinois river, 104 m. S.W. of Chicago. It is served by the Burlington Route, the Chicago and North Western, the Rock Island and the Illinois Traction (electric) railways. Pop. 6,493 in 1920, 34% foreign-born white. It is a shipping point for coal, zinc, cement and farm products. The city was founded in 1885 and chartered in 1886.

SPRINKLER. The automatic sprinkler is a means of combating fire which has the approval of fire insurance companies, who often make a reduction in their premiums when it is employed. The essence of the device is to arrange, under the ceiling of the building to be protected, a series of sprinklers which discharge water as soon as the temperature reaches a certain point. The automatic release of the water is contrived by closing the valves of the sprinklers with fusible metal; the alloy employed being such as to fuse at a temperature of say 150° F. The sprinkler is so devised that the jet spreads the water in a shower, and the distance between the sprinklers is so arranged that every part of the floor is covered. The sprinklers are connected with lines of pipes conveying the water under pressure. In buildings where the water-pipes are likely to freeze, the ceiling connections are filled with air under pressure, so that when the valve opens through the metal fusing, the air escapes and the loss of pressure in the pipes works a lever that opens the valve of the water main. (*See* also FIRE PREVENTION AND EXTINCTION.)

SPRUCE (*Picea*), an important genus of evergreen coniferous trees of the pine family (Pinaceae), called also spruce-fir, including about 40 species, natives of the cold and temperate regions of the Northern hemisphere. They are pyramidal trees, with whorled branches; thin, scaly bark; linear, spirally-arranged leaves, each jointed near the stem on a separate woody base; and ovoid, oblong or cylindrical spreading cones, which become pendent when mature. The spruces are readily distinguished from the pines by their solitary instead of fascicled leaves and from the firs in having pendent cones with persistent scales instead of upright cones with deciduous scales.

In an economic sense the most valuable species is the Norway spruce (*P. excelsa* or *P. Abies*), native to northern Europe and Asia and well known in plantations in the British Isles and eastern North America, though hardly attaining in cultivation the great height and noble form which it displays in its native woods. In favourable situations it becomes the tallest and one of the stateliest of European trees, sometimes rising to a height of 170 ft. and attaining a trunk diameter of 5 to 6 ft. at the base. It has a nearly straight, tapering trunk, throwing out in somewhat irregular whorls its widespreading branches densely clothed with dark clear green foliage. The boughs and their side branches, as they increase in length, have a tendency to droop, the lower tier, even in large trees, often sweeping the ground—a habit that gives a peculiarly picturesque effect. The slender, sharp, slightly curved leaves are scattered thickly around the shoots; the upper ones pressed toward the stem, and the lower directed sideways, giving a somewhat flattened appearance to the individual sprays. The cylindrical cones, 4 to 7 in. long, grow chiefly at the ends of the upper branches.

The Norway spruce is very widely distributed, growing on most of the mountain ranges of Europe from the Pyrenees northward and extending to 68° N., while in Asia it extends eastward to the Lena river and from the Altai mountains to beyond the arctic circle. On the Swiss Alps it is one of the most prevalent and striking of the forest trees. In the lower districts of Sweden it is the predominant tree in most of the great forests; in Norway it constitutes a considerable part of the dense woods of the southern valleys, flourishing on mountain slopes up to 3,000 ft. and clothing the shores of some of the fjords to the water's edge.

While less valuable than the pine, the Norway spruce is an important timber tree. When produced in close forests the white wood is of compact and even grain and suitable for a great variety of uses. Immense quantities of spruce lumber are imported into Great Britain from north-western Europe. Great quantities also of younger trees are imported as poles, used for scaffolding, ladders and mining timber. In Norway the wood is very extensively made by hydro-electric power into wood pulp.

As an ornamental tree Norway spruce has been commonly planted in Great Britain since about 1600. It is also grown as a "nurse" for other trees, for shelter for wall-fruit, for cover for game, and for small stakes and poles. As a picturesque tree for park and other ornamental plantation it ranks among the best of the conifers, bearing the smoke of cities better than most of the fir-group, though subject to blight, which gives it an unhealthy appearance after a certain age. In North America the Norway spruce is extensively planted in the eastern States and Canada.

In North America there are seven native species of spruce; of these, three are found in the eastern United States and Canada, two occur in the Rocky Mountain region and two are confined to the Pacific coast. The white spruce (*P. glauca* or *P. alba*) is found from Maine to Minnesota northward to Labrador and Hudson bay and north-westward to Bering strait in Alaska. It grows to a height of 150 ft. and a trunk diameter of 4 ft., with cylindrical cones 2 in. long. The white spruce is very valuable for lumber and especially for wood pulp, being the chief species utilized in the Canadian wood pulp industry. The red spruce (*P. rubra*) occurs from Nova Scotia to New York and southward in the mountains to Tennessee. It is the dominant spruce in the Adirondack region, attaining a height of 60 to 100 ft., with brownish-red, ovoid cones, about $1\frac{1}{4}$ in. long; it is extensively used for lumber and pulp wood. The black or bog spruce (*P. mariana*), native to swamps from Newfoundland to Alaska and southward to Virginia and Minnesota, commonly 20 to 30 ft. but sometimes 90 ft. high, with small globose cones, is utilized for pulp wood and is the source of spruce gum.

The Engelmann spruce (*P. Engelmanni*), native to the Rocky Mountain region and extending westward to British Columbia and California, is a handsome tree of high altitudes. It grows from 20 to 150 ft. high, with slender branches and oval cones, sometimes 3 in. long. The blue spruce (*P. pungens*), native to the central Rocky Mountain region, is one of the most distinctive American species. It grows from 80 to 150 ft. high, with stiff, horizontal branches, and rigid, bluish-green to silver-white, spiny-tipped leaves, and oblong cones, $2\frac{1}{2}$ to 4 in. long. Several varieties with characteristically blue foliage, as the well-known Koster blue spruce (var. *Kosteriana*) are widely grown for ornament.

The Sitka or tideland spruce (*P. sitchensis*) occurs along the Pacific, extending about 50 m. inland, from Kodiak island, Alaska, southward to northern California. It is the most massive of the spruces, sometimes attaining a height of 190 ft. and a basal trunk diameter of 20 ft., but it usually grows about 100 ft. high, with a trunk 3 ft. in diameter, with widely spreading, rigid branches, stiff, usually prickly-pointed leaves, and oblong cones 2 to 4 in. in length. The Sitka is a valuable timber tree, and is extensively lumbered. The rare weeping spruce (*P. Breweriana*), with hanging branches clothing the trunk to the ground and with the few horizontal branches decorated with cordlike hanging branchlets, is confined to the coastal mountains of northern California and adjacent Oregon.

Among the various Old World spruces planted as ornamental trees are the Serbian spruce (*P. Omarika*); the oriental spruce (*P. orientalis*), of Asia Minor; the Himalayan spruce (*P. Smithiana*), the Alcock spruce (*P. bicolor*) and the tiger-tail spruce (*P. polita*), natives of Japan.

See Veitch, *Manual of Coniferae* (2nd ed., 1909); C. S. Sargent, *Manual of the Trees of North America* (2nd ed., 1922); L. H. Bailey, *Standard Cyclopedia of American Horticulture* (1914–27) and *Manual of Cultivated Plants* (1924), and G. B. Sudworth, "Check List of the Forest Trees of the United States, Their Names and Ranges," *U.S. Dept. Agric., Misc. Cir. 92* (1927).

SPRUE. Sprue is a disease of tropical and subtropical regions, and possibly cases arise in temperate climates also.

Symptoms.—The symptoms usually begin with dyspepsia and irregularity of bowel action. In a fully declared case the chief signs are the passage of bulky, frothy, pale porridge-like, stools, much flatulence and acidity, a sore, ulcerated mouth, a red, smooth and tender tongue, often with exquisitely painful ulcers on the fraenum and at the sides. Loss of flesh is very rapid amounting perhaps to 40lb. in two months. Cramps of the fingers and of the feet and calves are common in severe cases. Death occurs from exhaustion and intercurrent disease or, more usually, from intense anaemia, or rarely from perforation of an intestinal ulcer.

Treatment.—The treatment is rest in bed for a fortnight on a diet restricted to milk (increasing from 4 to 7½ pints daily) together with calcium lactate (gr. 15 thrice daily) and extract of parathyroid (gr. 1/10th twice daily). The parathyroid *must* be free from admixture with thyroid (most preparations contain some of the latter) for if any of the latter be present, the symptoms become aggravated and palpitation and other indications of thyroid excess are superadded. With a pure preparation, however, the sprue symptoms improve within a fortnight, the ionic calcium increases to about 8 mg. %, the stools are reduced to one a day and the soreness of the mouth disappears. At the end of four weeks in favourable cases, the calcium lactate can be dropped and the parathyroid reduced to half doses. About this time the blood serum will show a normal calcium content, but the parathyroid extract should not be left off entirely for another three to four weeks. Should symptoms recur, a return for a few days to a simpler diet and to the parathyroid extract will restore health.

Many patients treated on these lines have returned to their duties abroad, many others have been treated in the tropics and have recovered. A few years ago the appearance of sprue meant immediate return to a temperate climate and prohibition of future residence in the tropics. (H. H. S.)

SPUR, an instrument attached to the heel of a rider's boot for the purpose of goading the horse. (A.S. *spura, spora,* related to *spornan, spurnan,* to kick, spurn.) The earliest form of the horseman's spur armed the heel with a single prick. In England the rowel spur is shown upon the first seal of Henry III., but it did not come into general use until the 14th century. In the 15th century spurs appear with very long shanks, to reach the horse's flank below the outstanding bards. After this time, and until the Restoration, they take many decorative forms, some of which remain in the great spurs worn by Mexican cavaliers. Gilded spurs were reckoned the badge of knighthood, and in the rare cases of ceremonial degradation they were hacked from the knight's heels by the cook's chopper.

In architecture, a spur (Fr. *griffe,* Ger. *Knoll*), is the ornament carved on the angles of the base of early columns; it consists of a projecting claw, which, emerging from the lower torus of the base, rests on the projecting angle of the square plinth; the earliest known example is in Diocletian's palace at Split (Spalato). In Romanesque work the oldest examples are those found on the bases in crypts, where they assumed various conventional forms; being, however, close to the eye, the spur soon developed into an elaborate leaf ornament, which in French 13th-century work and in the early English period is of great beauty.

SPURGE, a name applied to plants known botanically as Euphorbia (*q.v.*). The spurge-flax is *Daphne Mezereum,* and the spurge-laurel *Daphne Laureola,* both found in Great Britain.

SPURGEON, CHARLES HADDON (1834–1892), English Nonconformist divine, was born at Kelvedon, Essex, on June 19, 1834. He was the grandson of an Essex pastor, and son of John Spurgeon, Independent minister at Upper Street, Islington. He went to school at Colchester and Maidstone, and in 1849 he became usher at a school in Newmarket. He joined the Baptist communion in 1851, and in 1852 he became pastor of Waterbeach. His powers as a boy preacher became widely known, and at the close of 1853 he was "called" to New Park Street Chapel, Southwark. In a very few months' time the chapel was full to overflowing. Exeter Hall was used while a new chapel was being erected, but even that could not contain Spurgeon's hearers. The enlarged chapel at once proved too small for the crowds, and a huge tabernacle was projected in Newington Causeway. The Tabernacle was opened for service on March 25, 1861. Spurgeon preached at the Tabernacle on Sundays and Thursdays.

His Sunday sermons were sold literally by tons. They are models of Puritan exposition and of appeal through the emotions to the individual conscience, illuminated by frequent flashes of spontaneous and often highly unconventional humour. Collected as *The Tabernacle Pulpit,* the sermons form some fifty volumes. His book of sayings called *John Ploughman's Talks; or, Plain Advice for Plain People* (1869) found many readers. In the summer of 1864 a sermon which he preached on *Baptismal Regeneration* (a doctrine which he strenuously repudiated, maintaining that immersion was only an outward and visible sign of the inward conversion) led to a difference with the bulk of the Evangelical party, both Nonconformist and Anglican. Spurgeon maintained his ground, but in 1865 he withdrew from the Evangelical Alliance. Subsequently in 1887 his distrust of modern biblical criticism led to his withdrawing from the Baptist Union. He died at Mentone on Jan. 31, 1892.

See the *Life* by Schindler (1892) and Spurgeon's *Autobiography,* compiled by his widow and his private secretary from his diary, sermons, records and letters (1897–1900).

SPURN HEAD, foreland of the North Sea coast of Yorkshire, England, projecting across the mouth of the Humber. From Kilnsea it is 4 m. long but seldom exceeds 300 yd. wide. Formed of sand and shingle from the rapidly denuding Holderness coast to the north, it is only a few feet above sea-level.

SPY, a commune near Namur, Belgium. Here in 1886, in Betche aux Roches cavern, Maximin Lohest and Marcel de Puydt found two nearly perfect skeletons (man and woman) at the depth of 16 ft., with numerous implements of the early Aurignacian period. All the human remains are now in the Lohest Collection, Liége. The skulls are of the Neanderthal type.

See *L'Homme contemporain du mammouth à Spy* (Namur, 1887); G. de Mortillet, *Le Préhistorique* (1900); Sir A. Keith, *Antiquity of Man,* 2nd ed. (1925).

SPY. By The Hague Convention IV., 1907, a spy is a person who acting clandestinely or on false pretences obtains or endeavours to obtain information in the zone of operations of a belligerent, with the intention of communicating it to the hostile party (art. 29). If captured he is liable to be shot. A soldier not wearing a disguise is not a spy, though he may be found within the zone of the hostile army and though his object may be to obtain information; nor are soldiers or civilians spies who cross enemy lines openly carrying messages. This applies even to persons sent in balloons for the purpose of carrying despatches. A spy must not be "punished" without previous trial (art. 30), nor can he be treated as a spy if he is captured after he has rejoined his army. He must then be treated as an ordinary prisoner of war (art. 31).

The term "spy" is applied also to those who in time of peace secretly endeavour to obtain information concerning the forces, armaments, fortifications or defences of a country for the purpose of supplying it to another country.

SQUADRON, (1) a military term referring to the subdivision of a cavalry regiment, (2) a naval term referring to a detachment of war vessels, and (3) an air force term denoting a unit of a "group." Literally the term means a body of fighting men formed into a square. In 1656 the term was appropriated by horsemen but even in 1810 Scott in *The Lady of the Lake* refers to "squadrons tramping." The earliest use of the word in the military sense appears to be in 1562 and in 1581 Styward in *Martial Discipline* gives a clue to its origin: "The poore Swizers not being able to furnishe themselves with horse, were the first devisers of the pike and the squadrone," from which it is inferred that a body of pikemen formed into a square were employed on the flanks of a formation. This appears to be confirmed by Bullokar who wrote in 1616 that a squadron was a "square form in a battel." Previous to this, Sir John Smyth in 1590 refers to squadrons in reference to infantry, as also does Ward as late as 1639. Moryson in 1617 mentions "two squadrons of foot 250 men each." In 1702 a squadron of horse was anything between 100 and 200 men but by 1779 the number had been reduced to 80–120. At that date the squadron was composed of three complete troops. The Cavalry Regulations (British) of 1832 state that "Two or more squadrons compose a regiment." In the modern military sense a squadron is one of the principal units into which a regiment of cavalry is divided, corresponding to a company of infantry, the normal being three or four squadrons, sub-divided into "troops." Squadrons are usually between 120 and 200 men. (*See* Cavalry.)

In the naval sense the term refers to a part of a fleet usually commanded by a flag-officer, or it may be applied loosely to any number of vessels less than a whole fleet.

For its application to the air force *see* Group Captain and Air Forces.

In British military use, "squad" (a shortened form of "squadron") is used of any small detachment of men temporarily formed for drill or fatigue work or other duty. In the U.S. army, however, the squad is the basic infantry unit.

SQUALL, the name given to any sudden large increase of wind velocity of less transient character than a "gust." A squall, usually lasting for some minutes at least, is attributable to meteorological causes, while gusts, which may succeed one another every few seconds, are the result of some mechanical interference with the direct flow of air, and are thus produced by turbulence. A squall may include a succession of gusts. A *coefficient of gustiness* has been determined for several stations by dividing the width of the ribbon (max. veloc.-min. veloc.) by the mean velocity. These coefficients show a wide range.

Pendennis castle (Falmouth) S. wind	Coefficient of gustiness	·25
Southport (Marsh side)	,, ,, ,,	·3
Shoeburyness, E.N.E. wind	,, ,, ,,	·3
Holyhead (Salt island)	,, ,, ,,	·5
Scilly (St. Mary's)	,, ,, ,,	·5
Pendennis castle (Falmouth) W. wind	,, ,, ,,	·5
Alnwick (roof of schoolhouse)	,, ,, ,,	·8
Shoeburyness W. wind	,, ,, ,,	·8
Kew observatory (roof)	,, ,, ,,	1·0
Aberdeen (roof of King's college)	,, ,, ,,	1·0

The most gusty exposure of the stations reporting to the Meteorological Office, is Dyce, near Aberdeen, with a coefficient of 1·3. At this station the mast of the tube-anemometer projects 15 ft. above surrounding tree tops, which are particularly liable to produce turbulences.

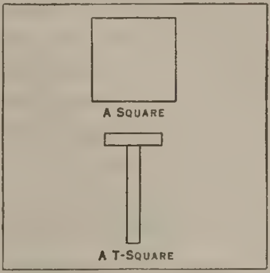
In the present state of anemometry it is difficult to give exact figures for the actual force of the wind during gusts, but 106·5 m.p.h. were recorded at Pendennis castle on March 14, 1905. Squalls with velocities reaching 55 m.p.h. are not uncommon, and the range of wind velocity during gusts in such a squall may be anything between 40 m.p.h. and upwards of 100 m.p.h.

The gradual veering of the westerly wind to the north-west is a common experience with squalls at Scilly. Changes in wind velocity are generally associated with some change in wind direction. The increase of wind velocity occurs suddenly. At sea, the ruffling of the surface can be seen travelling over the water, and, on land, the approach of a violent squall is frequently marked by falling trees, etc.

These phenomena are best exhibited in "line squalls." As the name suggests, a number of places arranged, roughly, in a continuous line, often hundreds of miles long, experience simultaneously a similar sequence of events. The line of action advances with an approximately uniform speed across the country, and somewhat resembles the dash forward of the water of a broken wave. Its velocity can be determined easily from the time of occurrence of the various changes at different places. Though these changes normally occur at all places on the line, their intensity varies considerably; there is usually greater violence in the middle portion, and the disturbance becomes more intense as the whole line advances. The course of events in typical line squalls has been worked out by R. G. K. Lempfert and Richard Corless. The violent winds may therefore be attributed to the breakdown of the dynamical system under the stress of these local but sharp differences of pressure. In this respect a V-shaped depression (*q.v.*) may be regarded as a special case of a line squall in which the two currents are from approximately opposite directions, and the line of the trough which sweeps forward, keeping parallel to itself, represents the linear front. An example of a violent and destructive form of line squall is shown in the records for June 1, 1908. The Kew squall of wind which destroyed a number of the trees of Bushey avenue maintained its violence for a considerable period. Many other famous line squalls, such as those of Feb. 19, 1907, Oct. 14, 1909, etc., have been examined. (*See* Lempfert and Corless, *Line Squalls and Associated Phenomena* [Q.J.R. Met. Soc., vol. xxxvi., 1910].) One of historic interest caused the loss of H.M.S. "Eurydice" off the Isle of Wight on March 24, 1878. It was among the first to receive special attention, and was discussed by Abercromby in 1884 (*Quart. Journ. Roy. Met. Soc.*, x. 172) and previously by Clement Ley (*Symon's Met. Mag.*, April, 1878). The events of the World War deprived Norwegian meteorologists of weather telegrams from a considerable part of Europe, and, in consequence, they were compelled to base their forecasts on the intensive study of a small region. This study resulted in much new light being thrown on the movements of air currents.

In addition to the references given in the text, *see* Napier Shaw's *Life History of Surface Air Currents, Forecasting Weather* (1923), *The Air and its Ways* (1923), *Manual of Meteorology* (1919, 1926, 1928); V. Bjerknes, *On the Dynamics of the Circular Vortex with Applications to the Atmosphere* (Christiania, 1921), together with various papers in the *Q.J. Met. Soc.* from 1910 onwards; J. Bjerknes and H. Solberg, *Life Cycle of Cyclones and the Polar Front Theory of Atmospheric Circulation* (Oslo, 1922).

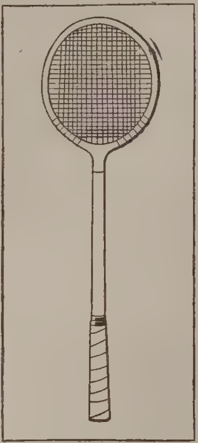
SQUARE, a term variously used in mathematics, in technical work, and metaphorically. In geometry it designates a rectilinear figure having four equal sides and four equal angles, the angles being right angles. Such a figure is a special kind of rectangle (equilateral) and of parallelogram (equilateral and equiangular). It has four axes of symmetry and its two finite diagonals (as in the case of any rectangle) are equal. If the side is s, the area is $s \times s$, or s^2, the name "s squared" being derived from this geometric relation. Hence the analytic square is the product arising from multiplying any algebraic expression by itself; *e.g.* $(a+b)^2=a^2+2ab+b^2$ (*see* Binomial Formula). The Latin writers called the side of a square its *latus* (side), and hence the square root of a number was often called the *latus*. In technical work the word is applied to instruments used for drawing or testing right angles, as in the case of the T-square here shown and the familiar carpenter's square.



SQUASH RACKETS. A game played on exactly the same principle as rackets but in a smaller court and with a ball made of india-rubber. The rules are in most particulars similar to rackets but the scoring is different. In matches in England, hand-in only can win an ace. The rubber is the best of five games of 9 up. If, however, the score becomes 8 all, the player who reached 8 first has the option of a set to two. In America a game consists of 15 points up, and an ace is scored for each rally irrespective of which player is serving, all matches being the best three out of five games. The rotation of service in England is just as in rackets. In the American game, the winner of one rally serves in the next.

The Court and Implements.—Squash rackets can be played in courts of many sizes and descriptions both covered and uncovered with three or four walls and made of concrete or wood. The first standardization of a court in England was made by the Tennis and Rackets Association in 1911. Shortly after the World War the Association issued revised standard dimensions and the great majority of British courts have been built to these dimensions since. The standard court has four walls and can either be covered or uncovered. In length it is 32 ft. and in breadth 21 ft. The front and side walls are 15 ft. in height and the back wall is 7 ft. in height. The floor in a closed court should be made of wood; in an open court, of cement. In a closed court the front wall should be of composition.

The markings on the floor and front wall of the court are exactly similar to those in a racket court. On the front wall, the top of the play line is 19 in. from the floor and the service line is 6 ft. from the floor. The short line is 14 ft. from the back wall. The service boxes are 5 ft. 3 in. square. In the space between the play-line and the floor is generally placed a strip of tin or some other metal in order to differentiate clearly in sound when the part of the front wall "in play" or "out of play" is hit. The lines on the wall and floor are painted red. Maple is considered a most suitable wood for the floor. The courts should be lighted from the roof, and nearly all modern courts, in addition to this lighting are fitted with electric light for evening play.



ENGLISH, BENT ASH FRAME, SQUASH RACKET

The American standard court is of different size to the English, being considerably narrower, 31 ft. by 18 ft. 6 in. The racket is precisely similar to the implement used in the game of rackets, only shorter in the handle. The ball is of black rubber. Many different forms of ball have been tried and formerly, when there were no standard courts, the ball which seemed best suited to the particular conditions was generally used. For the present standard English court the Association has adopted three standard balls. The ball used in America is larger than that in England.

Open competitions at squash rackets were unknown in England before the World War. In the years since, several have been started, the most important being the London inter-club tournament (teams of three) for the Bath Club cup; the amateur championship, the royal navy and army championships, and the ladies championships. The winners of the amateur championship have been:—April 1923, Capt. T. O. Jameson; Dec. 1923, Capt. Jameson; Dec. 1924, W. D. Macpherson; Jan. 1926, Capt. V. A. Cazalet; Dec. 1926, Capt. J. E. Tomkinson; Dec. 1927, Capt. V. A. Cazalet; Dec. 1928, W. D. Macpherson. Other leading British amateurs are H. W. Backhouse, Col. W. J. Bassett, C. Browning, R. G. de Quetteville, P. Q. Reiss, F. M. Strawson and G. N. Scott-Chad, the army champion. The prince of Wales is a very keen player and has competed several times in the amateur and army championships.

The British professional champion is Charles Read (Queen's Club) who defeated O. Johnson (R.A.C.) for the title in 1928. Leading lady players are Miss C. Fenwick, Miss Cave, Miss Joyce Cave and Miss S. Huntsman.

The development of the game in America has been even more rapid than in England. The large cities of the United States, particularly New York, Boston and Philadelphia, are amply supplied with courts and the game is also played with much keenness in Canada. Two British teams have visited America in the last few years and a United States team has also toured in England. Among leading American amateurs are M. Baker, W. Palmer Dixon and W. S. Wright. The champion in 1928 was H. N. Rawlins.

The French Squash Rackets Association was formed in 1926 and four courts were opened in Jan. 1927. Outside Europe and America courts are to be found in several parts of the British empire, especially in India and the far East. There are courts in New Zealand and in South Africa.

See E. H. Miles, *Racquets, Squash Tennis* (1902); C. Arnold, *The Game of Squash Rackets* (1926); E. B. Noel, *The Field Handbook of Squash Rackets* (1926). (E. B. N.)

SQUIB, a firework bursting with a flash and a clatter: hence a slight satirical composition put forth on an occasion, which should make a noise by its explosion, not by the possession of any permanent importance. Steele says, in the *Tatler,* that "squibs are those who in the common phrase of the world are call'd libellers, lampooners and pamphleteers," showing that in his time the satirist as well as the satire was called a squib. Swift speaks of the rapidity with which these little literary fireworks flew about, and was himself a proficient in the making of them. A good type of a squib is Gray's *Candidate.* (*See* LAMPOON.)

SQUID, the popular name given to a large number of cephalopod molluscs which include (*e.g.*) the common squids of the Atlantic (*Loligo, Ommastrephes*), the giant squids (*Architeuthis*) and the fire squids (*Lycoteuthis, Abralia*). They are exclusively marine animals of world-wide distribution and form an important part of the population of marine swimming and floating animals.

A typical squid, e.g., *Loligo vulgaris,* the common squid of the north-east Atlantic and Mediterranean, has an elongate slender body (visceral sac) edged by triangular fins, a short square head provided with well-developed eyes and ten arms. On the undersurface of the latter are arranged rows of suckers which are strengthened by tough horny rings. Two of the arms (tentacles) are longer and more mobile than the other eight (sessile arms) and the suckers are concentrated at the extremity as a "hand." The long tentacles are used for capturing prey, the sessile arms for transferring the latter to the mouth and grasping it while it is being crunched by the horny jaws which are situated around the mouth in the centre of the circlet of arms.

Situated within the muscular tissues of the "mantle" is a long horny structure, the "pen" or gladius. This is the rudiment of a shell and consists actually of a secondary growth (the proostracum) which has replaced the true shell-rudiment. In the genus *Ommastrephes* there is a vestige of the original shell.

The majority of the squids are active, highly mobile animals of aggressive habits and are probably all carnivorous.

Originally the squids were distributed among the two "tribes," Egopsida and Myopsida, of the ten-armed Cephalopoda (Decapoda). Recently, however, Naef and other students have proposed a more suitable classification of the Decapoda according to which the squids are all placed in a single sub-order, the Teuthoidea.

These forms are divisible into two groups originally called by C. Chun the *Oegopsida libera* and *Oegopsida consuta.* The first include the large, active and freely swimming forms (*Architeuthis, Loligo, Ommastrephes,* etc.). The second comprise a smaller assemblage of curious and highly modified forms which are less common than the Libera and are very largely planktonic. The distinction between these two groups is based on the mode of attachment of the ventral edge of the mantle to the head. In the Libera this attachment is effected by a stud and socket junction (*see* CEPHALOPODA) between the head and the edge of the mantle and can be freed from the head when necessary. In the Consuta the ventral edge of the mantle is permanently fixed to the head.

The Libera are represented by about 65 genera. Among them *Architeuthis* is the most striking on account of its size. The genus includes the largest living invertebrate animals, *Architeuthis princeps* of the north Atlantic attaining a maximum record length of 52 ft. (including the outstretched tentacles). *Sthenoteuthis,* a group of smaller forms, which attain a size of over seven feet, may be also reckoned "giant squids."

Another interesting group are the phosphorescent squids, *Nematolampas, Thaumatolampas* (*Lycoteuthis*) and *Abralia,* which bear light-organs in certain regions of the body (on the mantle, arms, inside the mantle-cavity and around the eyes). Certain of these animals when seen alive are very beautiful creatures.

Ommastrephes bartrami, the so-called "flying squid," is found throughout tropical and temperate seas. Its flight is, strictly speaking, a series of leaps across the surface of the sea which are often strong enough to land it on the deck of a ship. This feat is no doubt rendered easier in high seas.

The Consuta are mainly small animals. Their fins are largely reduced and the mantle is swollen and tun-like in *Cranchia, Bathothauma,* etc. In the latter, and in *Sandalops,* and *Corynomma* the arms are much reduced and the eyes are situated on stalks. Unlike the larger swimming squids these animals probably float largely at the mercy of the currents and are thus to be reckoned as "plankton." (*See* CEPHALOPODA.)

See G. Pfeffer, *Die Cephalopoden der Plankton-Expedition* (1912); C. Chun, *Wiss. Ergebn. d. Deutsche Tiefsee Expedn.* Bd. xviii. (1910). (G. C. R.)

SQUILL, the name under which the bulbous root of *Urginea Scilla* (family, Liliaceae) is used in medicine. The medicinal squill is a native of the countries bordering the Mediterranean, and grows from the sea-level up to an elevation of 3,000ft. The bulbs are globular and often weigh more than 4lb. Two varieties are met with, the one having white and the other pink scales. They are collected in August, when leafless, the membranous outer scales being removed and the fleshy portion cut transversely into slices and dried in the sun.

Three pharmacopoeial preparations of this powerful drug are of importance: the syrup, composed of one part of squill, eight of dilute acetic acid and four of sugar; the *Pilula Ipecacuanhae cum Scilla,* in which ipecacuanha and opium are the chief constituents; and the tincture made by macerating one part of squill with five of alcohol. The drug is a cardiac stimulant. Even in small doses it is a powerful expectorant and a fairly active diuretic. The drug must not be given alone, owing to its irritant action.

An allied species, *Urginea indica,* is used in India in the same manner as the European species. The true squills are represented in Great Britain by two species, *Scilla autumnalis* and *S. verna.* These are confined to the sea-shore. There are 80 species or more in temperate regions of the old world. Several species are grown in gardens, notably *S. bifolia* and *S. sibirica,* originating from the Caucasus region and S.W. Asia. *S. nonscripta* or English bluebell and *S. hispanica* or Spanish bluebell are also widely cultivated.

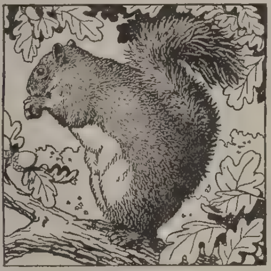
SQUINCH, in architecture, a general term for several means by which a square or polygonal room has its upper corners filled in to form a support for a dome: by corbelling out the courses of masonry, each course projecting slightly beyond the one below; by building one or more arches diagonally across the corner; by building in the corner a niche with a half dome at its head, or by filling the corner with a little conical vault which has an arch on its outer diagonal face and its apex in the corner. The arched squinch seems to have been developed almost simultaneously by the Roman builders of the late imperial period and the Sassanians in Persia.

Squinches are often found both in Romanesque and Mohammedan work. In Italy the form is either the conical type as in the church of S. Ambrogio at Milan (crossing 11th or 12th century) or as a succession of arched rings as in the 13th century central tower of the abbey church at Chiaravalle Milanese; more complex forms, with niches and colonnettes are characteristic of the French Romanesque of Auvergne, as in the cathedral of Le Puy en Velay (late 11th and early 12th century); the allied churches of the south-west coast, such as St. Hilaire at Poitiers, use conical squinches of the Italian type. Mohammedan architecture, borrowing from the Sassanian precedent, makes great use of squinch forms, particularly in the Syrian, Egyptian and Moorish phases; the stalactite work, which is so marked a feature of later Muslim architecture, is, in essence, merely a decorative development of a combination of niche squinch forms. In Gothic architecture squinch arches are frequently used on the insides of square towers to support octagonal spires. (*See* BYZANTINE AND ROMANESQUE ARCHITECTURE; DOME; MOHAMMEDAN ARCHITECTURE; PENDENTIVE.)

SQUIRE, JOHN COLLINGS (1884–   ), British man of letters, was born at Plymouth on April 2, 1884, and educated at Blundell's school, Tiverton, and St. John's college, Cambridge. He then engaged in publishing and journalism, working for a time in the Press Gallery of the House of Commons. He became literary editor of *The New Statesman* in 1913, and was its acting editor in 1917–18. His early poems were issued as *Poems and Baudelaire Flowers* (1909), after which came some clever parodies, *Steps to Parnassus* (1913) and *Tricks of the Trade* (1917). Further poems included *The Lily of Malud* (1917), *The Birds* (1919), *The Moon* (1920), and *American Poems* (1923). In 1919 Squire founded *The London Mercury,* a monthly journal of literature and the arts, soon a distinctive stronghold in contemporary English criticism. He was also responsible for several volumes of reprinted essays and reviews (some originally under the pseudonym of "Solomon Eagle"), a number of anthologies of verse, and a book of short stories, *The Grub Street Nights Entertainments* (1924). (*See* ENGLISH LITERATURE.)

His later works include *The Comic Muse* (1925); *Poems in One Volume* (1926); *Life of the Mermaid* (1927); and an anthology entitled *The Cambridge Book of Lesser Poets* (1927); *See* I. A. Williams, *J. C. Squire (A Bibliography of His Works)* (1922).

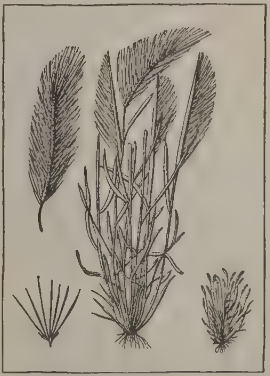
SQUIRREL, the name of a red, bushy-tailed arboreal rodent, but also extended to include allied species. Typical squirrels are found throughout the tropical and temperate regions except in Madagascar and Australia. The common squirrel (*Sciurus vulgaris*) is found over the whole of Europe and North Asia, though showing great range of colouring in the various parts of its habitat. The ears are tufted, and the animal feeds largely on vegetables and fruits, varied with mice, small birds and eggs. In North America this species is replaced by the grey *S. carolinensis,* a larger and more powerful form, that has been introduced into Great Britain, where it has exterminated the native species in many places. Squirrels vary in size from that of a mouse, as *Nannosciurus minutus* of West Africa, to that of a cat, as the black and yellow *Ratufa bicolor* of Malay. In India the commonest species are the little striped palm squirrels, *Funambulus pulmarum* and *F. Pennanti,* the latter being the more northern species. One oriental squirrel (*S. caniceps*) assumes a definite breeding dress. Squirrels form the family *Squirridae* of the order Rodentia (*q.v.*). (*See* also GROUND-SQUIRREL, CHIPMUNK, SPINY SQUIRREL, GROOVE-TOOTHED SQUIRREL, FLYING-SQUIRREL.)



GREY SQUIRREL (SCIURUS CAROLINENSIS), EASTERN NORTH AMERICA

SQUIRREL MONKEY, a small golden-haired South American monkey, *Chrysothrix sciurea;* the name is also applied to the two other species of the genus, whose collective range extends from Costa Rica to Bolivia and Brazil. The squirrel monkeys belong to the Cebinae (*see* CAPUCHIN-MONKEY), from the other members of which they differ by their practically non-prehensile tails, smaller size, their large eyes and the backward prolongation of the hinder part of the head. (*See* PRIMATES.)

SQUIRREL-TAIL GRASS (*Hordeum jubatum*), a name widely given in the United States to a species of wild barley, native to Europe, Asia and western North America and naturalized extensively in the eastern States and Canada, often becoming a troublesome weed, especially in alfalfa fields. It is a perennial, with slender stems usually from 1 to 2½ ft. high, bearing nodding, soft, brushlike, long-awned flowering spikes, from 2 to 4 in. long and about as thick, whence the common name. It is also known, locally as barley-grass, foxtail and tickle-grass.



BY COURTESY OF IOWA GEOLOGICAL SOCIETY
SQUIRREL-TAIL GRASS

SRINAGAR, capital of the state of Kashmir, in Northern India, 5,250 ft. above sea-level, on both banks of the river Jhelum, which winds through the city with an average width of 80 yds. and is crossed by seven wooden bridges. The houses occupy a length of about 3 m. and a breadth of about 1½ m. No two buildings are alike. The curious grouping of the houses, the frail tenements of the poor, the substantial mansions of the wealthier, the curious carving of some, the balconies of others, the irregular embankment and the mountains in the background, form a quaint and picturesque spectacle. Pop. (1921), 141,736. The city is exposed to both fire and flood. The artisans of Srinagar enjoy a high reputation. Unfortunately, the historic industry of shawl-weaving has been replaced by carpet manufacture. Other industries are paper, leather, silver and copper ware, and wood-carving.

SRIRANGAM, a town of British India, in Trichinopoly district, Madras presidency, 2 m. N. of Trichinopoly city. Pop. (1921), 23,152. It stands on an island of the same name, formed by the bifurcation of the river Cauvery and by the channel of the Coleroon. The town is celebrated for its great temple, dedicated to Vishnu, composed of seven square enclosures, one within another, and 350 ft. distant from each other. Each enclosure has four gates with high towers, placed one in the centre of each side opposite to the four cardinal points. The outer wall of the temple is not less than 4 m. in circumference. It is a great place of pilgrimage.

STAAL, MARGUERITE JEANNE CORDIER DELAUNAY, Baronne de (1684–1750), French author, was born in Paris on Aug. 30, 1684, the daughter of a painter named Cordier. She adopted her mother's maiden name, Delaunay. She was educated at a convent at Evreux, later accompanying Madame de Grieu to the convent of St. Louis where the latter was appointed abbess. Mlle. Delaunay held a little salon there until 1710, and after the death of Mme. de Grieu entered the household of the duchesse du Maine at Sceaux. She helped her mistress to draw up the *Mémoire des princes légitimes,* demanding the meeting of the states-general. After a short imprisonment in the Bastille, on account of her implication in the Cellamare conspiracy (1718), she returned to the service of the duchess. She had had many admirers, and some serious passions, when, in 1735, being then over fifty, the duchess arranged her marriage with the Baron de Staal. She remained a member of the duchess's household, and became the friend and correspondent of Mme. du Deffant. She died at Gennevilliers on June 15, 1750.

Her *Mémoires* appeared about five years later, and have often been reprinted. In these memoirs the humours of the "court of Sceaux" are depicted as hardly any other society of the kind has ever been. "Dans cet art enjoué de raconter," says Sainte-Beuve, "Madame de Staal est classique."

Her *Mémoires* were edited (1877) by M. de Lescure, and translated by S. Bathurst (1877) and by C. H. Bell (1892). Mme. de Staal also left two excellent short comedies, performed at the court of Sceaux, and some letters.

STABAT MATER, famous mediaeval Latin hymn on the Crucifixion, which has enjoyed unexampled esteem throughout the ages, believed to have been written by Jacopone, a Franciscan monk of the 13th century. Though not originally intended for this purpose, it was early introduced into liturgical use and was adopted as one of the Sequences of the Roman missal in the 18th century. Among the many settings of the poem by eminent composers may be mentioned those of Josquin des Prés, Palestrina, Pergolesi, Haydn, Rossini, Verdi and Dvořák.

STABIAE, an ancient town of Campania, Italy, on the coast at the east extremity of the Gulf of Naples (mod. Castellammare di Stabia). It was dependent upon Nuceria Alfaterna. In 89 it was taken and destroyed by Sulla, and its territory given to Nuceria as a reward for fidelity to Rome.

STADE, a town of Germany in the Prussian province of Hanover, situated on the navigable Schwinge, 3½ m. above its confluence with the Elbe, 20 m. W. of Hamburg on the railway to Cuxhaven. Pop. (1925) 11,992. The rise of Harburg has deposed it from its former position as the chief port of Hanover.

STADION, JOHANN PHILIPP KARL JOSEPH (1763–1824), Austrian statesman, was ambassador in London (1790–93). After some years of retirement he was entrusted (1800) with a mission to the Prussian court, where he endeavoured in vain to effect an alliance with Austria. He had greater success as envoy at St. Petersburg (Leningrad), where he played a large part in the formation of the third coalition against Napoleon (1805). Notwithstanding the failure of this alliance he was made foreign minister, when he helped to prepare archduke Charles for a fresh trial of strength with France. In 1808 he abandoned the policy of procrastination, and with the help of Metternich hastened the outbreak of a new war. The unfortunate results of the campaign of 1809 compelled his resignation, but in 1813 he was commissioned to negotiate the convention which finally overthrew Napoleon.

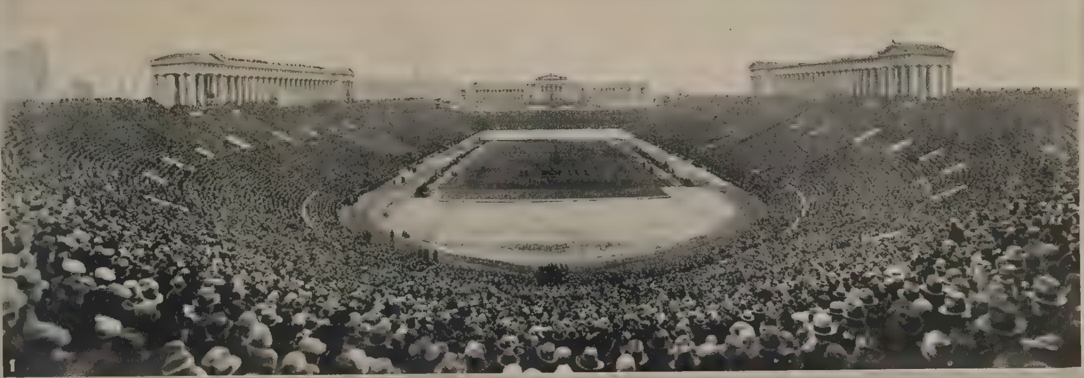
See A. Beer, *Zehn Jahre österreichischer Politik, 1801–1810* (Leipzig, 1877); *Die Finanzen Oesterreichs im 19 Jahrhundert* (Prague, 1877). *See* also AUSTRIA.

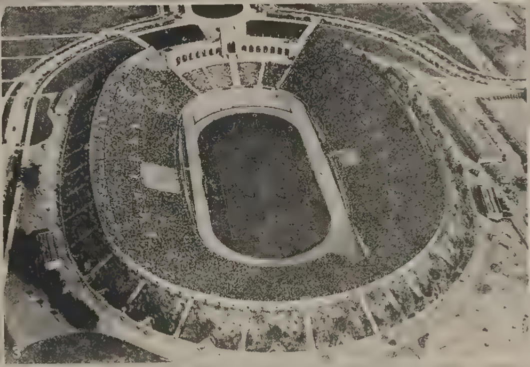
STADIUM, the Latin form of a Greek word for a standard of length. A stade = 100 ὀργυιαί (about 6 ft. or one fathom) = 6 πλέθρα (100 Greek or about 101 English feet) = about 606 English feet, or about one-eighth of a Roman mile. The course for the foot-race at Olympia was exactly a stade in length, and thus the word for measurement became transferred first to the race and then to the place in which it was run. The modern word stadium is used for the permanent construction of an amphitheatre in which games and sports of various kinds can be conducted on a central space surrounded by continuous tiers of seats for the spectators. For a description of the Colosseum and other Roman amphitheatres, with illustrations, *see* AMPHITHEATRE.

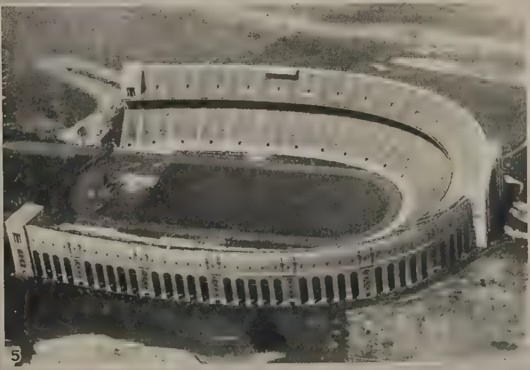
The amphitheatre was a distinctively Roman building. The Greeks had their palaestra, their theatre and their circus. Upon the ruins of one of the most famous of these latter, the first "stadium" used for the first modern celebration of the revived Olympic games was built. Its original design was carried out in 330 B.C. in Athens. Its reconstruction by Herodes Atticus some 500 years later nearly exhausted the marble of the Pentelic quarries. It then fell gradually into decay. Excavations were begun by the king of Greece in 1870, and, in preparation for the Olympic games of 1896, this stadium was magnificently restored in white marble, with an arena seating 60,000 spectators, by the personal generosity of M. Averoff, a wealthy Greek merchant of Alexandria. It enjoys a setting which no other structure of the kind can ever equal, for above it are Lycabettus and the Acropolis. Unfortunately, as may be seen from the picture, the track contains corners at each end which make really high speed impossible and cannot now be altered, and the central enclosure is too narrow for the proper arrangement of the details of a modern Olympic programme. These are the results of taking the Greek instead of the Roman plan as the key of the design.

Though nothing can take from Athens the honour of having been the scene of the first meeting of the revival, it was clear that as soon as the Olympic games were fixed for London (in 1908) more care would have to be taken for the requirements of the modern athlete. The London stadium has remained the type of all subsequent constructions for successive Olympic meetings, and is also illustrated here, for it is still in use; and the consideration arises that, as the years pass, many such constructions, more or less permanent, will form an integral part of every great city in which the Olympic games have been or will be held. Those at Stockholm and Paris are also illustrated here. London's stadium at Shepherd's Bush could hold the whole external breadth of the Athenian marble building upon the 100 yd. of turf inside its running track, and the 235 yd. in length of that same turf is bigger than the external measurement of the Colosseum. The cinder-path all round the grass measures 1,760 ft., or exactly one-third of a mile. A concrete cycle-track runs all round and outside the cinder-path, and is embanked at each corner with solid slopes that form the inside of the wall containing a large public promenade all round the lowest tiers of seats. There are seats for more than 50,000 spectators, built up of steel girders and concrete, containing beneath the audience an enormous range of dressing rooms, committee rooms and offices. Two large portions of the seating area are completely sheltered from the weather; and opposite the royal box is a great concrete swimming bath, built just inside the running track, 109½ yd. long by 50 ft. wide, and a depth of 12 ft. in the middle, with movable raised platforms for high diving. The turf in the centre is 235 yd. long by 99 yd. broad, the cinder-path is 24 ft. wide, and the concrete cycle track is 35 ft. broad. The first stanchion was set on July 31, 1907; and the final cost was in the neighbourhood of £40,000. Even larger, and with far more architectural pretensions was the gigantic stadium erected after the World War at a cost of about £200,000 for the Empire Exhibition at Wembley, and that too is, of course, still in use.

After 1908, the next Olympic meeting was held in Stockholm, and the stadium erected by Sweden may be seen in the picture. It is also of a more permanent character than that at Shepherd's Bush; and though its cost (before the war) was nothing like that entailed at Wembley, it preserves all the essential features of London's Olympic building at Shepherd's Bush and combines with





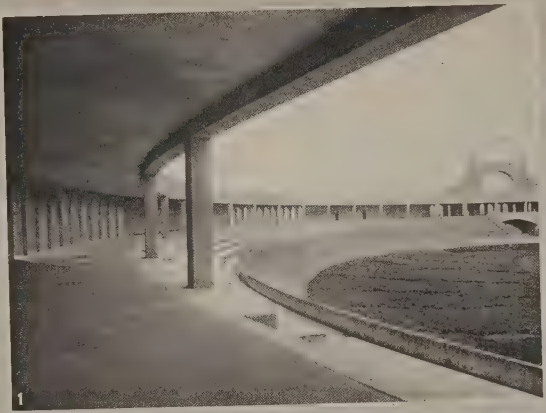


BY COURTESY OF (2) THE YALE COOPERATIVE CORPORATION, (3) THE LOS ANGELES CHAMBER OF COMMERCE; PHOTOGRAPHS, (1, 4) KAUFMANN AND FABRY, (5) COPR. RINEHART-WEAVER

STADIUMS IN AMERICA

1. Soldier's Field, Chicago, with a seating capacity of approximately 150,000, built as a result of the enormously increasing public interest in sports of various types.
2. The Yale Bowl, first used in 1914, covers 25 acres, has 30 entrances, and seats approximately 80,000. Photograph taken just before the start of a Yale-Army game
3. Municipal Coliseum, Los Angeles, holding about 75,000 spectators. Used for sports contests, concerts, and productions of various kinds
4. University of Illinois Memorial Stadium at Urbana. Its seating capacity is approximately 60,000 and it is built of re-inforced concrete. The double decks are of steel
5. Ohio State University Stadium at Columbus, Ohio, accommodating about 75,000 spectators. The horseshoe shape is a distinctive feature of this stadium. Architect, Howard Dwight Smith; Engineer, Clyde T. Morris

STADIUM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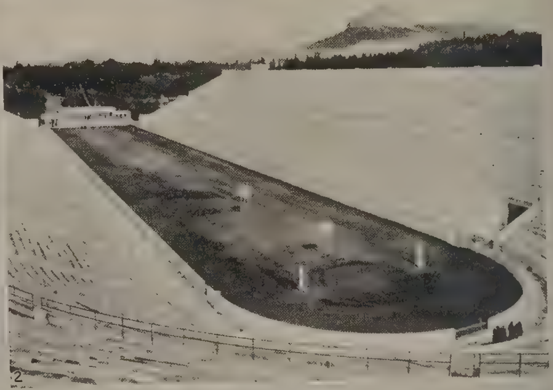
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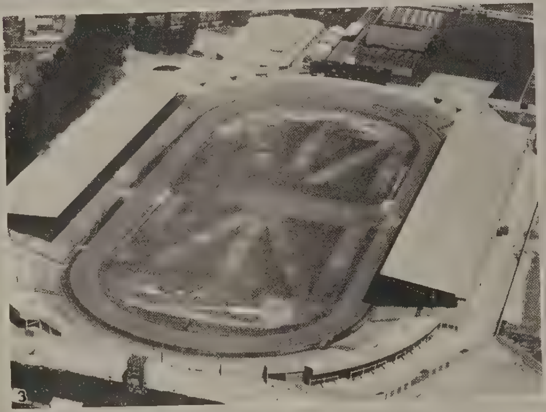
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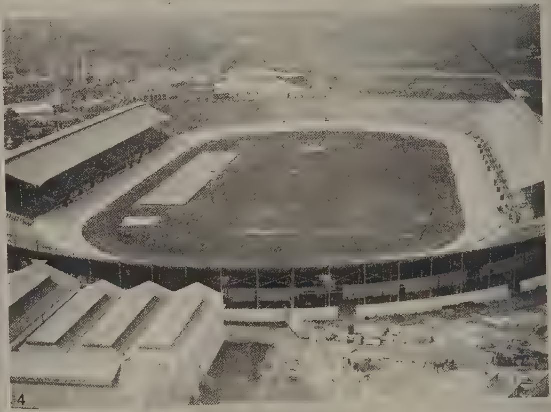
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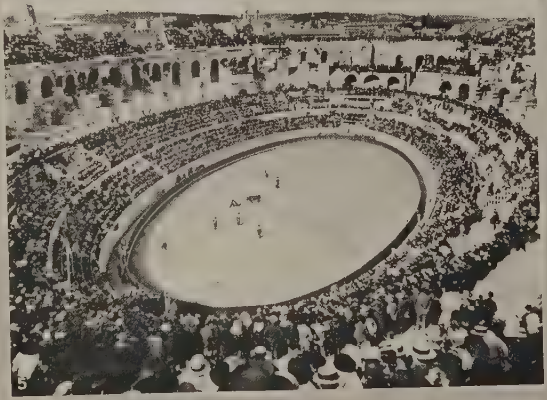
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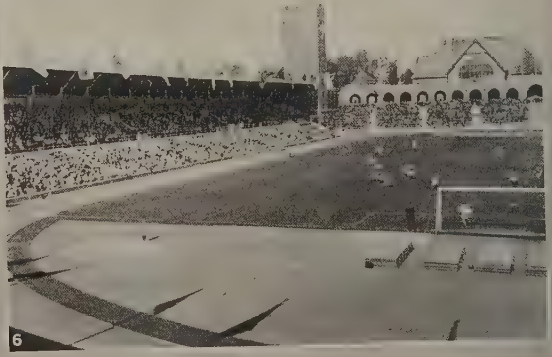
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STADIUMS OF EUROPE

The construction of the huge stadium at Athens in 1896 for the revival of the Olympic games, and the subsequent increase of interest in sports throughout Europe, have resulted in the building of several large stadiums and the reconstruction of others

1. Lyons Stadium in the old city of Lyons, France
2. Stadium completed in Athens in 1906 for the holding of the Olympic games. There are seats for more than 50,000 spectators
3. Paris Colombe stadium, strictly practical design, constructed for the Olympic games of 1924
4. Ambitious stadium at White City, London, erected after the World War at a cost of about £200,000
5. "Les Arènes" ancient amphitheatre at Nîmes, France. About 2,000 persons were living within its walls in 1809 when it was cleared by order of the prefect. It is now restored and used as a stadium. Photograph shows a bullfight in progress
6. Stockholm Stadium built for the fifth Olympiad in 1912, with a seating capacity of 15,000. Modeled after the London Olympic stadium with certain characteristics of Scandinavian architecture added

them certain typical and pleasing characteristics of Scandinavian architecture. The stadium built by France at Colombes for the games of 1924 is a strictly practical design, with arenas for lawn tennis, football and other games close beside it. The Amsterdam stadium was built for the games of 1928. (T. A. C.)

IN THE UNITED STATES

Athletics have come to form such an essential part of the curricula of modern universities that a general plan for these institutions can hardly be considered complete until suitable architectural provision has been made for the athletic activities. The enormously increasing public interest in such games as football, baseball and track and field sports has given rise to a definite architectural problem which has found its most notable solutions in the United States. In America the stadia, comprising the field for games and seats for spectators, have grown steadily both in size and number, so that where there were only five of importance in 1913 there are now more than 30. Independently of the universities, several cities, recognizing the value of physical culture in a community, have provided stadia of great size, such as the Municipal stadium of Philadelphia, with its permanent seating capacity of 80,000 persons, the Los Angeles stadium, and the Chicago stadium with a permanent seating capacity of 55,000, capable of large increase.

Architecturally, the problem of the stadium is governed by the requirements of the sports practised within its walls. Certain stadia, for instance, are designed for one sport only, such as football (*e.g.,* Yale Bowl, stadium of the University of Michigan, etc.), and the baseball parks found throughout the United States; others for two sports, such as football and track racing, in which case the football field is surrounded by a quarter mile track provided with a straightaway for the dashes (*e.g.,* those at Harvard and Ohio State universities and at Pasadena). Others are designed for three sports; viz., football, baseball and track racing (*e.g.,* universities of Pennsylvania, Pittsburgh, etc.); this combination is difficult, owing to the wide difference between the shape of the football field and that of the baseball diamond, for if the seats for the spectators are placed close enough to the gridiron the arrangement will not accommodate the diamond.

The general shape of the stadium has been subject to much experiment and varies widely. Starting with the arrangement of two stands lying parallel to the side-lines of the football field, it has taken, successively, the U-shape, as in the stadia at Harvard and the universities of Pennsylvania and Kansas; the horse-shoe shape, as at Ohio State university; the ellipse of the old Roman amphitheatre, as in the Yale Bowl and at the University of Pittsburgh; and finally a rectangular shape with rounded corners. The last two types are suitable only for football. In several recent instances the early type of the two opposite spectators' stands has been revived, but it is so arranged that the larger number of seats are massed at the centres of the sidelines, on the theory that it is more important for the spectator to command an equal view of the goal lines than to be near the level of the field. In this case, the stands take the form of a crescent, as at Cornell university, or of a trapezoid, as at Brown university, with about three times as many seats in the centre as at the ends.

In elevation the forms of stadia vary even more; they range from an excavation in the ground, with the playing field below the level of the surrounding land, as at Yale and the University of Michigan, through the semi-buried type, such as the Philadelphia Municipal stadium, to a structure above ground enclosing a playing field at the ordinary level, as at Harvard and Princeton universities. This last type of construction, sometimes in two decks, as at the universities of Pennsylvania and Illinois and at the Ohio State university, is usually of reinforced concrete, with the double decks of steel. The design of the outer walls adopts suitable simplicity and is usually developed as a series of arcades, the concrete being sometimes faced with brick. The interest excited by the international tennis matches has necessitated the construction of stadia of a similar type, enclosing three courts (West Side tennis club, Forest Hills, N.Y.).

See also AMPHITHEATRE. (P. P. CR.)

STAËL, MADAME DE. ANNE LOUISE GERMAINE NECKER, BARONNE DE STAËL-HOLSTEIN (1766–1817), French novelist and miscellaneous writer, was born at Paris on April 22, 1766. Her father was the famous financier Necker, her mother Suzanne Curchod, almost equally famous as the early love of Gibbon, as the wife of Necker himself, and as the mistress of one of the most popular salons of Paris. The future Mme. de Staël was from her earliest years a romp, a coquette and passionately desirous of prominence and attention. She was a plain child and a plainer woman, whose sole attractions were large eyes and a buxom figure. She is said to have written her father a letter on his famous *Compte-Rendu* and other matters when she was not fifteen, and to have injured her health by excessive study and intellectual excitement. There is no doubt that her father's dismissal, and the consequent removal of the family from the busy life of Paris, were beneficial to her. During part of the next few years they resided at Coppet, her father's estate on the Lake of Geneva, which she herself made famous. They returned to Paris, or at least to its neighbourhood, in 1785, and Mlle. Necker resumed literary work of a miscellaneous kind, including a novel, *Sophie,* printed in 1786, and a tragedy, *Jeanne Grey,* published in 1790. She married Eric Magnus, Baron of Staël-Holstein, who was first an attaché of the Swedish legation, and then minister. For a great heiress and a very ambitious girl the marriage scarcely seemed brilliant, but the king of Sweden promised the ambassadorship for twelve years and a pension in case of its withdrawal, and the marriage took place on Jan. 14, 1786. The husband was thirty-seven, the wife twenty. Mme. de Staël was accused of extravagance, and after 11 years (1797) an amicable separation of goods was arranged. There was no scandal between them; the baron obtained money and the lady obtained, as a guaranteed ambassadress of a foreign power of consideration, an established position. In 1788 she appeared as an author under her own name (*Sophie* had been already published, but anonymously) with some *Lettres sur J. J. Rousseau.* She stood at this time for a mixture of Rousseauism and constitutionalism in politics. She visited Coppet once or twice, but for the most part in the early days of the revolutionary period she was in Paris taking an interest and, as she thought, a part in the councils and efforts of the Moderates. At last, the day before the September massacres, she fled from France, befriended at this critical juncture by Manuel and Tallien.

She betook herself to Coppet, and there gathered round her a considerable number of friends and fellow-refugees. In 1793 she visited England, and established herself at Mickleham in Surrey as the centre of the Moderate Liberal emigrants—Talleyrand, Narbonne, Jaucourt and others. In the summer she returned to Coppet and wrote a pamphlet (*Réflexions sur le procès de la reine*) on the queen's execution. The next year her mother died, and the fall of Robespierre opened the way back to Paris. M. de Staël (whose mission had been in abeyance and himself in Holland for three years) was accredited to the French republic by the regent of Sweden; his wife reopened her salon and for a time was conspicuous in the motley and eccentric society of the Directory. She also published several small works, the chief being an essay *De l'Influence des passions* (1796), and another *De la Littérature considérée dans ses rapports avec les institutions sociales* (1800). It was during these years that Mme. de Staël was of chief political importance. Benjamin Constant, whom she first met at Coppet in 1794, had a very great influence over her, as in return she had over him. Both personal and political reasons threw her into opposition to Bonaparte. Her own preference for a moderate republic or a constitutional monarchy was quite sincere, and, even if it had not been so, her own character and Napoleon's were too much alike in some points to admit of their getting on together. For some years, however, she was able to alternate between Coppet and Paris without difficulty, though not without knowing that the First Consul disliked her. In 1797 she, as above mentioned, separated formally from her husband. In 1799 he was recalled by the king of Sweden, and in 1802 he died, duly attended by her. They had three children: Auguste-Louis, Albert and Albertine, who married Victor, duc de Broglie.

The exact date of the beginning of what Mme. de Staël's admirers call her duel with Napoleon is not easy to determine. Judging from the title of her book *Dix années d'exil,* it should be put at 1804; judging from the time at which it became pretty clear that the first man in France and she who wished to be the first woman in France were not likely to get on together, it might be put several years earlier. In 1802 she published the first of her really noteworthy books, the novel *Delphine.* In 1803 she returned to Paris. She was directed, by order of Napoleon, not to reside within forty leagues of Paris, and after considerable delay she set out, in company with Constant, by Metz and Frankfort to Weimar, and arrived there in December. There she stayed during the winter and then went to Berlin, where she made the acquaintance of August Wilhelm Schlegel, who afterwards became one of her intimates at Coppet. Thence she travelled to Vienna, where the news of her father's death (April 8) reached her.

She returned to Coppet, and found herself its wealthy and independent mistress, but her sorrow for her father was deep and certainly sincere. She spent the summer at the château with a brilliant company; in the autumn she journeyed to Italy accompanied by Schlegel and Sismondi, and there gathered the materials of her most famous work, *Corinne.* She returned in the summer of 1805, and spent nearly a year in writing *Corinne;* in 1806 she broke the decree of exile and lived for a time undisturbed near Paris. In 1807 *Corinne,* the first aesthetic romance not written in German, appeared. It is in fact, what it was described as being at the time of its appearance, "a picturesque tour couched in the form of a novel." The publication was taken as a reminder of her existence, and the police of the empire sent her back to Coppet. She stayed there as usual for the summer, and then set out once more for Germany. She was again at Coppet in the summer of 1808 (in which year Constant broke with her, subsequently marrying a German lady) and set to work at her book, *De l'Allemagne,* which occupied her for the next two years. She decided to publish the book in Paris. The submission to censorship which this entailed was sufficiently inconsistent and she wrote to the emperor one of the unfortunate letters, at once undignified and provoking, of which she had the secret. The reply to her letter was the condemnation of the whole edition of her book (ten thousand copies) as "not French," and her own exile from France. She retired again to Coppet, where she was not at first interfered with, and she found consolation in a young officer of Swiss origin named Rocca, twenty-three years her junior, whom she married privately in 1811.

The operations of the imperial police in regard to Mme. de Staël are rather obscure. She was at first left undisturbed, but by degrees the château itself became taboo, and her visitors found themselves punished heavily. Mathieu de Montmorency and Mme. Récamier were exiled for the crime of seeing her. On May 23, she left Coppet almost secretly, and journeyed by Bern, Innsbruck and Salzburg to Vienna. There she obtained an Austrian passport to the frontier, and, after some trouble, receiving a Russian passport in Galicia, she escaped from Napoleonic Europe.

She journeyed slowly through Russia and Finland to Sweden, making some stay at St. Petersburg, spent the winter in Stockholm, and then set out for England. Here she received a brilliant reception and was much lionized during the season of 1813. She published *De l'Allemagne* in the autumn, was saddened by the death of her second son Albert, who had entered the Swedish army and fell in a duel brought on by gambling, undertook her *Considérations sur la révolution française,* and when Louis XVIII. had been restored, returned to Paris. She was in Paris when the news of Napoleon's landing arrived and at once fled to Coppet, but a singular story, much discussed, is current of her having approved Napoleon's return. There is no direct evidence of it, but the conduct of her close ally Constant may be quoted in its support, and it is certain that she had no affection for the Bourbons. In October, after Waterloo, she set out for Italy, not only for the advantage of her own health but for that of her second husband, Rocca, who was dying of consumption. Her daughter married Duke Victor de Broglie on Feb. 20, 1816, at Pisa. The whole family returned to Coppet in June, and Byron now frequently visited Mme. de Staël there. Despite her increasing ill-health she returned to Paris for the winter of 1816–1817, and her salon was much frequented. She died on July 14, 1817.

Baron Auguste de Staël (d. 1827) edited the complete works of his mother in seventeen volumes (Paris, 1820–21), with a notice by Mme. Necker de Saussure, and the edition was afterwards republished in a compacter form, and, supplemented by some *Oeuvres inédites,* is still obtainable in three volumes, large 8vo (Didot). The *Considérations* and the *Dix années d'exil* had been published after Mme. de Staël's death. Some *Lettres inédites* to H. Meister were published in 1903. There is no recent reissue of the whole, and the minor works have not been reprinted, but *Corinne, Delphine* and *De l'Allemagne* are easily accessible in cheap and separate forms. Of separate works on Mme. de Staël, or rather on Coppet and its society, besides those of MM. Caro and Othenin d'Haussonville, may be mentioned the capital work of A. Sorel in the *Grands écrivains français.* In English there are biographies by A. Stevens (London, 1880), and Lady Blennerhasset (1889).

See also E. Herriot, *Un ouvrage inédit de Mme. de Staël* (1904); P. Kohler, *Mme. de Staël et la Suisse; Etude biographique et littéraire* (Lausanne, 1918); I. Boy-Ed, *Germaine von Staël* (Stuttgart, 1921); H. Glaesener, *La Révélatrice d'un peuple. Mme. de Staël* (1921); D. G. Larg, *Mme. de Staël. La Vie dans l'Oeuvre,* 1766–1800 (1924); O. B. P. G. de Cléron, *Mme. de Staël et M. Necker, d'après leur correspondance inédite* (1925).

STAFF, MILITARY. It was not until the time of Cromwell and his "New Model Army" that we find anything comparable to our modern staff system. The organization of the staff of the "New Model Army" was based on that of the Brandenburg army of Gustavus Adolphus, the forerunner of the Prussian staff of later years. It bears little resemblance to the extensive and specialized staff organization of to-day, but was a great improvement on anything which had preceded it and was well suited to the small numbers and narrow battle fronts with which it had to deal. It consisted of a headquarters under a "Sergeant-Major-General" as chief of staff, and an administrative staff for each of the three commands, infantry, cavalry and train. It contained nothing corresponding to our present organization of a general staff responsible for the preparation of plans and the formulation of orders.

At the beginning of the 18th century and during the War of the Spanish Succession the increasing size of armies rendered it impossible for the commander-in-chief to exercise personal control over the whole of his forces. It was therefore found necessary to decentralize command by the grouping of units into permanent fighting formations called "brigades." At the same time the organization of the staff began to develop as a means of co-ordinating the action of these formations. Marlborough remodelled Cromwell's system and gave to his chief of staff, the "Quartermaster General," wider scope and greater responsibility than had his predecessor, the "Sergeant-Major-General," including administrative arrangements, reconnaissance and the collection of information. A large staff of aides-de-camp and gallopers was employed to convey orders on the battlefield, but these were not staff officers in the modern sense: they were rather the forerunners of our present signal service for the transmission of orders.

In 1760 during the Seven Years' War (1756–1763) Frederick the Great instituted the Prussian new academy and organized a body which he called the "Quartermaster General's Staff"; this latter was primarily responsible for the duties of preparing plans of fortifications and collating and publishing topographical information. The French, following the tendency to further decentralization of command, introduced the divisional organization, afterwards developed by both Wellington and Napoleon.

The Napoleonic Period.—The increase in the size of armies in the Napoleonic wars led to greater sub-division in organization and still wider decentralization of command. Wellington created a staff organization consisting of three branches, the Quartermaster General's dealing with administration, movements, fortification, topography and intelligence, the Military Secretary's dealing with correspondence of a confidential nature and the Adjutant General's dealing with personnel. The Quartermaster General still acted as chief of staff though as such his functions were limited, because Wellington, like Napoleon, was to a large extent his own chief of staff requiring no advice, but merely the machinery to convey orders and arrange routine.

The staff system used by Napoleon was designed by Louvois in 1687 and adapted in 1796 by Berthier, his chief of staff, to Napoleon's special requirements: it was organized as a writing staff, a fighting staff and a riding or liaison staff. Napoleon himself controlled the preparation of plans, reconnaissance and movements, and the conduct of operations; his autocratic military genius required only a confidential clerk of mechanical perfection and reliability, such as was Berthier, to complement it, and he had no use for a chief of staff, as we understand that term. Napoleon's orders were usually issued in the form of instructions which he expected his generals to carry out in the spirit of his intentions; his control was much less rigid than that of Wellington, whose problem was a more limited one and who was also characteristically more chary of decentralization. Napoleon's army, corps and divisional staffs, like Wellington's, consisted chiefly of aides-de-camp of various grades whose principal duty it was to convey orders on the battlefield and also between theatres of war: one such aide-de-camp rode with despatches from Salamanca to Moscow, a distance of over 2,000 m. They were sometimes given command of troops and appointed to govern provinces.

In the Prussian army, on the other hand, marked progress was made towards the realization of a modern staff system, following the defeat by Napoleon at Jena and the Treaty of Tilsit. Scharnhorst in his reorganization of Prussia's military forces was faced by a new problem; the total strength of these forces had been limited by Napoleon to 42,000 men and to circumvent this restriction it was necessary to resort to a short service system which provided large reserves of trained men for the expansion of the army in war. This new idea of a national militia required a highly trained staff to organize and train the man-power of the nation in peace and to mobilize it in war: with what success the demand was met is shown in the victories of 1864, 1866 and 1870. The Congress of Vienna in 1815 ended a period of 20 years of war and was followed by 40 years of peace in Europe, an era of military stagnation. In England no development resulted from the experience gained in continental campaigns and the country was glad to be quit of things military; in fact Wellington only preserved the nucleus of an army by keeping it abroad and out of sight as far as possible.

The Crimean War of 1854 found the British army, in consequence, unprepared and ill-organized. In 1857 a Council of Military Education was set up under the presidency of the commander-in-chief, the Duke of Cambridge; one of its first tasks was to study and define the qualifications necessary for a staff officer. This was followed by the creation of a Staff College with competitive examination as a condition of entrance, the first examination being held in February 1858 and the first course starting in April of that year.

Lessons of 1866 and 1870.—The successes of Prussia in the wars of 1866 and 1870 emphasized the importance of staff work. The development begun under Scharnhorst and Gneisenau had been continued by Clausewitz, Roon and Von Moltke; the latter became Chief of Staff in 1858 and to him is mainly due the organization and training of the Prussian staff of 1866 and 1870. Scharnhorst's rule to the effect that staff officers must return periodically to regimental duty had been adhered to, and this, combined with a sound system of training, had produced a common doctrine throughout the army, which added greatly to its strength and efficiency in war through co-operation and economy of effort.

In France on the other hand there had been a reaction after the Napoleonic wars similar to that which had taken place in England, and the lessons of those wars were neglected. In 1818 an "École d'Etat-Major" was founded, but it provided instruction in the routine of staff duties only, combined with nothing of a higher nature. Officers entered it direct from St. Cyr and the Polytechnique (corresponding to the British Royal Military College and Royal Military Academy) and passed thence to the Staff Corps with which they remained for the rest of their service, a narrow-minded corps apart and out of touch with the troops. Another factor drawing French military thought in a false direction was the conquest of Algeria begun in 1830, a small war against a savage enemy. This kind of fighting came to be considered as typical of all war and the mental outlook and training of the French commanders and staff officers were restricted accordingly. Thus Napoleon had organized corps and grouped corps into an army, but in 1870 the idea of an army did not exist. Napoleon before the battle of Jena in 1806 had moved six corps by three roads at twenty miles a day, billeting in depth; but in 1870 the French corps marched as in savage warfare, closing up on the head at the end of the march, the rate of movement being reduced in consequence to eight miles a day. But fortunately for France there were young men of ability and foresight serving in the army of 1870 and they determined to discover the real cause of the disaster. These men were Bonnal and Lanrezac serving as subalterns, Foch a private in the ranks, and Maillard, later famous for his tactical teaching. They studied deeply the campaigns of Napoleon, and showed how he had applied the principles of war. In 1880 the "Corps d'Etat-Major" was abolished and the "École de Guerre" or Staff College was founded, Maillard being the first professor of strategy. It was recognized that the successes achieved by the Prussians in the wars of 1866 and 1870 had been largely due to their staff organization and training; this led to the adoption, during the last quarter of the nineteenth century, of similar systems by all the military powers except Great Britain and the United States of America.

British Reorganization.—In 1895 the Duke of Cambridge resigned his post of commander-in-chief, and the concentration of military responsibility vested in him was dissipated, leaving the new commander-in-chief, Lord Wolseley, with little authority beyond what was involved in the vague term "general supervision." The supreme management of the affairs of the army devolved upon the Secretary of State for War assisted by several officers of equal status *inter se*. But in 1896 a step forward was taken by the formation of the Defence Committee of the Cabinet, which later became the Committee of Imperial Defence.

After the South African war a special committee, known as the "War Office Reconstitution Committee" was set up in 1903 with Lord Esher in the chair. This committee found that the lack of a trained general staff and the fact that some of the most important duties of such a staff were not assigned to any body of officers gravely prejudiced the conduct of operations in South Africa, and that it therefore attached extreme importance to the constitution of a general staff.

The Committee also advocated the abolition of the office of commander-in-chief instituted by the Duke of York in 1795 and its replacement by a Chief of the General Staff and an Army Council, whose function it would be to control and administer the army in accordance with the policy of the government and to act in an advisory capacity to the Secretary of State for War. These recommendations were adopted, and in February 1904 Lord Roberts, the commander-in-chief, retired and the new Army Council came into being. Its first task was the creation of a general staff charged with the duties of advising on the strategical distribution of the army: supervising its training and preparation for war; collecting and collating military intelligence; directing the general policy of the army and securing continuity of action in the execution of that policy. And so for the first time in British military history the staff became a well balanced organization with two clearly defined functions: on the one side the preparation of plans, training and conduct of operations dealt with by the general staff, and on the other the supply of personnel and material, medical arrangements, transportation and quartering dealt with by the administrative staff which also controls the necessary services such as the R.A.S.C., ordnance, medical and veterinary services. But it is important to note that, although the work is divided into separate branches, there is but one staff with a single purpose, namely to assist the commander when framing his plan and the troops and services in carrying it out. The division of staff duties under the two main heads of operations and administration is now the key-note of the British system.

In 1904, in accordance with another and very important recommendation of the Esher Committee, the Defence Committee of the Cabinet was reconstituted as the Committee of Imperial

Defence, whose function it was to act in an advisory capacity to the government, ensure continuity of policy and co-ordinate the work of all government departments concerned in national defence. Prior to the formation of the Committee of Imperial Defence there existed no precedent for the formation of a council of war, or any standing advisory body to assist the Cabinet in time of peace in matters of national defence. An Imperial Defence Conference was held in 1909 at which it was decided that the general staff at the War Office should be made responsible for advising the government on all matters connected with the defence and military preparation of the Empire as a whole; the Chief of the General Staff became Chief of the Imperial General Staff responsible for the preparation of plans and estimates of the imperial forces required to give effect to these plans.

Following the report of the Esher Committee the staff system was modernized and developed, with the result that at the outbreak of the World War the task of mobilizing the expeditionary force and despatching it to France was carried out with extraordinary smoothness and efficiency. In the field also the new system stood the test and strain of war very well in spite of the difficulty of meeting the demands of the largely expanded army. But, as regards the higher direction of the war, matters did not proceed so smoothly. In its conception in 1904 the Imperial General Staff was designed to have responsibility for providing the government with advice; it was however at first mainly occupied in shaping a policy for the direction of affairs within the army itself and thus failed to study at all adequately its main function in relation to the supreme direction of imperial military policy.

Lessons of the World War.—The resultant lack of co-ordination as between policy and strategy led to great wastage of effort and man-power, and resort to improvisation in the machinery for the direction of the war. To avoid similar mistakes in future it is necessary that there should be a clear definition and understanding of the respective functions of the statesman and his military advisers. Since the Cabinet alone is qualified to co-ordinate and direct the whole strength of the nation in war, it follows that it must exercise the supreme control. The duty of the head of the government is to formulate policy and to ensure that that policy is suited to available means. The duties of the chiefs of the navy, army and air force are to prepare plans for the execution of the policy of the government, to act as professional advisers and to issue the orders required for carrying out the accepted plan; whilst the co-ordination of plans is now provided for in the Chiefs of Staff Sub-Committee of the Committee of Imperial Defence.

Germany also experienced serious difficulties in regard to the supreme direction of the war owing to the fact that the Kaiser was the nominal commander-in-chief of the army and as such took the field. The result of this was that the machinery for the central control of the war became situated at general headquarters on the western front where it could not work effectively in co-operation with the government, whilst it necessitated headquarters themselves being placed too far from the front to be able to control operations. The growth of armies had long rendered the government of a state, whether vested in a sovereign or exercised through other channels, incapable of direct command and even of formulating a military policy; hence the necessity for a professional head of the military executive who could function for the government in adapting the military to the national policy. So long as war was confined to a single theatre and small armies, the professional head might also exercise command in the field, as did von Moltke in practice in 1866 and 1870. When, however, war is waged simultaneously in more than one theatre and by nations in arms, a further expansion in organization is essential.

The study of the broad aspects of the German staff organization and its functions during the World War leads to the following conclusions. The central government must have in immediate touch with it a professional military executive responsible for controlling military policy both as regards plans and the provision of means in men and material to execute those plans. This military executive must implement a policy formulated on the advice of a single individual, whether he be called chief of staff or commander-in-chief. But in each theatre of war there must be a separate commander-in-chief who is in executive control of such forces as are placed at his disposal, and who regulates his action in accordance with the instructions he receives from the central authority. The staff of the commander-in-chief in each theatre of war must be organized in branches corresponding to those of the central staff organization and in direct touch with them in so far as this does not militate against the control exercised by the commander.

Special British Problems.—Continental nations have very clearly defined problems to deal with and can therefore prepare detailed plans and an organization to execute them. With the British, however, it is not possible to do more than provide for the detailed organization of the central authority at home which exists in peace and should not require any change in war; the detailed composition and organization of command and staff in the field must be dependent upon the particular conditions of operations which cannot usually be foreseen. Consequently the system must be such as to be easily adaptable to whatever demands may be made upon it.

That the organization of the British staff in the field during the World War was sound in principle is shown by the fact that it was not necessary to make any material changes in spite of the enormous expansion of the army and the imposition of new duties through the remarkable progress of modern science as applied to war. This organization consisted at general headquarters of a staff divided into three branches, the general staff branch under a chief of the general staff dealing with operations, intelligence and training, the Adjutant-General's branch dealing with personnel, discipline and the medical service and the Quartermaster-General's branch dealing with supply and transport. Each of these principal staff officers had the right of direct access to the commander-in-chief in all matters appertaining to his branch, whilst the chief of the general staff was responsible for co-ordinating the work of the three branches in accordance with the policy laid down by the commander-in-chief. The same system was applied in lower formations except that the functions of the Adjutant-General and the Quartermaster-General were combined in one staff officer.

The alternative to this system is that adopted in other armies including those of the United States of America, France, Germany and Japan, namely a chief of staff responsible not only for co-ordination of the work of the various branches of the staff, but also for its execution. The objections to this system are that the chief of staff becomes a "bottle-neck" prejudicing the right of access to the commander of branches and departments and forced to devote a great deal of his time and attention to administration at the expense of operations and training. The advantages claimed for it are that the commander-in-chief has only one staff officer with whom he deals direct, instead of three or four, as in the British system; and, since the army cannot fight without supplies, that the chief of staff is responsible for both operations and maintenance; in practice, however, there is an inevitable tendency for him to become overloaded with detail.

It will be seen therefore that there is a fundamental difference between the British staff system and that of other armies; in the former, operations and administration are dealt with separately, whereas in the latter they are combined under a chief of staff. Judged by experience, the British system by which the senior staff officer in each branch has direct access to the commander and the senior general staff officer is responsible only for co-ordination of the work and not for its execution, is the one best suited to British requirements and temperament; and that it can be applied successfully was amply proved in the World War; where failures occurred, as in Mesopotamia and Gallipoli, they were due to non-observance of the principles of staff organization rather than to any fault in the scheme of organization itself.

Mainly as a result of developments in mechanization since the war it has been decided to effect certain changes in the British staff organization at general headquarters. This will now consist of a Chief of the General Staff, a deputy Adjutant-General, deputy

Quartermaster General and deputy Master General of the Ordnance. Thus there will be now four principal staff officers instead of three, and each, as formerly, has the right of direct access to the commander-in-chief in matters relating to the respective branches, the work of the staff as a whole being co-ordinated, as necessary, by a deputy Chief of the General Staff. The cause and effect of these changes are briefly as follows. The four military members of the Army Council are the Chief of the Imperial Staff, the Adjutant General, Quartermaster General and Master General of the Ordnance: of these the Chief of the Imperial General Staff has the peculiar responsibility of adviser to His Majesty's Government in all matters affecting the military policy of the British Empire, and in this capacity he cannot be represented at general headquarters in the field; there is therefore a Chief of the General Staff at these headquarters, and the other three military members are represented by deputies, who deal directly with their chiefs on the Army Council in departmental matters. The addition of a deputy Master General of the Ordnance is principally due to the demands of mechanization. At the War Office responsibilities in connection with maintenance are divided between the Quartermaster General and the Master General of the Ordnance: in the field, however, there has hitherto been no representative of the latter at general headquarters: consequently the whole responsibility for maintenance has rested with the Quartermaster General in addition to that of movement. Though this centralization has certain advantages, it now tends through the increasing demands of mechanization to exceed the scope of a single principal staff officer and his branch. A further advantage of having a representative of the Master General of the Ordnance at general headquarters in war is that he acts as the link between the field army and the Ministry of Munitions or other body dealing with research and experiment at home. Following on these changes a certain reallotment of duties as between the Quartermaster General and the Master General of Ordnance at the War Office has been effected. The re-allotment of duties leaves the control of all transport by sea, rail, road and inland water under the Quartermaster General. The division of responsibility in the matter of maintenance places under the Quartermaster General the provision of accommodation, remounts, supplies of food, forage, fuel and petrol, and responsibility for all duties in connection with engineer services and barrack construction; while the Master General of Ordnance is responsible for providing clothing and equipment, guns, ammunition and vehicles of all types.

The air forces of the Great Powers, except Britain, France and Italy, are an integral part of the navy and the army and are administered as an arm of the service and not as a separate service; therefore there is no special air staff organization. In the British air force the work of the staff is controlled by three principal staff officers dealing respectively with air, personnel and equipment. Each of these officers has the right of direct access to the commander, the co-ordination of their work being vested in the senior air staff officer. The staff is assisted by advisers, whose specialized technical knowledge is at their disposal.

See Bronsart von Schellendorf, *Duties of the General Staff* (1875–76); H. Spenser Wilkinson, *The Brain of an Army* (1895); *British Field Service Regulations Part I.;* W. R. Robertson, *Soldiers and Statesmen* (1926); F. B. Maurice, *Governments and War* (1926); A. R. Godwin-Austen, *The Staff and the Staff College* (1927); W. G. Lindsell, *A and Q or Military Administration in War* (1928); *Official report of the Dardanelles Commission* (1917–19); J. H. Boraston and G. A. B. Dewar, *Sir Douglas Haig's Command* (1922); J. F. C. Fuller, *The Foundations of the Science of War* (1926); J. von Falkenhayn, *G.H.Q., 1914–16, and its critical decisions* (1919); E. Ludendorff, *My Memoirs* (1919); J. de Pierrefeu, *G. Q. G.* (1920, Eng. trans., 1924).

(B. C. T. P.)

THE UNITED STATES

The President, by virtue of his office being commander-in-chief of the Army of the United States, exercises control thereof through the secretary of War, who, with the aid and advice of the chief of staff, is responsible for the efficiency of the military establishment. Under the secretary of War, command is exercised by corps area and department commanders, commanders of independent activities and commanders of the various tactical units. The staff does not exercise command. While the army had no general staff prior to 1903, it has invariably had an administrative staff, whose strength and composition has varied according to needs. Under the secretary of War and the various commanders, the administrative staff has performed staff duties pertaining to administration, inspection, discipline, supply, pay, medical attendance and sanitation.

Under the National Defence Act of 1920, the administrative staff corps and departments authorized are: The adjutant general's department, the inspector general's department, the judge advocate general's department, the quartermaster corps, the finance department, the medical department, the ordnance department and the chemical warfare service. The headquarters of each corps area or territorial department and of each tactical unit down to include the division is provided with representatives of each of the staff corps or departments named. At the headquarters of stations and at the headquarters of tactical units below the division where representatives of the various staff corps or departments are not provided, other staff officers or officers of the line detailed for that purpose perform the necessary administrative staff duties.

Prior to 1903, the army was commanded, under the secretary of War, by the commanding general of the army. His command did not extend to the supply departments, and the chief of each supply department reported directly to the secretary of War. There was no officer nor body of officers charged with co-ordinating the work of the staff departments with the work of the line, nor was there any officer or body of officers whose principal duty it was to prepare plans for the national defence. The necessity for such a body of officers, charged primarily with co-ordinating and planning, was clearly demonstrated during the Spanish-American War, and, as a result, the act of Feb. 14, 1903, authorized the War Department general staff. Under its initial organization, it consisted of three divisions. From 1903 until 1917, as the result of the limited experience which could be gained in peace-time, many changes were made in the organization during its process of development. During the World War, as necessity demanded, many further changes were made in it, and the present general staff, organized under the provisions of the National Defence Act of 1920, is the result of that experience.

The National Defence Act prescribes that the duties of the War Department general staff shall be to prepare plans for national defence and the use of the military forces for that purpose, both separately and in conjunction with the naval forces, and for the mobilization of the manhood of the nation and its material resources in an emergency, to investigate and report upon questions affecting the efficiency of the Army of the United States, and its preparedness for military operations; and to render professional aid and assistance to the secretary of War and the chief of staff. It is the agency for preparing the plans and policies under which the administrative and command agencies operate.

The chief of staff, the deputy chief of staff, 5 assistant chiefs of staff, and 87 other officers, compose the War Department general staff over which the chief of staff presides. He prepares the necessary plans for the use of the military forces for national defence and upon approval of such plans by the secretary of War, is charged with the supervision necessary to make them effective. Each assistant chief of staff is the head of a division and has authority to make decisions for the secretary of War within certain limitations. The personnel division (G-1) is charged with those duties which relate to the personnel of the army as individuals. The military intelligence division (G-2) is charged with those duties which relate to the collection, the evaluation and the dissemination of military information. The operations and training division (G-3) is charged with those duties which relate to the organization, training and operation of the army. The supply division (G-4) is charged with those duties which relate to the supply of the army. The war plans division is charged with those duties which relate to the formulation of plans for use in the theatre of war of the military forces, separately or in conjunction with the naval forces.

The organization of the War Department general staff is such that some of the officers who had been engaged in the formulation and preparation of plans of operation could take the field in time of war and could be utilized as general staff officers with troops to supervise the execution of these plans. This could be accomplished without disrupting the entire staff, as was done when the United States first entered the World War.

As distinguished from the War Department general staff, the National Defence Act prescribes that the general staff with troops shall perform the general staff duties of the headquarters of territorial departments, armies, army corps, divisions and brigades, and shall render professional aid and assistance to the general officers over them. It shall also act as their agents in harmonizing the plans, duties and operations of the various organizations and services under their jurisdiction, in preparing and supervising detailed instructions for the execution of the plans of the commanding generals. At the headquarters of each corps area and department and of each tactical unit authorized to have a general staff, the general staff is divided into four sections corresponding to the first four divisions of the War Department general staff. (C. P. Su.)

STAFF, NAVAL. All the principal navies of to-day have a body of officers specially charged with war plans, operations, intelligence and the policy to be adopted in such professional matters as training, design of warships, naval aircraft and armament.

In the British Navy the Naval Staff at the Admiralty (*q.v.*) consists of the Chief of the Naval Staff, who is the First Sea Lord, the Deputy Chief of the Naval Staff, the Assistant Chief of the Naval Staff, together with the directors and officers of the various staff divisions. The latter include: operations, plans, intelligence, trade, gunnery, torpedo, training and staff duties, together with the naval air and tactical sections.

At sea, the commander-in-chief has a staff which includes a chief of staff, captain of the fleet, staff officers for operations, gunnery, torpedo, signals, wireless, intelligence, aviation, physical training, engineering, accountancy, medical duties and education. Flag officers in command of divisions or squadrons have a smaller number of staff officers, certain duties being combined or omitted where they are carried out in the fleet flagship. In addition every admiral has a personal staff consisting of his flag lieutenant (A.D.C.) and secretary.

Previous to the World War, although Britain had the largest and most powerful navy of any nation and in consequence was regarded as being a leader in naval enterprise, both the Admiralty and the fleet were singularly deficient in a properly organised staff. This may be attributed in part to the influence of traditions emanating from the days of the sailing navy, when communications were slow and primitive and once an admiral was out of sight of land he was thrown entirely on his own resources and had to act as circumstances arose or as emergency rendered necessary.

Even in more modern times, unfortunately, a school of thought developed which was definitely antagonistic to the idea of a naval staff. As late as the outbreak of the World War there were to be found a number of flag officers of distinction who resented the suggestion that they could be assisted in the execution of their command by comparatively young officers who, it seemed to them, would be usurping some of the functions of an admiral.

The influence of this reactionary school of thought continued to dominate Admiralty policy in this matter until, in 1911, the matter was brought to a head by the discovery that the Admiralty had one lot of war plans and the War Office another, and that these were by no means attuned. In 1912, Winston Churchill, as First Lord, initiated the principle of a Naval Staff. The resignation of the then First Sea Lord, Admiral of the Fleet Sir Arthur Wilson followed. Incidentally this marked the end of the "one-man" régime. With his retirement, too, may be said to have disappeared the habit of intense secrecy, a habit which led to most dangerous ignorance of strategical plans and tactical intentions in the minds of those not in the innermost confidence of the high command.

In spite of the sound decision to create a naval staff, it could not be said that great progress had been made in this direction by August 1914. True there was a Chief of the Naval Staff, a Director of Operations, and from time to time, if the need arose, additional staff appointments were created, while at sea the commander-in-chief of the Grand Fleet and other admirals in important commands, had a number of officers on their staffs. But for the most part the officers in these Admiralty Departments and on the admirals' staffs at sea were untrained in staff work, while many flag officers, both ashore and afloat, had never learned how to use a staff. With traditional adaptability and with that ability to extemporise which comes from sea training, the navy met each and every emergency as it arose, sometimes successfully, but sometimes buying experience at great cost, until ultimately victory came. But one of the outstanding lessons of the World War from a naval point of view was the necessity for not only training officers to fill numerous minor staff appointments, but also to educate those destined for higher command in the use of a staff.

By 1928 the Naval Staff College at Greenwich was engaged in turning out year by year officers trained for duty on admirals' staffs at sea or for the lower staff appointments at the Admiralty, and already this training is beginning to make itself felt as Staff College graduates are beginning to reach more senior rank.

The old antipathy towards a naval staff has died down, and most flag officers to-day make use of their staffs as a matter of course in the same way that general officers in the army have done for many years past. At the Admiralty (*q.v.*) there is a fully-equipped staff, the head of which is the First Sea Lord (Chief of the Naval Staff), whose business it is to study the problems of defence and to prepare in advance for any emergencies which may arise. This staff also forms the nucleus of the far larger organisation which the World War proved to be necessary on the outbreak of hostilities. Incidentally, too, it provides the necessary machinery for close co-operation with the staffs of the other two fighting Services. The three professional heads of those Services meet from time to time as a Chief of Staffs Committee, where matters are discussed and joint proposals formulated in preparation, if need be, for meetings of the Committee of Imperial Defence (*see* NAVAL STRATEGY AND TACTICS).

Apart from its other advantages, the staff system, as it works to-day at the Admiralty, provides a body of officers whose energies are not absorbed by questions of material and supplies, these being dealt with by other departments. Nevertheless, even here there is the necessary co-ordination to ensure that plans, preparations, construction and supplies should march hand in hand. (E. A.)

United States.—An act of Congress of Feb. 14, 1903, created a General Staff Corps and provided for the appointment of a Chief of Staff of the U.S. Army. No similar corps or Naval Staff has ever been authorized for the U.S. Navy, but an act of Congress of March 3, 1915, provided for the appointment of a Chief of Naval Operations specifically charged, under the direction of the Secretary of the Navy, with the operations of the fleet and with the preparation and readiness of plans for its use in war. In a general way the Chief of Naval Operations holds a position in the naval establishment corresponding to that of the Chief of Staff of the Army, but there are many and important differences in the duties and responsibilities of these two officers. The Chief of Naval Operations is appointed by the President by and with the consent of the Senate for a term of four years. The position carries with it the rank of admiral and precedence over all other officers in the naval service.

The Chief of Naval Operations is charged under the Secretary of the Navy with the organization, operation and training of the fleet and its readiness for war. He co-ordinates matters relating to repairs, alterations, docking, manning and outfitting of ships, and determines their military characteristics. He prepares war plans, drill books, signal codes and naval regulations. He directs movements, manoeuvres, strategical and tactical matters, drills and exercises. He advises on the position, capacity and protection of navy yards, naval stations, fuel reserves, radio stations and other reserves and supplies. He handles naval matters touching on foreign relations and performs other duties as set forth by naval regulations, or as directed by the Secretary of the Navy.

In order to carry on the varied and detailed duties imposed on the Chief of Naval Operations his office is divided into a number of divisions or sections whose functions are indicated in a general way by their designations as follows: policy and liaison, war plans, naval intelligence, naval districts, fleet training, material, ships' movements, inspection, naval communications and secretarial. Each of these sections or divisions is headed by a flag officer or captain of the line of the Navy except the Secretarial Division which is in charge of the Chief Clerk of Naval Operations. A flag officer is detailed as Assistant Chief of Naval Operations. In addition to the immediate activities outlined above, the Chief of Naval Operations has general cognizance over the Naval War College at Newport, R.I., and is a member of the Joint Army and Navy Board, the Advisory Council of the Secretary of the Navy, and senior member of the General Board.

The Chief of Naval Operations is not the Chief of the General Staff in the sense that such an officer is found in the organization of certain other naval powers, although he performs many of the duties that would ordinarily fall to such an officer. For instance, the Chief of Naval Operations is not superior to the chiefs of bureaux and independent offices of the Navy Department, although he takes precedence over them by virtue of his rank. He is not, in fact, a link in the chain of command between the Secretary of the Navy and the chiefs of the various bureaux of the Navy Department who have the right, and freely exercise it, to consult the Secretary directly on matters concerning their bureaux, as well as to receive instructions directly from him.

When trying to compare the office of the Chief of Naval Operations with that of the U.S. War Department General Staff, it is to be remembered that the Chief of Naval Operations actually directs and controls the Navy and the larger part of his duties are administrative whereas the Chief of Staff of the Army acts largely in an advisory capacity.

The General Staff Corps of the Army is a separate and distinct staff organization whose officers are detailed to duty therein for a term of four years. General Staff officers may serve in the War Department General Staff or on the staff of commanders of troops. There is no similar corps in the Navy, the officers on duty in the Office of the Chief of Naval Operations and serving on the staffs of flag officers ashore and afloat being detailed to this duty in the same manner as to any other duty.

The differences between the staff organizations of army commanders in the field and of naval commanders afloat are even more marked than in the departmental organizations. Officers of naval staffs are usually selected by the flag officer whom they serve, any officer available and acceptable to the flag officer being eligible for such assignment. The number composing a staff depends primarily on the nature of the command, varying from one or more officers to as many as twenty. Quarters and office space required for staffs, being additional to that normally required for the ship's complement, are extremely limited. For this reason the size of a staff must be reduced to a minimum and, therefore, the assignment of duties to individual staff officers is governed to a very large degree by the personal qualifications of the various officers of the staff. This assignment of duties tends to obliterate clear-cut lines of demarcation between fixed divisions of staff cognizance and produces overlapping in the duties of individual officers. Close supervision and co-ordination of staff activities by the Chief of Staff and whole-hearted co-operation between staff officers is essential to the smooth and efficient performance of the work of a large staff. (C. F. H.)

STAFFA (Norse for staff, column, or pillar island), uninhabited island of the Inner Hebrides, Argyllshire, Scotland, 54 m. W. of Oban by steamer, about 7 m. from the nearest point of Mull, and 6 m. N. by E. of Iona. It lies almost due north and south, is ¾ m. long by about ⅓ m. wide, and its highest point is 135 ft. above sea-level. In the north-east it shelves to a shore, but otherwise the coast is rugged and much indented with numerous caves. During the tourist season it is visited regularly by steamer from Oban. In section the isle has first a basement of tufa, from which rise, secondly, colonnades of basalt in pillars forming the faces and walls of the principal caves, and these in turn are overlaid, thirdly, by a mass of amorphous basalt. On the south-east coast is the Clam-shell or Scallop cave. It is some 130 ft. long, and on one side of it the ridges of basalt stand out like the ribs of a ship. Near this cave is the rock of Buachaille ("The Herdsman," from a supposed likeness to a shepherd's cap), a pile of columns, fully seen only at low water. On the south-west shore are the Boat cave and Mackinnon's or the Cormorants' cave. Fingal's cave, the most famous, situated in the southern face of the isle, is 227 ft. long. On its western side the pillars are 36 ft. high. The cave is the haunt of seals and sea birds.

STAFFORD (Family). This famous English house was founded in England by Robert, a younger brother of Ralf de Tosny (Toeni), of a noble Norman house, who was standard-bearer of the duchy. Robert received at the Conquest a great fief extending into seven counties and became known as Robert de Stafford from his residence at Stafford castle. With his son the male line became extinct, and his sister's husband, Hervey Bagot, one of his knightly tenants, succeeded to the fief in her right (1194); their descendant Edmund de Stafford (that surname having been assumed) was summoned as a baron in 1299. His son, Ralph, conducted the brilliant defence of Aiguillon against the host of France, fought at Crecy and in the siege of Calais. Chosen a Knight of the Garter at the foundation of the order, he was created earl of Stafford in 1351.

His son Hugh, who succeeded as 2nd earl in 1372, served in the French wars. From 1376 he became prominent in politics, probably through his marriage to a daughter of the earl of Warwick, being one of the four lords on the committee in the Good Parliament, and also serving on the committee that controlled Richard II. (1378–80), whom he accompanied on his Scottish expedition in 1385. He died next year on pilgrimage at Rhodes. His son, Thomas, the 3rd earl, married in 1392 the daughter and heiress of Thomas, duke of Buckingham (son of Edward III.), who, on Thomas's death, married in 1398 his brother Edmund, the 5th earl. Their son, Humphrey (1402–1460), the first Stafford duke of Buckingham, was placed by his descent and his possessions in the front rank of the English nobility.

Henry, the 2nd duke, was attainted in 1483, but on the triumph of Henry VII. in 1486 Edward, the 3rd duke (1478–1521), regained the title and estates, and recovered the ancestral office of lord high constable in 1509. He was accused of treason and, after a nominal trial by his peers, was beheaded on May 17, 1521, a subsequent act (1523) confirming his attainder.

Henry (1501–1563), the son of the last duke, was granted by the Crown some of his father's manors for his support, and, espousing the Protestant cause (though married to a daughter of Margaret, countess of Salisbury and sister of Cardinal Pole), was restored in blood on Edward VI.'s accession and declared Lord Stafford, as a new creation, by act of parliament. His second surviving son, Thomas, eventually assumed the royal arms, sailed from Dieppe with two ships in April 1557, landed at Scarborough, seized the castle, and proclaimed himself protector. He was captured and executed for high treason. His father's new barony, in 1637, passed to a cadet in humble circumstances, who was called on, as a pauper, to surrender it to the king, which he did (illegally, it is now held) in 1639. The king thereupon bestowed it on Mary Stafford (the heir general of the line) and her husband, William Howard, in whose descendants it is now vested. Roger, who had surrendered the title, died in 1640, the last heir male, apparently, of the main line of this historic house.

See Dugdale, *Baronage* (1675), vol. i.; G. E. C(okayne), *Complete Peerage;* Wrottesley, *History of the Family of Bagot* (1908) and *Crecy and Calais* (1898). The important Stafford mss. in Lord Bagot's possession are calendared in the 4th Report on Historical mss., and the Salt Arch. Soc.'s collections for the history of Staffordshire are valuable for early records. Harcourt's *His Grace the Steward and the Trial of Peers* (1907) should also be consulted. The bishop of Exeter's Register was edited by Hingeston-Randolph in 1886. *Papers relating to the two Baronies of Stafford* (1807), and Campbell's *The Stafford Peerage* (1818) are useful for the pedigree, and there are collections for a history of the family in Add. mss. (Brit. Mus.).

STAFFORD, market town, county town, municipal borough, Stafford parliamentary division, Staffordshire, England, on the river Sow, a tributary of the Trent. Pop. (1921) 28,635. An important junction on the L.M.S. railway and 133½ m. N.W. from London, it is also served by the L.N.E. and G.W. railways. The town, while largely modernized, contains a number of picturesque half-timbered houses. The church of St. Mary, once collegiate, with its canons mentioned in Domesday, shows transitional Norman, Early English and Decorated styles. The complete foundation is attributed to King John. It contains a memorial to the famous angler, Izaak Walton, born at Stafford (1593). The older church of St. Chad contains good Norman details, but is chiefly a reconstruction. The William Salt library, presented in 1872, has a large collection of books and mss. relating to the county.

Stafford (*Stadford, Staffort, Stafforde*) is said to have originally been called Betheney from Berthelin, a hermit who lived here. In the Anglo-Saxon Chronicle it is stated that Aethelflead, lady of the Mercians, in 913 built a fort at Stafford, and a mint existed here in later Anglo-Saxon times. Stafford is a borough in Domesday Book, and the chief place in the county. The king received all dues, two-thirds as king, the other third as earl of Stafford. From the Domesday Survey it appears that the Conqueror built a castle at Stafford; this was destroyed in the wars of the 17th century. The existing ruin of Stafford Castle is that of an unfinished mansion (1810), which replaced the old stronghold. Beyond it is an early encampment, Bury Ring. A charter from John (1206) constituted Stafford a free borough.

STAFFORDSHIRE, a midland county of England, bounded by Derbyshire, Leicestershire, Warwickshire, Worcestershire, Shropshire and Cheshire. The area is 1,158·3 square miles. The county may be divided into three geographical divisions, north, middle and south Staffordshire, depending on the geological structure. The highest land is in the north. Here the southern ends of the Peak folds bring up Lower Carboniferous rocks, with limestones in the north-east and the Pendleside shales and Coal-Measures forming four basins in the north-west and centre. The district is drained by the headwaters of the Trent and its tributaries the Dove, Hamps, Manifold and Churnet and shows a diversity of scenery, the limestone hills being domed and treeless, whilst the Pendleside shales form heather-covered moors, and the grit bands have bold scarp faces. Axe Edge (1,756 ft.), and the Roaches are the highest hills, being formed by Millstone Grit. The four coal-basins are the Pottery, Cheadle, Shaffalong and Goldsitch Moss coalfields. The last two are small and contain only the lowest coal-measures and are no longer worked. The Pottery and the Cheadle basins are more important and contain valuable seams of coal. The Bunter sandstones of the Cheshire plain overlap the coal-measures in the west of the Pottery basin.

Middle Staffordshire is a broad undulating plain, occupied by various members of the Triassic series and drained by the Trent. The plain is divided into an eastern and a western portion by Cannock Chase, formerly a royal preserve, now an important coalfield concealed beneath a cover of glacial sands and gravel which rest upon Bunter sandstone. The high ground rises to about 500 feet. The "Black Country" occupies the greater part of South Staffordshire. Here again the country is low and undulating covered on its margins by the Trias whilst in the middle lies the South Staffordshire coalfield, in which there are several small inliers of Silurian rocks which stand up above the surrounding country to a height of 800 feet. Most of the county is drained by the river Trent, a few streams drain into the Dane which flows into the Mersey, whilst a small area in the west and south-west forms part of the Severn drainage system. The only considerable sheet of water is Aqualate Mere on the Shropshire boundary.

Staffordshire is an important coal-mining county. The Southern coalfield has an estimated reserve of 1,415 million tons and the northern coalfields 4,460 million tons. The latter contains the valuable black-band ironstones which are of commercial importance, and a smaller amount of iron is mined in the south where, however, there are important quarries for road metal.

History and Early Settlement.—Although remains of Palaeolithic man have been found in the Derbyshire caves over the border, no finds are known from Staffordshire itself. Neolithic implements, especially round barrows and Beaker pots of later date are found almost entirely and in fairly large numbers in the north-east section of the county. In early times this region must be considered as part of the Peak district of Derbyshire. In the remainder of the county there are isolated finds of Bronze, notably palstaves at Brewood, Biddulph, Bushbury and Stretton, a bronze sword at Alton Castle and a leaf-shaped spear-head at Yarlet. These isolated finds serve to indicate the beginnings of movement along the valley ways and the importance of the roads around the hills into Wales and the west. In Roman times Letocetum just south of Lichfield was the most important settlement.

In the 6th century a tribe of Angles settled about Tamworth, afterwards famous as a residence of the Mercian kings. Later the invaders advanced beyond Cannock Chase. The district was frequently overrun by the Danes, and it was after Edward the Elder had finally expelled the Northmen from Mercia that the land of the south Mercians was formed into a shire around the fortified burgh which he had made in 914 at Stafford. The county is first mentioned by name in the Anglo-Saxon Chronicle in 1016.

The resistance which Staffordshire opposed to the Conqueror was punished by ruthless harrying and confiscation, and the Domesday Survey supplies evidence of the depopulated and impoverished state of the county. The five hundreds of Staffordshire have existed since the Domesday Survey, and the boundaries have remained practically unchanged. The shire court for Staffordshire was held at Stafford, and the assizes at Wolverhampton, Stafford and Lichfield, until by act of parliament of 1558 the assizes and sessions were fixed at Stafford.

In the wars of the reign of Henry III. most of the great families of Staffordshire, including the Bassets and the Ferrers, supported Simon de Montfort, and in 1263 Prince Edward ravaged the lands of Earl Robert Ferrers and destroyed Tutbury Castle. During the Wars of the Roses, Eccleshall was for a time the headquarters of Queen Margaret, and in 1459 the Lancastrians were defeated at Blore Heath. In the Civil War of the 17th century Staffordshire supported the parliamentary cause, but Tamworth, Lichfield and Stafford were garrisoned for Charles, and Lichfield Cathedral withstood a siege in 1643.

Much of Staffordshire in Norman times was waste land, but the moorlands of the north afforded pasturage for sheep, and in the 14th century Wolverhampton was a staple town for wool. In the 13th century mines of coal and iron are mentioned at Walsall, and ironstone was procured at Sedgeley and Eccleshall. In the 17th century the north of the county yielded coal, lead, copper, marble and millstones, while the rich meadows maintained great dairies; the woodlands of the south supplied timber, salt, black marble and alabaster; the clothing trade flourished about Tamworth, Burton, and Newcastle-under-Lyme; and hemp and flax were grown in the county. The Staffordshire pottery industry is of early origin, but was improved in the 17th century. It has been greatly extended in modern times.

Architecture.—The most important churches are the beautiful cathedral of Lichfield, and the churches of Eccleshall, Leek, Penkridge, St. Mary's at Stafford, Tamworth, Tutbury and St. Peter's at Wolverhampton all of which are described elsewhere. Checkley, 4 m. south of Cheadle, shows good Norman and Early English details. Armitage south-east of Rugeley, has a church showing good Norman work. Brewood church, 4 m. south-west of Penkridge, is Early English. Audley church, north-west of Newcastle-under-Lyme, is a good example of Early Decorated work. The remains of the Cistercian abbey of Croxden, north-west of Uttoxeter, are fine Early English, and at Ranton, west of Stafford, the Perpendicular tower and other portions of an Augustinian foundation remain. Among mediaeval domestic remains are the castles of Stafford, Tamworth, Tutbury and Chartley. Beaudesert, south of Rugeley, is a fine Elizabethan mansion in a beautiful undulating demesne. In the south-west, near Stourbridge, are Enville, a Tudor mansion, and Stourton Castle.

Agriculture and Industries.—About three-quarters of the total area of the county is under cultivation, and of this three-quarters is in permanent pasture, cattle being largely kept, and especially cows for the supply of milk to the towns. Like most of the midland counties Staffordshire is well wooded.

The southern industrial district, the Black Country (*q.v.*), is the main seat in England of iron and steel manufacture in all its branches. It covers an area, between Birmingham and Wolverhampton, resembling one great town, and includes such famous centres as Walsall, Wednesbury, Dudley (in Staffordshire) and West Bromwich. The northern industrial district forms the Potteries (*q.v.*); Cheadle east of the Potteries, is the centre of a smaller coalfield; Burton-upon-Trent is famous for its breweries. Chemical works are found in the Black Country and at Tunstall, glassworks at Tutbury; there are also a considerable textile industry, as at Newcastle-under-Lyme, paper mills in that town and at Tamworth, manufactures of boots and shoes at Stafford and Stone, silk and artificial silk at Leek and other manufactures in the county include rubber goods, and motor cars.

Communications.—The main line of the L.M.S. railway runs from south-east to north-west by Tamworth, Lichfield (Trent Valley), Rugeley and Stafford. This company and the Great Western serve the towns of the Black Country by many branches from Birmingham, and jointly work the Stafford-Shrewsbury line. The L.M.S. has branches from Trent Valley to Burton-upon-Trent, and from Rugeley through the Cannock Chase coalfields, from Stafford and from Burton-upon-Trent northward through the Potteries, with a line from Uttoxeter through Leek to Macclesfield. The west and north line of the L.M.S. (Bristol–Derby) crosses the south-eastern part of the county from Birmingham by Tamworth and Burton with a branch to Wolverhampton. The L.N.E. serves Uttoxeter, Burton and Stafford. A considerable amount of coal transport takes place along canals, the Black Country especially being served by numerous branches.

Population and Administration.—The area of the ancient county is 749,602 acres with a population (1921) of 1,348,877. The area of the administrative county is 741,318 acres. Staffordshire contains five hundreds, each having two divisions. It contains 6 county boroughs and 5 municipal boroughs. The county boroughs are:—Stoke-on-Trent, Wolverhampton, Walsall, Smethwick, Burton-on-Trent and West Bromwich; and the municipal boroughs are:—Lichfield, Newcastle-under-Lyme, Stafford (county town) Tamworth and Wednesbury. There are 26 urban districts which are:—Ablecote, Bilston, Brierley Hill, Coseley, Darlaston, Heath Town and Wednesfield Heath, Perry Bar, Quarry Bank, Rowley Regis, Sedgeley, Short Heath, Tettenhall, Tipton, Wednesfield, Willenhall, Audley, Biddulph, Kidsgrove, Smallthorne, Wolstanton, Brownhills, Cannock, Leek, Rugeley, Stone and Uttoxeter. Among other towns may be mentioned Abbots Bromley, Brewood, Cheadle, and Eccleshall. There are two cities in the county, Stoke-on-Trent and Lichfield. The county is in the Oxford circuit, and assizes are held at Stafford. The county is mainly in the diocese of Lichfield, but has small parts in those of Worcester, Hereford, Southwell and Chester.

Staffordshire is divided into seven parliamentary divisions each returning one member, Burton, Cannock, Kingswinford, Leek, Lichfield, Stafford and Stone. The parliamentary boroughs of Stoke-on-Trent and Wolverhampton return one member for each of three divisions, and the boroughs of Newcastle-under-Lyme, Smethwick, Walsall, Wednesbury and West Bromwich each return one member. The county and parliamentary boroughs return in all 18 members.

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STAGE, in architecture, an elevated floor, particularly the various storeys of a bell-tower, etc. The term is also applied to the plain parts of buttresses between cap and cap where they set back, or where they are divided by horizontal strings and panelling. It is, too, the floor or platform on which plays are acted, whence the term has come to signify both the theatre (*q.v.*) and the drama (*q.v.*). *See* also Stage Design, below. From its etymological meaning of a station comes the sense of a place for rest on a journey, the distance between such places, etc.

STAGE DESIGN. Until about 1900 the pictures created on any stage, generally known as scenery, had no relation to the feeling for form, colour, composition or light which art from 1850 to 1900 had made a common possession. The picture of the world within the theatre was invariably dull, without illusion and rigidly painted,—painted, in fact, with the same merciless and metallic precision which led Manet to exclaim before one of Meissonier's paintings of charging cuirassiers, "Everything is of steel except their breast-plates." Trees stood invariably in regimental rows and their foliage hung in separate parallel layers above their trunks. The walls of hovels or palaces reminded the most careless eye that they were merely painted canvas; the sky flapped, an obviously painted sheet. The ugliness of the total result was all the more glaring because, in an age of realistic playwriting, actors were using every artifice they possessed to make an audience feel that they were Russian or Silesian peasants, Norwegian town councillors, or English clergymen and poets. Every word in the theatre was trying to convince its hearers that what they saw was not actors, but human beings in a world as real as the one they had just left to enter the theatre; that people "were like that"; that life had this significance and that meaning. But everything on the stage reminded the audience that, after all, what they were seeing was a play in a thoroughly artificial place, the theatre, that had no relation to life. Even when a poet held the stage the result was equally ludicrous. It was difficult for the singers of Wagner to transport an audience to the beginning of the world, where the gods were deciding the destiny of men, when everything about them seemed an enlarged landscape done in chromolithograph. Mary Garden wandered in a park that had neither magic nor mystery, in the supposed gloom of palace halls as bland as lithographs of English country houses, current in the '50s. Any symbolism that might have lurked in Maeterlinck's fairy tale of the terror and foreboding of young love was dissipated; and Mélisande's cry "I am not happy" seemed less a comment on the state of her soul than on the preposterous stage settings that surrounded her.

The inadequacy of this type of scenic background, so prevalent at the turn of the century, did not lie alone in its artificiality nor in the fact that it was an obvious and flimsy convention. Artificiality and the conventions of formally painted designs, as proved by the work of Inigo Jones, Bérain and the Bibienas, can breed beauty in the theatre just as easily as the same tradition in the 19th century bred ugliness. The reason for the change which makes painted scenery in one epoch enhance the meaning of the play and in another detract from it, is our changed attitude towards the theatre. The creative dramatists of the past 40 or 50 years, whom for convenience sake we may call modern, such as Ibsen, Shaw, Hauptmann, Chekov and Strindberg, Synge and O'Neill, are modern in the sense that one and all they do not regard the theatre as a place of pure entertainment. And they have succeeded so well that though we may still go to the theatre merely to be amused, we also go to watch a play with the same expectation with which we open a novel treating of modern life—in the hope of seeing more clearly into the springs of character, of getting a fresh sense of human destiny.

The Modern Scenic Movement.—The blatant dissonance between modern plays that were attempting to reconceive a world and scenic backgrounds that merely reflected the conventions of a purely theatrical theatre, was so preposterous that it could not endure. For that reason, directors of modern theatres in every country in Europe, beginning with Germany, and finally in the United States, enlisted painters or designers to make the world on the stage the world of the play. This is the genesis of the so-called modern scenic movement. It arose, not because modern art already existed, but because it became essential to the theatre in order to quicken the reactions of the audience until the world the dramatist asked them to believe in had the plastic reality of a world before their eyes or the imaginative quality of a poet's dream. The source of modern scenery has not been dogma. It did not arise because Gordon Craig prophesied that only screens could back a stage; modern scenery would have occurred whether or not Craig had ever existed or penned a line. He, however, was one of those who prophesied that a change must come and that stage settings must be designed to interpret the play they housed. Every manner and method of modern painting, has, with the aid of some mechanical device, been put to work in the theatre: the plaster dome, in conjunction with the flexibility of incandescent lamps which made the painted sky seem a heaven and filled the stage with all the ambient light of day; the spot-light, manipulated to create the chiaroscuro of Daumier; light mixed with colour in the manner of Monet and Seurat making colour vibrate, and achieving the atmosphere of the impressionists, or enmeshed in gauze, giving the atmosphere of Whistler's nocturnes. Every technique of modern art has been exploited, whether of impressionism, post-impressionism, cubism or futurism. However, from the point of view of pictures constructed within the proscenium frame of the theatre, almost every method at one time or another, in the hands of a particular director and in conjunction with the methods of his actors, has succeeded in convincing an audience and projecting the interpretation of a dramatist's ideas.

The point needs stressing because the history of modern scenery is usually regarded from the point of view of a mere chronology of begetting, and is continued in the strain of prophecy. A designer reading any of the current histories of his art would feel that the entire problem before him was the choice of a style. And the value to him, as a craftsman, of almost all discussions of the subject, is hereby rendered nil. The theatre, it is supposed, is about to be re-created, purged of evil, saved and given its final form if he, the designer, only makes the right choice; screens, a stage without curtains, scenery made of nothing but curtains, a circus theatre where the actor can mingle with the audience, scenery that is only light, scenery that is merely symbolic colour, scenery that is wooden trestles, and so on, depending upon which method at the moment has had the latest critical success in Europe. It is essential for the scene designer to avoid this critical approach if he wishes to analyse the basis of his craft. For whatever his preferences may be as a painter, he will find that the moment he sets out to design stage settings his problem is everywhere the same. He will find the problem of relating a particular play to a particular audience, the problem, as conceived by the director, of how the meaning of that play can be put over the footlights, and dramatized for that audience. His methods will be deduced not from any abstract aesthetics of the theatre but from the exigencies of that particular situation. For not all his convictions as to why imitation and realism is a defunct method will prevent George Bernard Shaw from continuing to write plays so provocative that they must be acted in country-house gardens, Salvation Army barracks and physicians' consulting rooms, for which the designer will have to build the walls, find the furniture and even evoke the flowers. On the other hand, not all the dogmas in the world as to the value of realism will prevent Shaw, or any other playwright, from reconstructing Antony's adventure in Egypt or Adam's adventure in the Garden of Eden, for which there is an equally avid audience; and the designer will have to find a decorative equivalent for the sphinx, or some symbolic equivalent of the tree of knowledge. And whether theatre audiences are those of London, Prague, Berlin or Warsaw, the designer will find that they came to the theatre to share experiences that are not their own, so that in the course of a single season the designer may have to help in making plausible the romantic scruples of a Hungarian schoolboy or a Hungarian servant, the feudal scruples of Japanese noblemen, the political dogmas of Slavonic revolutionists, the moral codes of American revolutionists and Russian peasants.

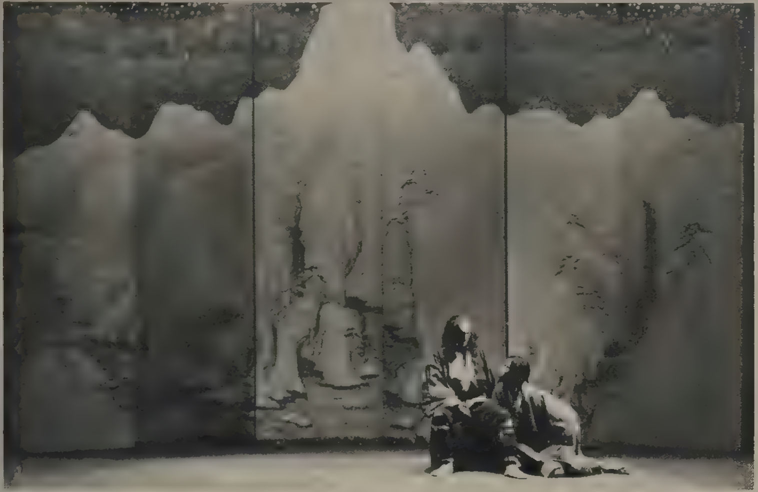
Staging of "The Faithful."—Some of the problems of scenic design as worked out by the present writer at the Guild theatre of New York, although not final in any sense as examples of theatre art, are typical of the problems which every stage designer must face in order to evolve design, whatever the pattern he may ultimately adopt. *The Faithful*, by John Masefield, tells the story of 47 Ronin, retainers and henchmen of a Japanese nobleman, tricked by a rival into committing an affront to the emperor's person for which the only expiation was suicide; of the voluntary exile of these Ronin as pariahs, and their final triumph over their dead master's enemy. It is a poet's celebration of the nobleness of loyalty. What is the producer's problem? Obviously something more than to demand poetic background for a poetic play, because the tale of the 47 Ronin, as much of a household story in Japan as Washington and the cherry-tree in America, is totally unfamiliar to Western audiences. He can count on no background in the audience's mind. But Japan is the background which he must create decisively five minutes after the curtain is up, for the reason is that the unforgivable act committed was nothing more than a mistake in ritual, a failure of ceremonial observance, not to the emperor himself, but vicariously to the emperor's person as personified by his envoy. The rigid code of Japanese feudalism is a tradition difficult for Westerners to conceive. The danger is that they will find it, if not preposterous, at least not plausible, so that they cannot identify themselves with the hero. The problem here is that to an audience not composed of orientals or members of Japanese societies, the normal reaction would be "Stab oneself because of a mistake in court etiquette? How preposterous! What a trivial people."

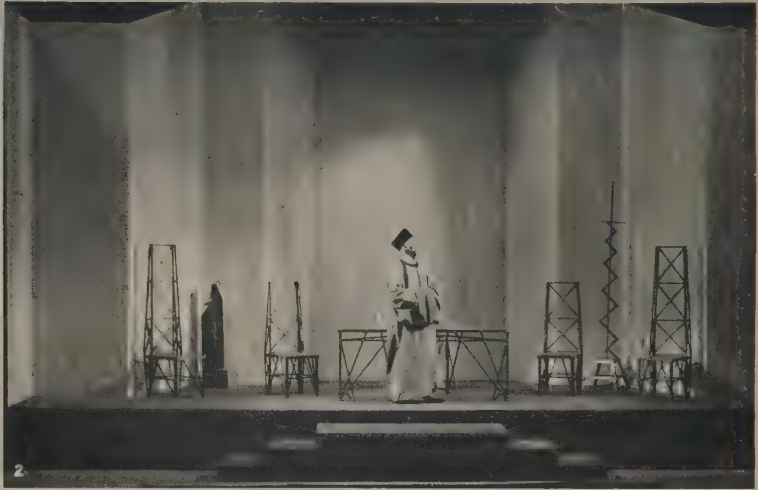
The playwright cannot solve this problem in the many ways that are offered to the novelist; he has no preliminary chapters or incidental comment to prepare the mind of his audience, as his story proceeds, to make them understand the rigid Samurai code of honour and accept the tragic alternatives imposed on its adherents. Aware of this problem, the designer finds, in making his first researches into the field of Japanese costume and architecture, that ritual ruled not only court etiquette but all Japanese life of the period, to the most trivial detail. Everything is prescribed and ordered; the degree to which the head is shaved, and the degree to which the hair is looped forward on the head; the precise way the obi or white silk belt is tied that holds the pleated skirt in place; the length of the sleeves, as well as the cut of the gown. Everything is ordered ceremonial, even the squares of the matting, the placing of the sword in its rack, the one picture niche where the solitary landscape scroll is shown and the way the single group of flowers is arranged under it. There are in the simplest acts, of receiving a friend and taking tea in his presence, countless opportunities of outraging him by breach of etiquette.

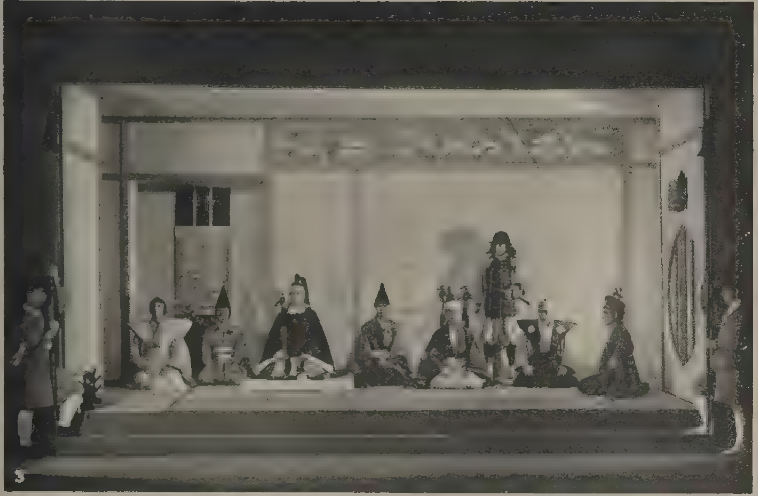
In a world of this sort, it begins to be comprehensible that a mistake in court etiquette could involve the death penalty. Hence every effort—and here the producer co-operates—is made to convey the ceremoniousness of the Japanese feudal world, in the gait of the actors, their gestures, their genuflections, the mode of entering or leaving a room. A Japanese is found to train them; he ties every obi, adjusts every costume, sets every hat and wig. The room which is the opening scene of the play is almost archaeological in its accuracy, and the line of every costume is established with realistic nicety and with an attention to correct cut and material that could hardly be outdone by the Moscow Art theatre. In short, realism as a method is employed in order to make a poetic theme plausible.

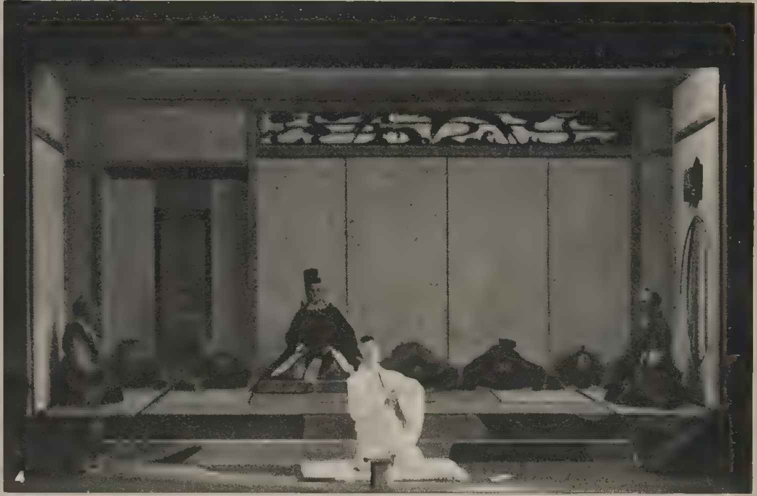
On the other hand, once the world of the Samurai is realized, and the tragedy is enacted, there is no further need of such realistic devices. The ragged Ronin wander in the snow, but the snow may be the snow gorges of Japan, painted upon a six-fold Japanese screen, without diminishing either the reality or the suffering of these outlaws. Here a deliberately decorative method seems the inevitable choice. Japanese landscape is known to Western audiences through the popularization of Japanese prints. A screen setting evokes this purely decorative pictorial tradition and suggests the countryside of Japan far more effectively than any attempt to reconstruct it realistically. Thus meticulous realism and deliberate decoration can be employed simultaneously in the same play, and for the same purpose. As pictures the snow scenes are far more effective (*see* Plate I.). But in the theatre the palace scene (*see* Plate I.) was far the more important of the two. For if that scene succeeded in conveying Japan effectively to the audience, the world of the Japanese could be taken for granted for the rest of the evening. A white sheet and the shadowgraph of a few pine boughs might have done just as well for the winter hills. This instance reveals how superficial it is to codify stage sets according to purely pictorial principles.

Staging of "Liliom."—Molnar's *Liliom* presents an analogous problem of transplantation, not from one century to an-





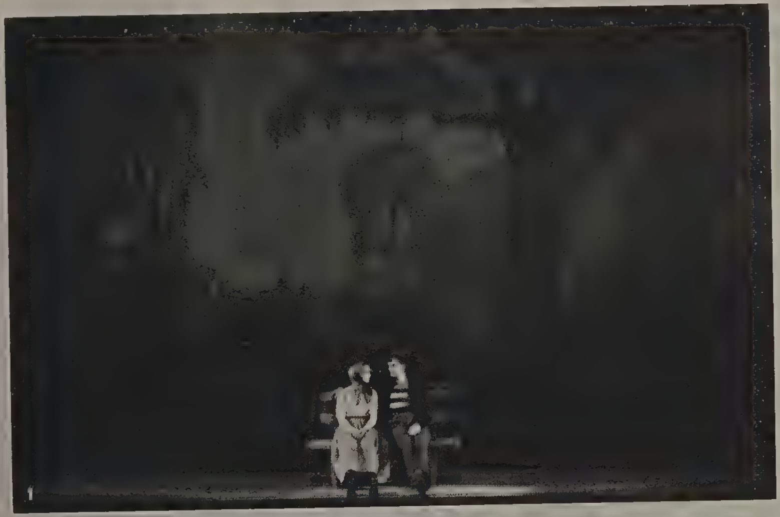


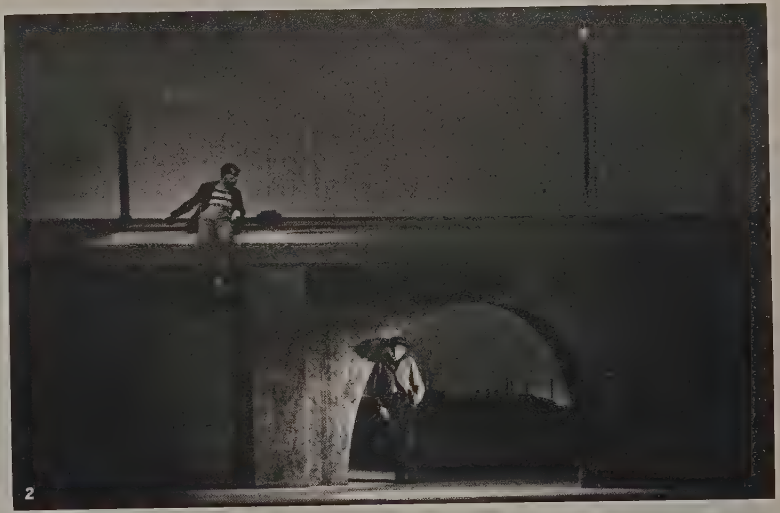


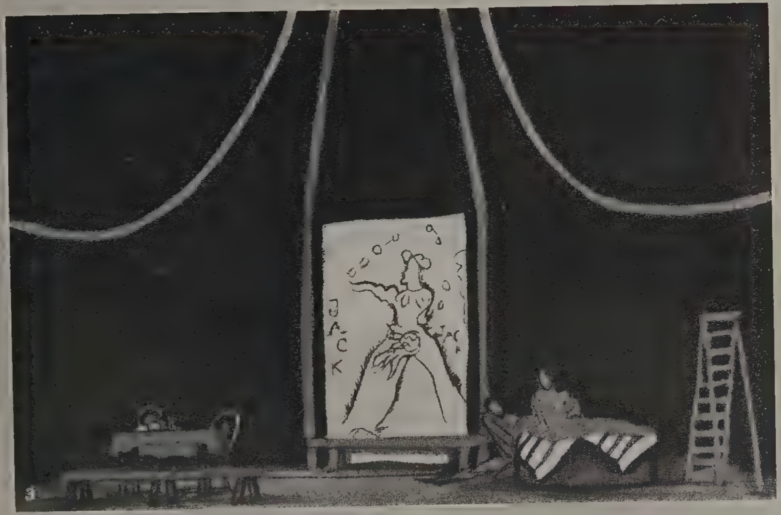
SETTINGS DESIGNED BY LEE SIMONSON FOR PRODUCTION BY THE THEATRE GUILD, NEW YORK; PHOTOGRAPHS, (1-4) BRUGIERE

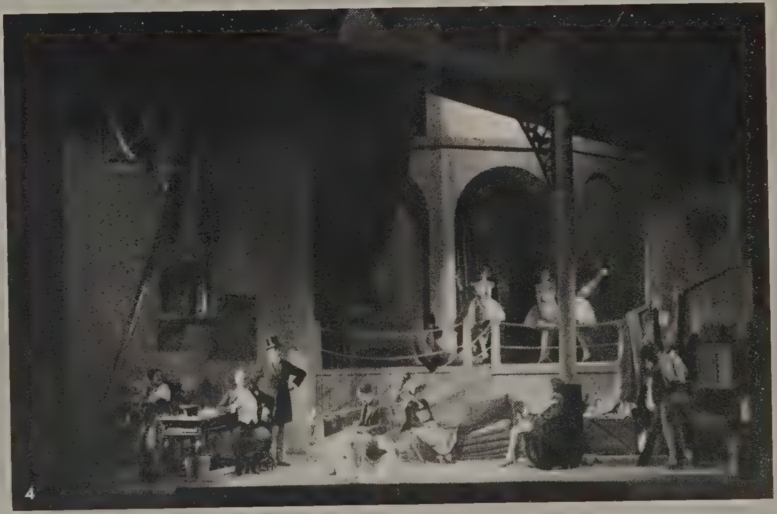
THE USE OF SCREENS AND AN EXAMPLE OF DRAMATIC LIGHTING

1. Snow scene formed by a painted six-fold Japanese screen. In "The Faithful" by John Masefield
2. Office of the prime minister, A.D. 2170, a setting in which screens are used as a background. In "Back to Methusaleh" by Bernard Shaw
3. Reception of the Imperial Envoy in "The Faithful." The snow screen was placed directly in front of the opening, making an out-of-door scene without shifting the main set
4. Suicide of the hero in "The Faithful." The setting is the same as that in fig. 3, the change, suggestive of a more tragic mood, being effected by means of lighting





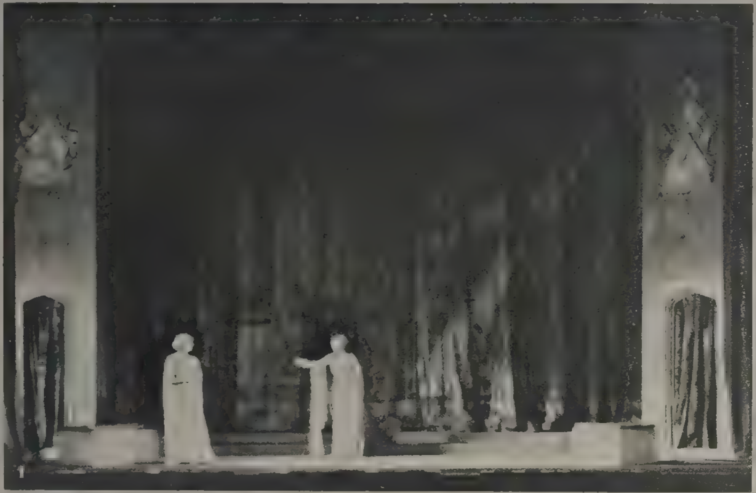




BY COURTESY OF (3) ROBERT EDMOND JONES, IN "CONTINENTAL STAGE CRAFT" (HARCOURT BRACE); PHOTOGRAPHS, (1, 2, 4) BRUGIÈRE; DESIGNS, LEE SIMONSON

ATMOSPHERIC AND PLASTIC REALISM AND VARIETIES OF INTERPRETATION

1. Park scene in Molnar's "Liliom," made by tree forms silhouetted on transparent gauze
2. The railroad bridge, a plastic setting in "Liliom"
3. A formal setting for George Pitoeff's production in Paris of "He Who Gets Slapped." The stage is draped in black curtains against which red curtains, looped from the proscenium arch, suggest a circus tent. The circus poster in the centre, changed from act to act marks the point of entrance and exit
4. Realistic setting used for the Theatre Guild Production of "He Who Gets Slapped"



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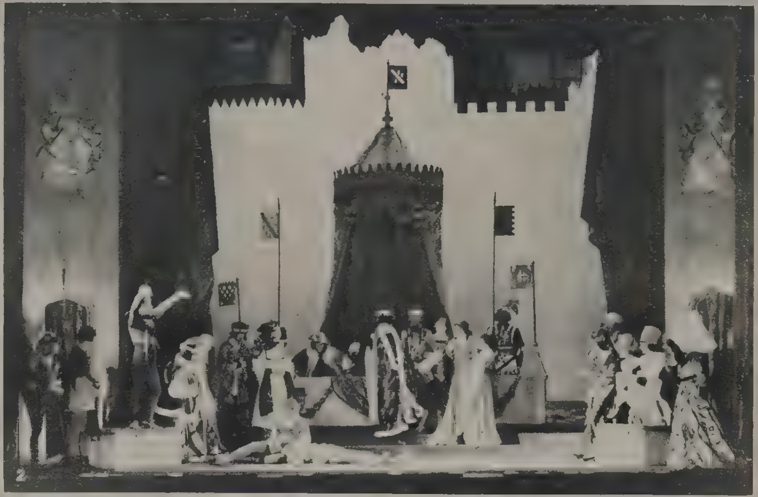

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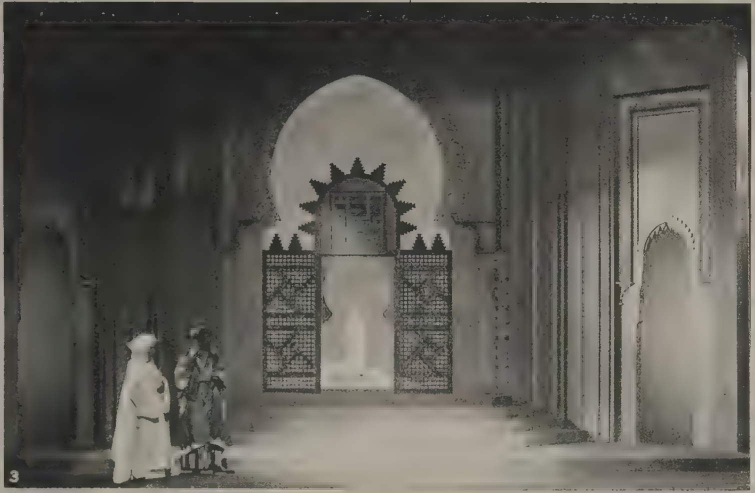

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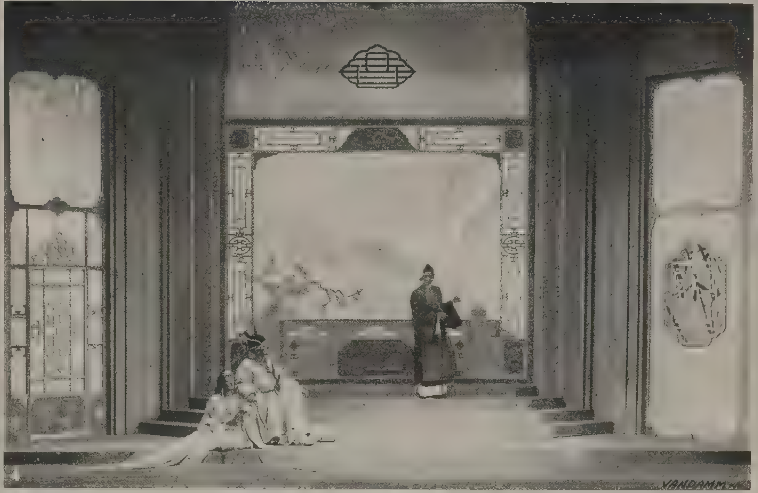

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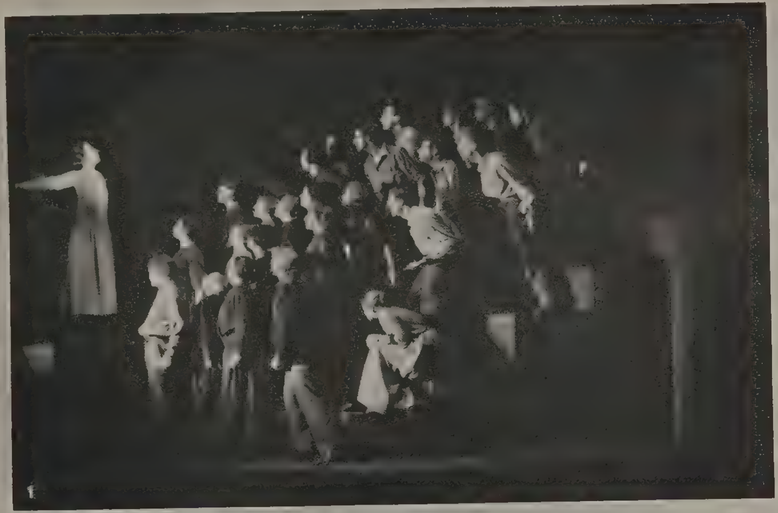
PHOTOGRAPHS, (1, 2) BRUGIÈRE, (3, 4) VANDAMM; DESIGNS BY LEE SIMONSON

THE UNIT SETTING

1. Palace scene in Act I. of "As You Like It"
2. The tournament scene in "As You Like It." The shift has been accomplished by draping back the centre curtains
3. Morocco in Eugene O'Neill's, "Marco Millions"
4. China in "Marco Millions." The scene shift is made by changing three panels in the permanent portals of the frame



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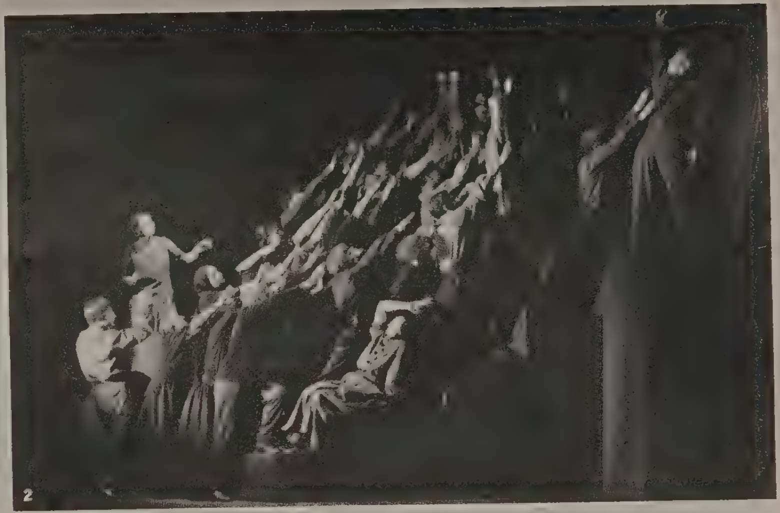

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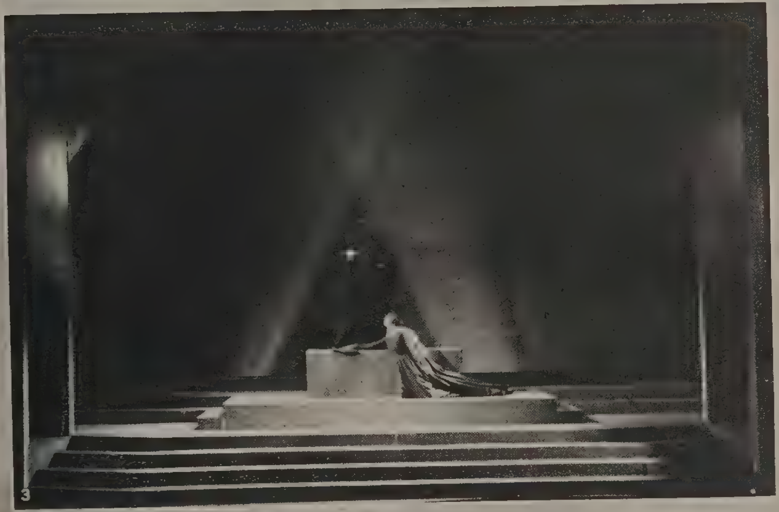

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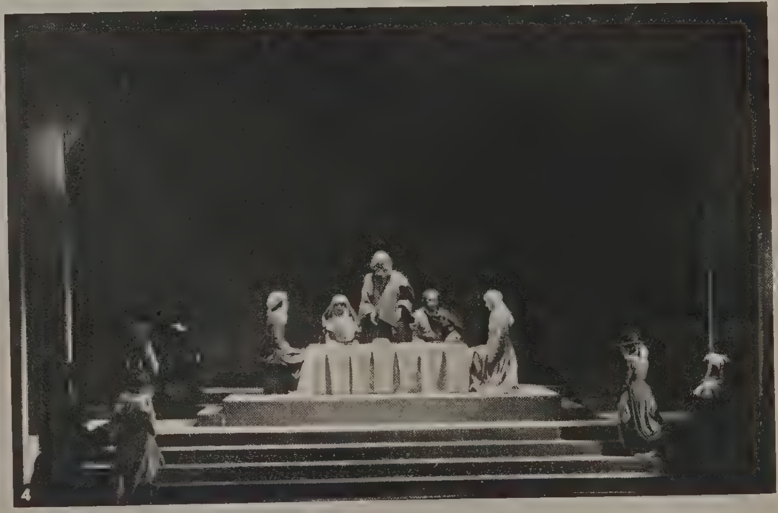

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PHOTOGRAPHS, (1, 2, 3, 4) BRUGIERE; DESIGNS, (1, 2, 4) LEE SIMONSON, (3) LEE SIMONSON AND F. KOMISSARJEVSKY

THE ABSTRACT SETTING

1. Scene from "Man and the Masses," an example of the formal stage in which mass movement of the actors creates the design
2. Revolution scene in "Man and the Masses," a complete change of mood and design by a change of mass action
3. The miracle in "Tidings Brought to Mary," a play in five acts by Paul Claudel presented throughout on the same platform with changes in lighting only
4. The farewell supper in "Tidings Brought to Mary"

other but from one country to another at the same period. The producer's problem in Liliom was, in essence, that his story deals with the creed of a gangster and a "tough" who is fundamentally romantic. Liliom falls genuinely in love with the servant, Julie, and evinces a belief in "the eternal feminine" worthy of a latter-day Faust. He is transported by the prospect of fatherhood. When he stabs himself rather than be captured by the police in an attempted hold-up that fails, his last cry is "Julie . . . my little girl . . . my little cricket." When, after facing the judgment of heaven and ten years' probation, he returns to earth as a beggar for an opportunity to win redemption, he steals a star to give to his daughter, and then in a moment of exasperation beats her, as he formerly beat her mother. The child cries "he hit me . . . but I didn't feel anything—as though someone had stroked my hand . . ." "Nothing has happened" her mother assures her, divining who the beggar is, "it is possible, my child, for someone to hit you—so that you don't feel any pain." Liliom is not forgiven in heaven; he is redeemed on earth by the persistence of human compassion. The beauty of the final scene made the play at the Guild theatre an allegory, the vindication of a romantic faith, and dictated the scenery. The play was something more than the story of a foreign underworld; its realism was made an ironic cloak for poetic truth. Thus the amusement park where Liliom flourished as a bully was made as authentically Hungarian as possible, so that the audience might accept the reality of a romantic gangster and not reject him as a maudlin invention. On the other hand, precisely because the play seemed important as an allegory because of its poetic truth, the tawdry squalor of Liliom's surroundings had to be invested with beauty, even the tumbledown shack in which he lived. And the railroad embankment, where he attempted his hold-up and met his death, was composed with some of the dignity and severity appropriate to tragedy.

Scene 2 represents the park where Liliom falls in love. The point is that, bully, seducer and braggart though he is, he does fall genuinely in love. He is transfigured and the moment becomes as beautiful for this Hungarian hooligan and a kitchen maid as it does for all lovers. Therefore, the park where they meet must be made beautiful. The hour is dusk, when, as Whistler reminded us, "the evening mist clothes the riverside with poetry as a veil, and the tall chimneys become campaniles, and the warehouses are palaces in the night and the whole city hangs in the heavens"; the "exquisite hour" as Verlaine calls it. Therefore the problem for a designer was to clothe that park with poetry as with a veil; with tree silhouettes hung on transparent gauzes (*see* Plate III.); putting into those tree silhouettes all the grace and the loveliness appropriate to the trees of a pastoral bower destined to arch over young lovers. Had the scene been one of cynical seduction, this quality of tenderness and brooding would have been irrelevant.

Scene 6 represents heaven. Liliom sees heaven in terms of the police courts with which he is familiar. He can conceive of no other bar of judgment; heaven is merely the last police court presided over by a police-court judge; the attendant angels are to his eyes only detectives and policemen. The stage directions emphasize the fact by stating that their costume is the usual police uniform. Nevertheless, Liliom has died; he is in heaven awaiting eternal judgment. If the play is to be properly interpreted this seat of judgment cannot be the proverbial heaven with a celestial throne. On the other hand, if the allegory of the play is to be made plain it cannot be shown simply as a police court. This dilemma was solved by making the scene as far as Liliom's eye ranged a drab room, with the ordinary judge's bench at one end; but the solid walls ended at the wainscoting and window frames. Beyond that was emptiness; the room sat without walls or roof under a blue sky as illimitable as stage light could make it. By this combination of realism and fantasy, the reality of heaven was established for the audience, and at the same time the fact was made clear that to Liliom its judgments were no different from what he had experienced on earth. These four scenes from two plays entirely different in type demonstrate how contradictions of realism and decoration in stage pictures are determined by problems of dramatic interpretation and not primarily by pictorial considerations. The picture is a result of a conviction as to what the meaning of a play is and how it can be reflected in pictorial form.

The Method of Abstraction.—Settings that eliminate the stage picture entirely are designed for the same reason and by the same process. *The Tidings Brought to Mary,* by Paul Claudel, was played on the same platform for its entire five acts, which according to the stage directions take place in a barn, a farm kitchen, an orchard and a road at the edge of a forest. Fedor Komissarjevski, the director, chose the unit platform because he felt that the play was mediaeval not only in its story but in its quality. It was a mystery, couched in the mystic faith of a truly mediaeval catholicism. A single square block served as a bench and, covered with a formal cloth, as a supper-table and an altar (*see* Plate IV.). The orchard became eight nuns clothed in Byzantine splendour, each holding a branch of silver flowers, who stood in a remote semi-circle. The sky behind them at this moment became green to suggest the foliage of out of doors. For the road-side scene at night, the same backdrop became the inky blue of a wintry night spangled with a few stars. And a cold steel-blue light thrown over the platform gave the illusion of winter snow. For the miracle the sky blazed forth gold, like the background of a 14th century mosaic, and aureoled the actors. The same intention was carried through the costumes: many were mediaeval French, but others—those of the father and mother—were clad in the traditional robes of early religious paintings, so that the mother had a suggestion of the Mother of Christ, the father, of one of Christ's disciples, and in its formal grouping, the supper of farewell suggested an apostolic meal.

In *Man and the Masses,* by Ernst Toller, the formal platforms became almost invisible. The settings were made wholly by the massing and the movement of the actors. The human beings on the stage provided all the scenery that was needed, for the play was conceived as an abstract allegory. One leader who tries to limit the workers to the bloodless methods of a general strike, is called simply The Woman. The agitator who incites them to revolution is called The Man. Though the workers are supposedly in their union hall, their angry indictments of capitalistic society are chanted in unison as a formal chorus. How could this meeting be placed in a realistic setting of an actual union headquarters, without making such formal choruses seem ridiculous? The title literally translated is "mass-man." The force of Toller's conception is his vision of mass-man. The working-men are a single stubborn unit, welded together in resentment and anger, from which only voices of the young and the old emerge to cry, threaten and lament. If a group of 30 or 40 actors on the stage are to give this feeling of mass power, they cannot be scattered, they cannot move about much; they must be welded. Hence a stage setting was devised that was a literal cross-section of an amphitheatre; the players never moved from the spot where they were wedged; they rose with waving arms and clenched fists to face The Woman, who pleaded with them (*see* Plate IV.); they towered over her; she was below them, supplicating. When this compact mass of 30 actors stood they seemed to represent "the masses"; it seemed that they could sweep down on The Woman and overwhelm her. Then The Man sprang out of their midst and slowly backed up step by step to the top of the amphitheatre. As his eloquence grew they swung slowly round, looking up towards him, turning their backs on The Woman as they ignored her pleas. Finally, at the moment when they were won over to a doctrine of violence, they were a solid mass, crouching under him waiting to spring; as he cried "revolution" they took one step up, the only step they took in the entire act, and lunged together like a huge beast, echoing his cry "revolution." Each one had turned completely round during the scene without once moving from the spot on which he or she stood. They remained a mass, and by a single mass movement expressed their change of faith.

Varieties of Interpretation.—The designing of scenery is thus never a purely pictorial problem; it is part and parcel of the act of interpreting a play. Whether a designer chooses abstraction or realism, a picture-stage which imitates the world as we see it in rooms with the fourth wall knocked out into which we peep, or a formal stage which symbolizes the world, is in itself a relative thing. The method of design chosen is only good even from a pictorial point of view provided it touches the imagination of an audience, and really convinces it of the truth and reality of the play. Setting the play is only part of the process of acting it so as to give it dramatic force; no method, however beautiful it is as a picture, is the right method if it fails to convince an audience; and there are as many types of audience as there are kinds of play. No play has only one meaning; it can mean all things to all men. The imagination of the director must decide and the pictorial imagination of the scene designer must second him. If you can make your audience accept Liliom's story as a modernistic fairy-tale, an allegory from the outset, Pitoev's method of presenting it in clear hard formal outline is the right one. If the play means more as a story in which the allegory is implicit, then the more realistic method of the Theatre Guild is better; similarly with *He Who Gets Slapped* (*see* Plate II.). To compare the two one would have to sit through the two productions as played by two different casts.

There is no one way of producing any play, even classic masterpieces. In fact every one, whether Euripides or Shakespeare, has to be constantly re-interpreted, in order to become relevant and remain living. If Shakespeare's characters seem important as figures rescued from an actual historic past then the elaborate and exact costuming of the Duke of Saxe-Meiningen or Henry Irving is not only necessary but effective. To one audience, which conceives them primarily as creatures of Shakespeare's time, the bare boards of the Elizabethan stage will make them live more completely. To another audience, particularly sensitive to Shakespeare's word-magic, formal scenery, even a single curtain, is enough. To a German audience, for whom much of the poetry is lost in translation, more pictorial backgrounds are necessary, into which that lost glamour must be projected. But to both German and American audiences for whom Shakespeare's protagonists are imaginative figures living in the world of the imagination, they become most real when part of an unreal world, a forest of dyed strips of tapestry or gauze (Barker's production of *A Midsummer Night's Dream* and Reinhardt's production of the same), or a blood red stairway (Jessner's production of *Richard III.*), or among golden screens (Craig's production of *Hamlet* with Stanislavski at the Moscow Art theatre). And if the tragedy of Hamlet begins to seem too remote and archaic to us, we can make him a human being, for certain audiences, by putting him in modern dress. The art of scene designing is a living art because it can find no final formula. It will live precisely as long as it can discover new meanings in every play of every epoch. Scenery is the background of a play, and as such is part of the continuous adventure of projecting the meaning of a play across the footlights, finding, firing, and then fusing the imagination of an audience. And that adventure will always be a different one in every country and every epoch.

Structural Innovations.—The technical and structural changes which determine the design of modern scenery are two: first, the modern theatre, in contrast to the 18th century theatre, has become an extremely shallow box; second, that black box can be completely flooded with electric light, modulated and controlled. The theatres of the late 17th and 18th century fixed the architectural type of our theatres, which with changes of ornament and the depth and arrangement of balconies is the type still prevalent to-day. But there is one vital difference: the proportion of the space occupied by the stage in relation to the space occupied by the audience in the auditorium. The 18th century stage averaged in depth 1 to 1½ times the depth of the auditorium pit, and was rarely less than 75 feet. To-day, the stage, except in opera houses and foreign State theatres, is rarely more than ⅓ the depth of the auditorium, and averages at the best 25 to 30 feet.

Moreover the 18th century stage was carefully calculated to enhance painting in perspective. The stage floor sloped up. The side flats receded until the rear of the stage was very near the true vanishing point, so that an alley of trees or an avenue of columns receded very much as they would in nature. But on the stage of to-day the spectators are looking into a space so shallow that any illusion of depth is difficult to attain. In an average production there is rarely more than 8 to 10 ft. from the garden wall to the distant mountains; often there can be only 4 or 5 ft. from a window to the sky.

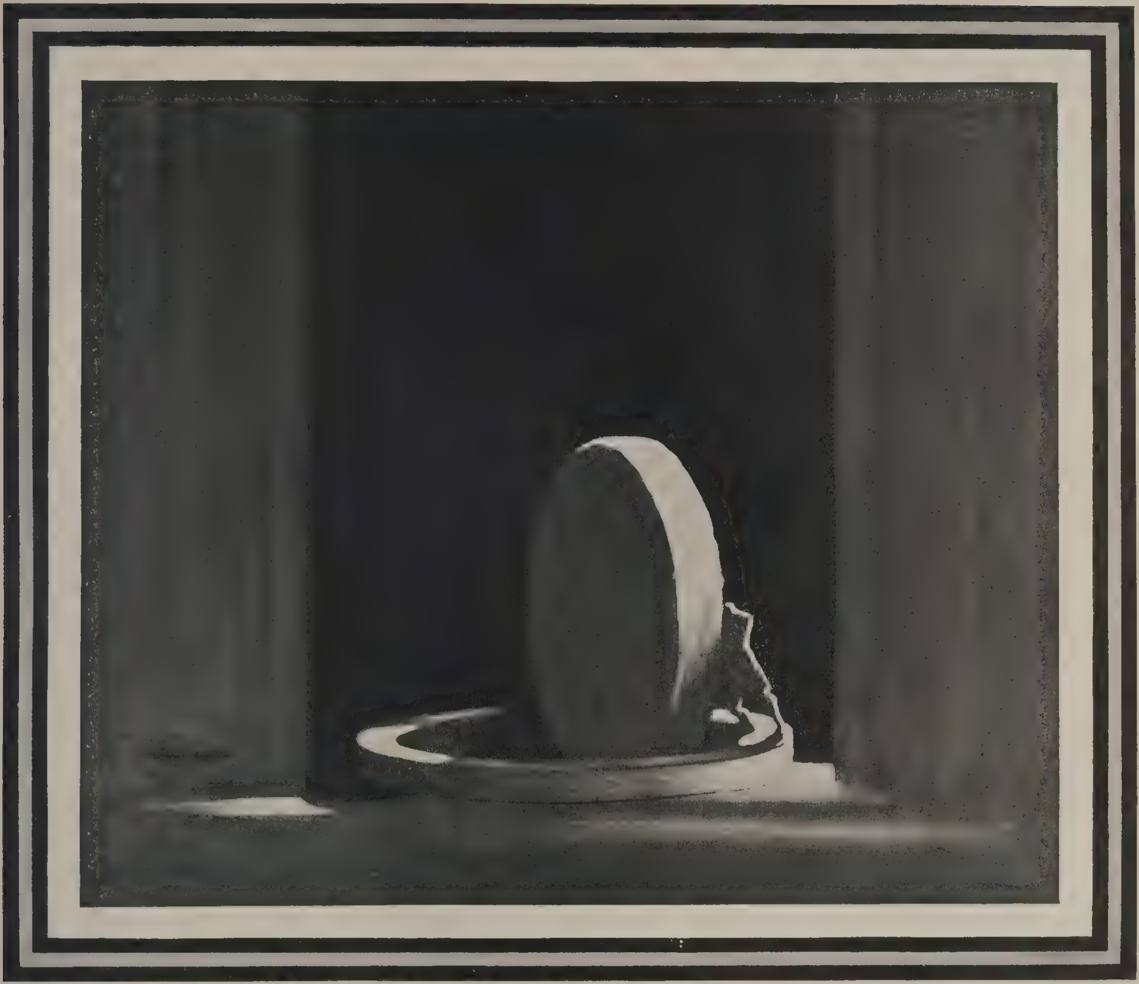
The early technique of shifting scenery was done by having the side flats on grooved slots, set in pairs, tied to a rod which connected with a series of windlasses in the cellar. At a given moment one turn of these windlasses would shoot the rear flats out like a shutter, and withdraw the front flats out of sight, achieving a complete change of scene with great precision. A beamed gridiron under the ceiling, with another series of windlasses, hoisted and lowered the clouds and the platforms on which gods and goddesses descended. Owing to the shallow space of the modern theatre and the suppression of the apron in front of the curtain, the front rows of spectators can see clear to the roof and to the side walls. The modern stage settings therefore have had to become a three-sided box with a lid over the top, when interiors are called for; for exteriors a curved sky, either of canvas or of plaster is used, instead of a sky in flounces as seen in the 18th century theatres. There is so little room on the stage for stacking scenery that most of it has to be broken apart, or unlashed, for each change of scene, and hoisted into the air where it hangs until it is needed again, and as certain sets may be 24 and sometimes 30 ft. high they have to be hoisted high enough to be out of sight when not in use. Hence the gridiron from which scenery is hung—handling is facilitated by having the lines that haul it attached to counterweights grouped at one side of the stage,—is the most important part of standard stage equipment. The opening which the audience sees, the proscenium frame, is in reality a mouse-trap shutter at the bottom of a tall shaft. The average proscenium opening is 24 to 30 feet. The curtain in actual use is rarely drawn higher than 20 ft. for exteriors, and 12 to 14 ft. for interiors; the remaining space is occupied by flounces and draperies. And the gridiron must be a minimum of 65 ft. in height; for hauling scenery out of sight, 80 to 85 ft. is better. At the Century theatre, New York, it is about 100 ft. above the stage floor.

In any case the space behind the stage opening is mainly storage space for hanging scenery in mid-air. The place occupied by the largest scene is approximately one-seventh of the total stage space, and the proportion will not vary greatly in American theatres or most commercial theatres of Europe.

The system outlined above is not by any means the best either mechanically or aesthetically. It is, in method, as archaic as hoisting sails; indeed the workmen on the stage who shift scenery are known as the crew to this day. The revolving stage introduced by Lautenschläger from Japan was used extensively, and did away with the necessity of a gridiron almost entirely. At Dresden, Linnebach at the State theatre and Hasait at the Opera, constructed elevator stages worked by hydraulic power, so that heaviest sets could be set in the cellar, hoisted to stage level and slid into place with extraordinary speed. The cellar being two or three storeys deep, the settings for two or three entire productions could be kept intact indefinitely.

These mechanical marvels have never developed because the economic trend of the time is against them. Land has become too expensive to allow the amount of space and excavation required; rising costs everywhere in Europe make the duplication of any such installation prohibitive. In the United States where a single elevator platform 12 by 30 costs approximately $25,000 to install, an entire stage so equipped would represent a capital investment that not even the wealthiest theatrical producer could carry. Thus theatres tend to become smaller and shallower and the theatre everywhere approximates to American conditions where everything has to be crowded into a standard building site of 100 ft. square.

Important architectural experiments have been made which aim at changing the conventional "peep-show theatre," as its critics have called it, where we look into a stage picture through a more or less gilded frame. Theatres have been projected with the stage as a formal platform, where the actor emphasized in space, picked

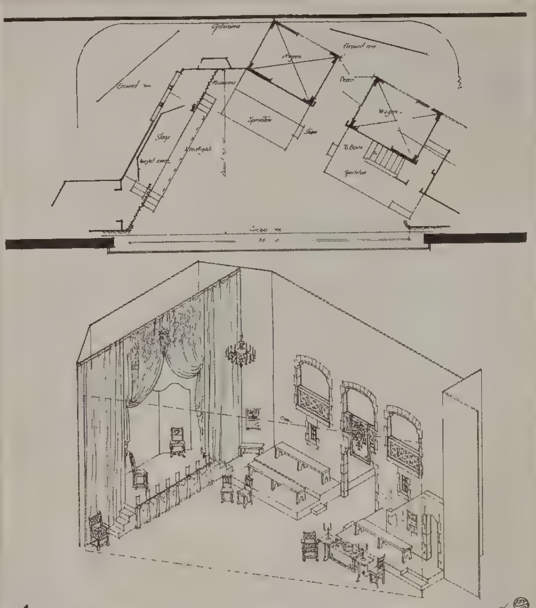


FROM THE DRAWING BY ROBERT EDMOND JONES IN "CONTINENTAL STAGE CRAFT" BY COURTESY OF KENNETH MACGOWAN

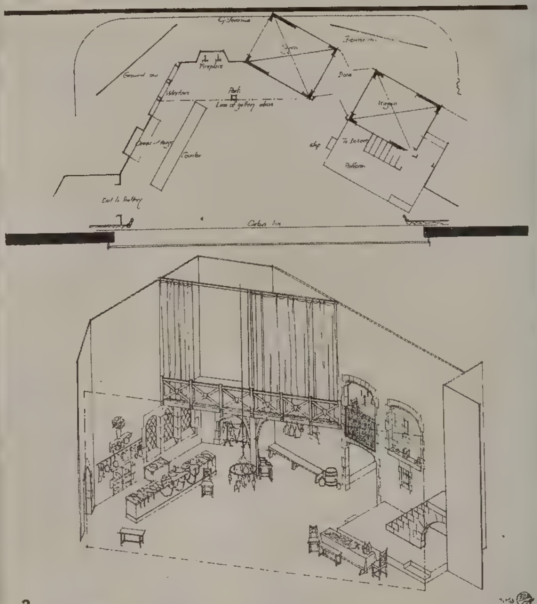
MODERN THEATRICAL PRODUCTION DESIGN

"The Mill," an example of ornamental theatrical setting designed by Isaac Grunewald for the production by the Royal Opera in Stockholm of "Samson et Dalila." The stage is black except for a vivid shaft of light which reflects on the millstone. As the stone slowly turns the reflection gradually widens from a narrow crescent into a circle of brilliant light, against which Samson is silhouetted at just the moment when his aria begins. Here we have a modern setting in which the forms are sublimated into a single dynamic composition

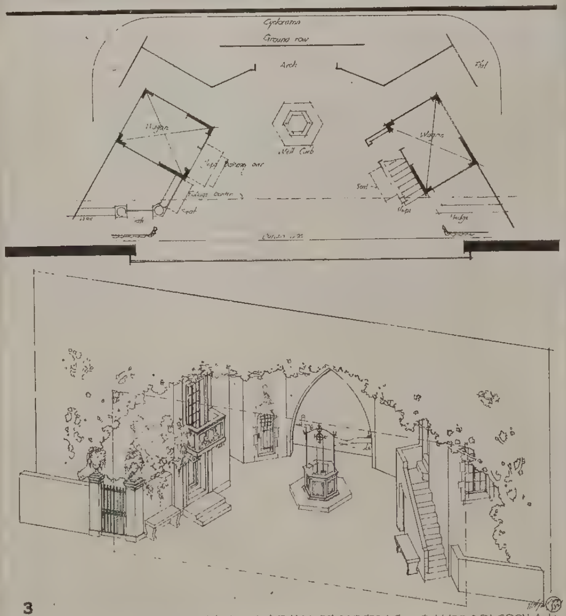
STAGE DESIGN


Cyclorama
Ground row
Wagon
Stage
Curtain line

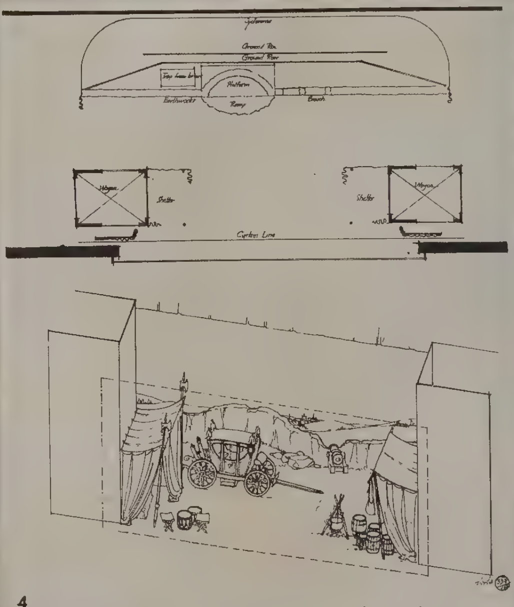
1
WALTER HAMPDEN'S PRODUCTION OF CYRANO DE BERGERAC—CLAUDE BRAGDON, Arch


Cyclorama
Fireplace
Wagon
Platform
Curtain line

2
WALTER HAMPDEN'S PRODUCTION OF CYRANO DE BERGERAC—CLAUDE BRAGDON, Arch


Cyclorama
Ground row
Arch
Wagon
Well Curb
Wagons
Steps
Seat
Hedge

3
WALTER HAMPDEN'S PRODUCTION OF CYRANO DE BERGERAC—CLAUDE BRAGDON, Arch


Cyclorama
Ground Row
Platform
Earthworks
Ramp
Bench
Wagon
Shelter
Shelter
Wagon
Curtain Line

4
WALTER HAMPDEN'S PRODUCTION OF CYRANO DE BERGERAC—CLAUDE BRAGDON, Arch

BY COURTESY OF THE ARCHITECTURAL RECORD

THE USE OF SCENERY "WAGONS" IN REALISTIC SETTINGS

The scenery wagons formed the keystone of this production of Rostand's "Cyrano de Bergerac," reputed to be the most difficult play to set according to the author's direction. Each wagon is rectangular, about 8 ft. by 12, with one floor or platform 18 in. above the stage and a second 7 ft. higher. They are mounted on ballbearing wheels and all four sides covered by 24 ft. "flats" containing doors, windows, arches, balconies, and so forth. By rolling these wagons into different positions and exposing different faces to the audience at different times; by combining them in one scene and separating them in another, and by supplementing them with sections of scenery of the ordinary sort it is possible to meet all the acting requirements and at the same time differentiate the scenes sufficiently to deceive all but the most expert and analytical eye. By this device the high and heavy scenery for all five acts is both set and stored before the rise of the opening curtain and the interiors of the wagons can be utilized for the storage of stage "properties" of which there are more than 200 in the cook-shop scene alone (fig. 2). This principle of the double and triple use of material extends to the minor items of the scene as well. The front of the inner theatre stage in the first act (fig. 1) becomes the counter in the cook-shop scene next following (fig. 2). The stairway which appears in the first, second and third acts is the same stairway, masked differently in each case. The ramparts in the fourth act (fig. 4) become the box hedges in the fifth (not shown in drawings) by the removal of the dyed burlap which has been thrown over them to give them the appearance of earthworks out by light, can mingle freely with the audience and is partially surrounded by them, a sort of electric contact being the goal sought. The most notable theatres of this sort have been the projects of the American Geddes, the Dutchman Vanderwelde and the Austrian Stranad. Jouvet's platform stage designed for Copeau existed in Paris for a number of years; a circus theatre by Poelzig, "the theatre of the 10,000," was actually built in Berlin, but like Copeau's theatre it was abandoned. Quite apart from economic problems, what thwarts the development of these playhouses is the fact that modern playwrights will not write enough plays that can be given in any such manner. O'Neill and Shaw, Toller, or Werfel, revert to realism quite as often as they depart from it and write plays which require the three-sided box room or the illusion of distance in an actual world which can only be achieved, in the theatre, by looking through a frame. Until modern playwriting achieves some unity of tradition, these formal stages must remain isolated experiments or dreams on paper.

Lighting.—The most important effect that the shallow-box stage has had on designing is the fact that perspective planning and painting become preposterous; anything that leads the eye from the front of the stage directly across it to the back wall, makes the eye realize that the picture is only 20 ft. deep. Hence the kind of composition modern scene design employs is not the Renaissance composition of distance into which the eye is led by receding parallel perspective, but distance suggested in the Japanese manner by planes cutting one another like the distant peak of Fujiyama appearing directly over the brink of a hill. The eye, leaping from one to the other, imagines the distance and gets the suggestion of space. Thus a space in modern settings is suggested rather than revealed: the base of one column will suggest an entire temple; one pillar in a gloom pierced by a stained glass window will convey an entire cathedral, and because there is no intermediate form between the pillar and the window, the blackness will seem as deep as the nave of a church. Even the window may not be shown but a shaft of light may be thrown from a point out of the spectator's range of vision in order to increase the scale by the same process of suggestion.

Light is the scene-painter of the modern theatre; light, not paint, draws the scene, and by varying planes of intensity, models it, and makes the corner of a building solid, a hill remote, a sky infinite though it be only two arms' length from the garden wall. If a stage 25 or 30 ft. deep is flooded with even radiance, nothing will persuade the eye that it is anything but a shallow box, however suggestive the arrangement of the setting itself may be. Settings are constructed now as in the Renaissance period, of canvases stretched on wooden frames and hinged or lashed together, but the paint on them is a mere preparation for the light to be thrown on. No setting can be designed until one is certain how one is going to light it; the colour painted is conceived as an undertone of what it will seem when lighted on the stage.

The railway viaduct in *Liliom,* for example, if it is to seem massive and menacing must have the light thrown across it, not at it, otherwise it will become flimsy canvas. Thrown from right to left the single pier casts a sharp shadow which gives a sense of solid masonry. The whole forepart of this scene must have a different quality and intensity of light from the distant silhouette of factory chimneys. With the right balance of light they will recede and seem distant even though they are actually only 8 ft. behind the arch culvert. And both foreground and background must be properly related to the sky if they are not both to fall into it.

So much for the scene; but there are the actors. They must be modelled and emphasized in the areas in which they move; sharply picked out at certain moments, where the action calls for it, at others almost blotted into half shadow, for this scene is one of ambush, of two thieves waiting to rob a cashier, and a rim of shadow into which they can retreat is part of the process of creating the atmosphere of terror and suspense when the crisis comes. Every scene has pools of light waiting for the actors, light which we do not see or know is there until the actor walks into it at a given moment.

Emotionally we react to light far more quickly than to any other medium in the theatre. We react to it even more quickly than to the actor's voice. In fact it sets the key of our emotions, and determines what effect the actor's voice will have on us. Lights not only paint and model the setting, emphasize its planes, and define its form; light also sustains the mood of a scene, and dramatizes its meaning. Crude or blatant lighting can war against the emotions an actor is trying to convey, and often destroy them entirely, all the more so because the lighting of any scene often does not remain static, but is dimmed or heightened, pulses and fluctuates with the action, like an orchestral score.

Change of light alone created every difference essential to the five acts of the *Tidings Brought to Mary.* The park scene of *Liliom* (Plate II.) consisted of two gauzes on which the silhouettes of trees were pasted. The entire mood of poetic dusk was created by a balance of lights. In *Man and the Masses,* the contrast between the mystic dream scenes (not shown) and the sculpturesque force of the mob scenes is entirely a matter of lighting. In the course of the play there were several hundred subtle shifts of lighting timed to coincide with the action of the play. The tree of knowledge in *Back to Methuselah* was entirely made with light, projected from the rear. The sphinx in *Peer Gynt* became a towering form by the same process. The sacred tree on the rim of the Persian desert in *Marco Millions* was merely a silhouette on a semi-transparent back-drop. But it towered in mysterious majesty because of the way light was thrown upon it, from both front and rear.

The technical basis of this important phase of modern theatre art is the spot-light—in contrast to the flood light—which can be controlled and focussed accurately upon one particular spot. To be effective these spot-lights must be separately controlled so that each can be set at any point of intensity from full to dim and fluctuated back and forth if need be during the progress of the play. Hence the rheostats, or dimmer board, that controls these lights, is to the designer's conception what the central nervous system is to the ideas in the brain. Increased subtlety both in design and control of electric light, and particularly the colour of light, is the key to theatrical design of the future. That must wait not only on the playwright and stage designer, but on the lighting engineer, who, more than anyone, holds the key to the modern theatre's destiny. (*See* THEATRE: *Modern Tendencies.*)

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(L. SI.)

STAGE EQUIPMENT

The mechanical equipment of present day stages exists for two purposes: (1) to change settings; (2) to light the stage. They are best considered separately.

Scenery Shifting.—The necessity of shifting scenery is supposed to be one of the characteristics of modern stagecraft, and the introduction of the first effective device to shift settings in the course of a play is assumed to be the turning point which determined the structure typical of playhouses to-day. The unity of place in the Greek theatre is usually pointed out in contrast and the assumption is common that imaginative Greek audiences, like those of the mediaeval market places and the Elizabethan inn yards, did not need the realistic simulation of changes of locale. Nevertheless, this orthodox doctrine is only relatively true. No theatre of the Western world has ever been satisfied with completely immovable scenery. The attempt to vary and change the backgrounds of a play has existed from the beginning of drama in Europe.

Even the Greeks needed the literal descent of their gods from the machine—an obvious derrick that hoisted them over the permanent background of a palace or temple wall. And both Haigh and Flickinger agree that Greek dramatists felt the necessity of showing scenes inside the permanent and immovable background of their tragedies and comedies alike, and so put on a tableaux stage the murders which by literary convention had to take place off stage and could be described only by a messenger or a chorus. "This was a small wooden platform (eccyclema) rolling upon wheels which was kept inside stage buildings. When it was required one of the doors in the background was thrown open and it was pushed forward on the stage. . . . On it were seen the corpses of the murdered persons, the murderers standing over them with weapons in their hands. . . ." This device was also occasionally used in comedy. Flickinger cites the fact that traces of the tracks for the wheels of this scene wagon are said to have been found in the ruins of one of the Greek theatres in Asia Minor.

Although the mediaeval market-place theatre did not shift its scenery as a whole, it built the various scenes of its morality and miracle plays side by side. The actors shifted to the sets and walked from heaven to purgatory and to the hell-mouth, as the action of the play demanded. (*See* the well-known print of "The Valenciennes Passion Play" reproduced in almost any handbook on the mediaeval stage.) Certain of the prompt books of other market place festivals have been discovered which call for a succession of realistic effects, such as the water that was piped to the roofs of houses in the market place and then, at a given signal, released as the deluge; the machinery that literally hoisted Jesus up on high, or made the angels tremble and totter before their fall. It is doubtful whether the discovery of shifting scenery, usually ascribed by the authorities to designs by Inigo Jones and Webb in England, was not anticipated in Italy by the contemporaries of Serlio and Sabbatini. In any case Vasari contains references to Italian court masques where the heavens opened, gods appeared in chariots and descended, while mounds, bearing cherubs and flowering bushes and caverns breathing smoke, appeared through the stage floor, thus implying a use of machinery that would have taxed the resources of the Drury Lane Theatre of yesterday.

The effort to change the stage-picture is incessant. For some inexplicable reason it never occurred to any of these earlier experimenters to lower a curtain, hide the stage and do this shifting of scenery out of sight. Jonson describes a device used by Inigo Jones in staging *Tethy's Festival:* "Three circles of lights and glasses" moved circularly so distracted the spectators that they "scarcely discerned" that the scenery had changed from a seaport to a cavern. Sabbatini's handbook lists the various methods of distracting an audience's attention for just this purpose: someone in the back of the hall may pretend to start a brawl, a sudden fanfare of trumpets or the roll of drums may be sounded.

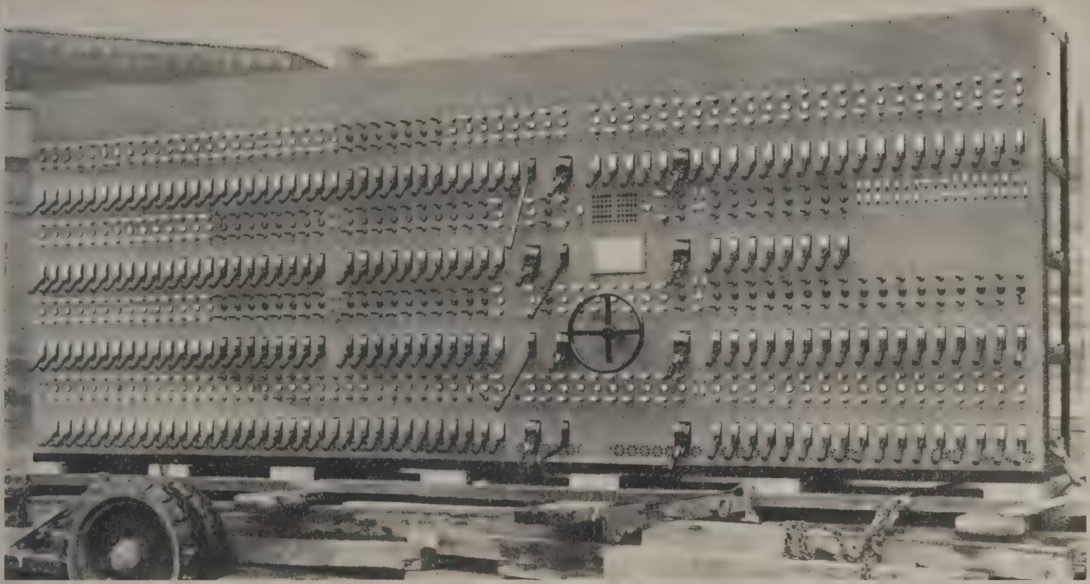
It has, however, become modern practice to lower the curtain and change (shift) settings out of sight of the audience, although this is occasionally also done with all lights out and curtain up on a dark stage. This mechanistic age has added very little that is modern to the devices of Renaissance and antiquity, except—and this only occasionally—to work them by electric or hydraulic power. The modern mechanisms which were generally part of the technical equipment only of German municipal and State theatres built between 1875 and 1900 are three:

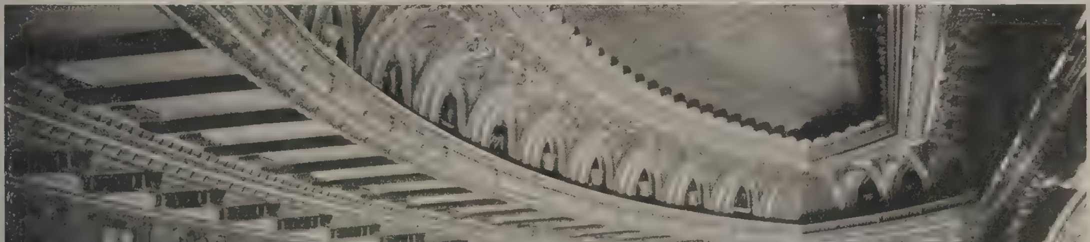
The Sliding Stage, in its essentials, the eccyclema of the Greeks, is built to run on tracks and is generally driven by electric power. Groups of two or three sliding stages are usually employed. Each sliding stage is as wide as the stage opening (called the proscenium opening or proscenium arch). While scene 1 is playing scene 2 is being "set" (set up) or is already in place. The curtain is lowered for an instant and scene 2 is pushed into space. The wagon stage, holding scene 1, is then "off stage" (out of sight) and can be rebuilt with scene 3 and the process reversed. Or if the scenes are not long enough to allow this, three sliding stages can be used and scene 3 be ready off stage with scene 1 drawn to the back (up stage). By the time scene 3 is over, there is invariably time for scene 1 to be "struck" (taken down) and replaced by scene 4, and the process continues indefinitely. The advantage of this system is that the time between shifts and scenes is reduced to a minimum; the disadvantage is that it requires a stage of such tremendous size that the ground rent of most cities precludes its use, unless the theatre is owned or subsidized by the municipality. For this reason this system of scene-shifting, notwithstanding its numerous advantages, has not become widespread.

The Revolving Stage, which was traditional on the Japanese popular stage, was seen there by the German technician, Lautenschläger, copied literally and imported into Germany. It is a turntable set level with the stage floor, and propelled by a windlass from below. The settings are arranged on it in rotation like the segments of a pie, all set before the play begins, and can be shifted in the twinkling of an eye. The advantages are obvious: speed of shifts and the fact that heavy and high constructions, such as rocks, walls, etc., can be used, which would be only slowly and laboriously moved in any other way. The disadvantages, less obvious, are: (1) In order to get a maximum number of scenes on to the circle of the turntable, they have to be triangular in shape—often a decided pictorial limitation. (2) Each sector must be so completely bounded as to hide the others, an open stage under a full sky, often artistically desirable, being impractical. (3) A deep stage for mob scenes, etc., often cannot be arranged for the same reason. (4) For any great number of scenes, as in a Shakespearian performance, even the largest revolving stage is inadequate. This can be obviated by ingenious dove-tailing for which Max Reinhardt and his designer Stern were particularly noted, and also by the practice, common in Germany, of beginning theatrical performances at 7.00 or 7.30 and having a half-hour intermission for refreshment in the course of the evening, during which an entirely new sequence of scenes can be set up for the rest of the evening. For this reason the revolving stage is not common outside of Germany. Moreover, for certain kinds of scene-shifts, as in Ibsen's *Little Eyolf,* where a three-sided interior must alternate with an exterior, an unobstructed view over the fjords, it is of no use whatsoever. The revolving stage cannot therefore be exclusively relied upon. And for that reason alone the expense of installing it usually bars it from being built as part of a theatre's equipment.

The Sinking Stage, of which the most notable types are those in Germany, built by Hasait and Linnebach for the Dresden opera-house and State theatre respectively. The stage floor from front to back is divided into three large platforms which are supported by elevator plungers. Each section can be raised independently to turn the stage into a series of grandiose terraces or lowered separately to the cellar and a new scene set and brought into place. In conjunction with sliding stages, as Linnebach uses it, there is no problem of scene-shifting that cannot be easily and successfully solved. The sinking stage allows for more freedom of design than the segmental system of the revolving stage, and the interior and exterior scenes can succeed each other with ease. It was devised to offset the limitations of the revolving stage which had become apparent by 1890. Unfortunately, it is extremely costly to instal. The machinery required to move these platforms, heavily-weighted with settings at sufficient speed to make scene-shifts quickly, is an elaborate piece of mechanical engineering, and the necessity for excavating a deep cellar underneath the stage adds greatly to the initial cost of constructing a theatre. For these reasons, except in playhouses whose repertory involves a daily change of classics or opera on a lavish scale, the capital investment is usually prohibitive. In consequence, elevator stages are not common even in Germany.

Machinery.—In this age of mechanical marvels the machinery commonly used for shifting settings is, except in details, not very different from that used in the French theatres of the 18th century. It is clumsy, involves a great deal of manual labour which yearly grows more expensive; it is slow in operation, except after





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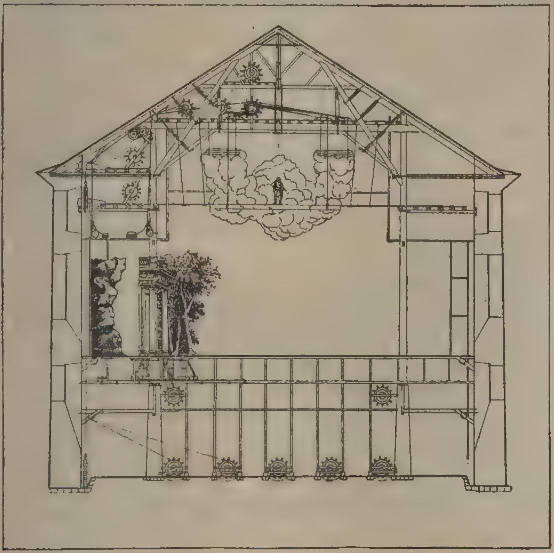
BY COURTESY OF S. L. ROTHAFEL, DIRECTOR OF THE ROXY THEATRE, NEW YORK

A LIGHTING SWITCHBOARD AND THEATRE AUDITORIUM

1. Huge switchboard of the type necessary in large, modern theatres. Each switch plays an important part in the lighting effects achieved
2. Roxy Theatre auditorium. Spotlights, placed in the niches of the ceiling dome, may be regulated in fixed positions or used to follow moving figures on the stage. The dome lights are used to illuminate the orchestra during an overture, and are flexible enough for almost any type of lighting effect. Additional light units from the projection booth at the base of the balcony may be used for the same purpose

extended rehearsal (again adding an increasing labour expense to the cost of every production). Thus, although shifting settings is the typical demand of modern play, a play requiring more than two scene-shifts (which can be done slowly in the usual intermissions) remains the director's and scenic designer's greatest problem.

The typical equipment of to-day involves a rudimentary system for "striking" a set by hoisting it out of sight. It is controlled by ropes or cables (lines), which are run to a slotted frame (gridiron) under the stage roof and then over pulleys to the pin-rail, where they are tied until the moment to "fly" them occurs. (*See* figure.) This gridiron, usually of iron and formerly of wood, is about 60 to 80 ft. above the stage floor. The pin-rail, formerly in a gallery about 20 to 24 ft. above the stage floor is now usually on the stage floor itself as each piece of scenery is properly counterweighted so that it can be raised and lowered with ease without being hauled up as dead weight. There are three lines to each large piece of scenery, called the long, middle and short line respectively, according to the position of the pin-rail. Any particular piece of scenery can be brought level to the stage floor or "trimmed" (tilted) by pulling more on the long or the short line or vice versa. However, these lines are only practical for pieces of scenery that can be set parallel to the front of the stage. Others can be set obliquely, but obviously they cut off the use of the number of sets of lines that intervene. (There are usually 50 to 70 such sets on the average gridiron.) Such slanting walls, palace fronts and exteriors, where the lines would be visible against the sky, must be handled by lowering them to the floor, snapping off the lines for the set and reversing the process for the strike. For that reason shorter pieces, such as sides of rooms which set up and down the stage (perpendicular to the audience), garden walls, etc., are usually "stacked" (pushed off the stage) and carried on by hand. Those of the stage hands who "strike" and "set" are the carpenters. But the furniture, and all the other things, such as books, inkwells, papers, jugs, etc., which the actors use and handle during a scene, are brought by others called property-men. Ten to fifteen stage-hands are usually required to make a comparatively simple scene-shift. A series of quick shifts may require as many as 20.



BY COURTESY OF SHELDEN CHENEY

DIAGRAM SHOWING POSSIBLE EFFECTS MADE THROUGH STAGE MACHINERY

A single setting though seen as a whole is, therefore, made to set and strike in a number of pieces, and then lashed together. But even these units are bolted together from smaller ones in order to get the set into the theatre and for ease in transporting it from town to town when on tour. The height of the average freight-car door in the United States, 5 ft. 9 in. determines the basic unit of scenery there. These "flats" or units, are still constructed as they were in Serlio's day in Italy in the 17th century; they are built on wooden frames (battens) and covered with canvas which is painted to simulate the texture of an exterior or interior wall. Ornament such as door frame mouldings, window frames, etc., is applied and screwed to supporting battens behind. The element of weight due to the primitive and clumsy mechanics of current stage equipment, is an important factor in the designing of scenery. Every set must be designed not only for the play, but with an eye as well on the problem of striking and setting it. Many intrinsically excellent ideas are therefore often discarded at the outset.

As an alternative the unit setting is often used. This consists of a structural frame which remains standing throughout the performance. Inserts within it, small in size and easier to handle, are changed, thus giving the illusion of a change of locale. Such schemes stimulate the imagination of both the designer and producer, and are often as welcome to audiences as the easier reliance on literal realism.

This kind of simplification has often been carried further, as in Jessner's production of *Othello,* in Berlin, when a single pillar suggested the senate chamber, a bed on a platform, Desdemona's bedroom. Nevertheless, such important playwrights as Shaw and O'Neill continue to write plays which require realistic settings. And the inability of playwrights in general to confine themselves to any one tradition makes a steady use of any method of stylization impossible. Theatrical productions have become unceasingly a matter of competitive private enterprises for which costly mechanical installation is too great an investment risk. Modern theatres are, therefore, still built, with rare exceptions, to house the equipment for scene-shifting described, which remains mechanically clumsy, crude, and wasteful of both time and labour.

ELECTRICAL EQUIPMENT

The incandescent electric lamp is the modern invention which has radically changed stage equipment. Electricity is the one element of production which makes the modern stage different from any that preceded it. (For its place as an aesthetic factor in modern stage design *see* p. 285.) The drastic changes in stage lighting (*v. inf.*) made possible by electric light result from the fact that the current can be run over coils of resistance wire (dimmers) and the intensity of light subtly changed from one moment to another, to fit the changing mood or accompany reaction of a play. Adolphe Appia was the first modern experimenter to indicate the dramatic importance of this method of lighting plays and the technique of stage-lighting is still very largely a development of his ideas outlined in *Die Musik und die Inscenierung.*

The first electrical equipment consisted of rows of small-powered incandescent lamps in narrow metal troughs (light borders) and hung in series of two or more rows parallel to the footlights which were relied upon to illuminate the actors' faces. These, with the other borders, were usually arranged in circuits of yellow (amber), white and blue—the lamps being dipped in a transparent dye—and each circuit dimmed or cut off to change the colour of any scene. The various drawbacks of this system were that the footlights, if sufficient to light the actors, flooded the settings with needless brilliance, casting shadows behind them. The whole stage being flatly and evenly lighted, contrast and emphasis became impossible. This type of light is very fittingly known as flood-lighting.

The development of incandescent spot-lamps has greatly improved lighting. These consist of high-powered bulbs of 500, 1,000 and 1,500 watts in a metal hood which can be tilted to any angle, the light projected through a lens focused upon any given stage area. (A smaller, 250 watt type is known as a baby-spot.) The area of light can be spread or be narrowed down to the size of a face. Spot-lamps were at first mostly used on a light bridge hung just inside the proscenium frame, where the electricians (operators) could walk to and fro and re-angle them as needed. Owing to the steady rise in the cost of labour it is a common practice to use more lamps previously set and angled for successive scenes. Some are hung from a bridge or iron pipe overhead. But, as these tend to cast heavy shadows in the sockets of the actors' eyes, groups of 10 to 20 are mounted in a standing iron pipe (light tormentor) on each side of the stage (*see* diagram). Footlights are kept low and reinforced by additional spot-lights from the front of the first balcony or the ceiling of the theatre if space has been provided for them. In a recent production of *Faust* (at the Theatre Guild, N.Y., 1928) 80 spot-lights were used for its 17 scenes on the fore-stage alone.

The effectiveness of spot-lighting depends entirely on the flexibility of lighting control; *i.e.*, the dimmer. The only satisfactory system is to have each spot-light controlled by a separate dimmer so that every lamp can be brought independently to the degree of intensity required. But for complete changes of light, groups of lamps must be dimmed together. Hence the nerve centre of stage lighting is the dimmer-board, where the switches and dimmers are grouped; it may be compared to the sensory and motor nerve system of the body. The most important and difficult piece of mechanical construction in the modern stage equipment is this switch-board and dimmer-board and the coupling of both so as to obtain the greatest ease in controlling the lights in any desired order or grouping.

The American type of dimmer is not the most effective. In this the resistance, divided into 100 steps (called a dimmer-plate), is wound in direct connection with the handle that controls it, and then banked in rows behind the face of the board. They are heavy and cumbrous, and tend to overheat rapidly. The Theatre Guild switch-board of 102 dimmer-plates is 11 ft. long and 6 ft. high. Coupling or interlocking handles to bring down groups of lamps in unison involves much friction and is cumbersome to operate even in its most compact form. The German system of control perfected by Schwabe and the Allgemeine Elektrizitäts-Gesellschaft, is mechanically a great improvement. The resistance coils are stacked underneath the stage floor (or above it) in a fireproof chamber. A carbon-brush contact is connected by a fine cable brought to the stage over pulleys and wound on a counterweighted circular drum which serves as an indicator. As this indicator handle is shifted the contact brush in the cellar slides up and down. The great advantage of this system is that the indicator coils are small, being only cable controls, light in weight, and easy to move; the circular indicator is one-third the size of a standard American dimmer-plate, so that a bank can be easily brought within the reach of a mechanician, and the gearing of any group of them is mechanically much simpler and easier to move. Valuable stage space is saved by having the resistance coils in the cellar. They can be made larger, the number of steps increased and the dimming of light be advanced almost imperceptibly. This system is now being copied in England. It is to be hoped that its adoption will soon be universal.

In the last decade some progress has been made in projecting scenery to replace the always somewhat hard and non-atmospheric painted back-drop. The first was the Linnebach lamp. (*See* section on *Modern* stage design.) The Tree of Knowledge in the *Garden of Eden* was projected by this lamp. (*See* illustration.) The principle is that of the shadowgraph thrown on a drop transparent sheeting. The general forms are outlined by an opaque silhouette painted in lamp-black on a glass slide about 24 by 30 in. which is then coloured and slid over a square hood containing a carbon arc light. The line divergence of the arc rays achieves the magnified projecting without the aid of a lens. For this reason definition can not be exact, and although a large space can be covered approximately 30 by 24 ft. at a distance of 15 ft., distortion begins if any wider space is to be covered. The lamp is large and difficult to conceal and cannot be shot at an angle.

The G.K.P. lantern recently perfected in Vienna is a great improvement; the plate as small as the average lantern slide is mathematically distorted so that it can be thrown from any angle or height and cover the background of the largest stage. Any drawing can be reproduced with photographic accuracy and keep the exact quality of the artist's work. Schwabe and Co., of Berlin have perfected an elaborate motor-driven lamp which projects moving clouds and similar effects with remarkable realism. But such efforts are unimportant to current stage-craft except for certain traditional interpretations of operas.

The control of the colour of light is still in a primitive and experimental stage. Light is coloured by a series of gelatine slides placed over the spot-light lens. But the colour steps are a crude series of yellows (light dark and medium amber), a few pinks, and greens and three or four blues. Gelatines fade quickly. The colours are not standardized. Glass slides which obviate these disadvantages are not produced on a commercial scale except in Germany. The relation of the colour of lights to the dyes of materials and paint has not yet been worked out. The only scientific step has been a number of systems for illuminating the sky-drop by three-colour systems of light primaries. Red, blue and green being the light primaries, with a proper mixture of groups of all three, *i.e.*, by dimming one group or another, the colour on the sky can be moved through the entire range of the spectrum if the colour mediums used are spectroscopically pure. These have not yet been produced on a commercial scale. The present range of colour is only approximate. But the Schwabe or A.E.G. in Europe, the Pevear system in America are an indispensable unit in theatre equipment.

The Cyclorama.—Another necessity in the average theatre is the cyclorama as a substitute for the sky-drop, in open-air scenes, the angle of sight from each side of the house being such that a third of the audience can see past the ends of a sky-drop into the wings of the stage. A cyclorama is either a cylindrical expanse of canvas with an arc wide enough to block these sight lines, or an arched plaster dome that covers the whole stage. The drawback of the canvas cyclorama is that it usually hangs in wrinkles; the plaster dome blocks the use of the gridiron except on exceptionally large stages. Both Hazait and Linnebach have perfected a wrinkleless canvas cyclorama that unrolls in 1½ min. like an upright window shade, on an overhead track. These are driven by motor-power and leave the stage entirely free for shifting and striking of settings. But either these or the plaster dome in conjunction with a good system of light primaries, produce the necessary illusion of infinite depth of sky, the ambient of open air, and the subtle gradations of colour necessary to outdoor settings.

A gridiron with properly counterweighted lines, used if possible in conjunction with a revolving stage or sliding stages, a cyclorama, a three-colour border for lighting it, an ample array of focusing spot-lights on dimmers flexibly controlled by a large dimmer-board constitute the present day stage equipment which producers and designers must use. (*See* THEATRE: *Modern Tendencies.*)

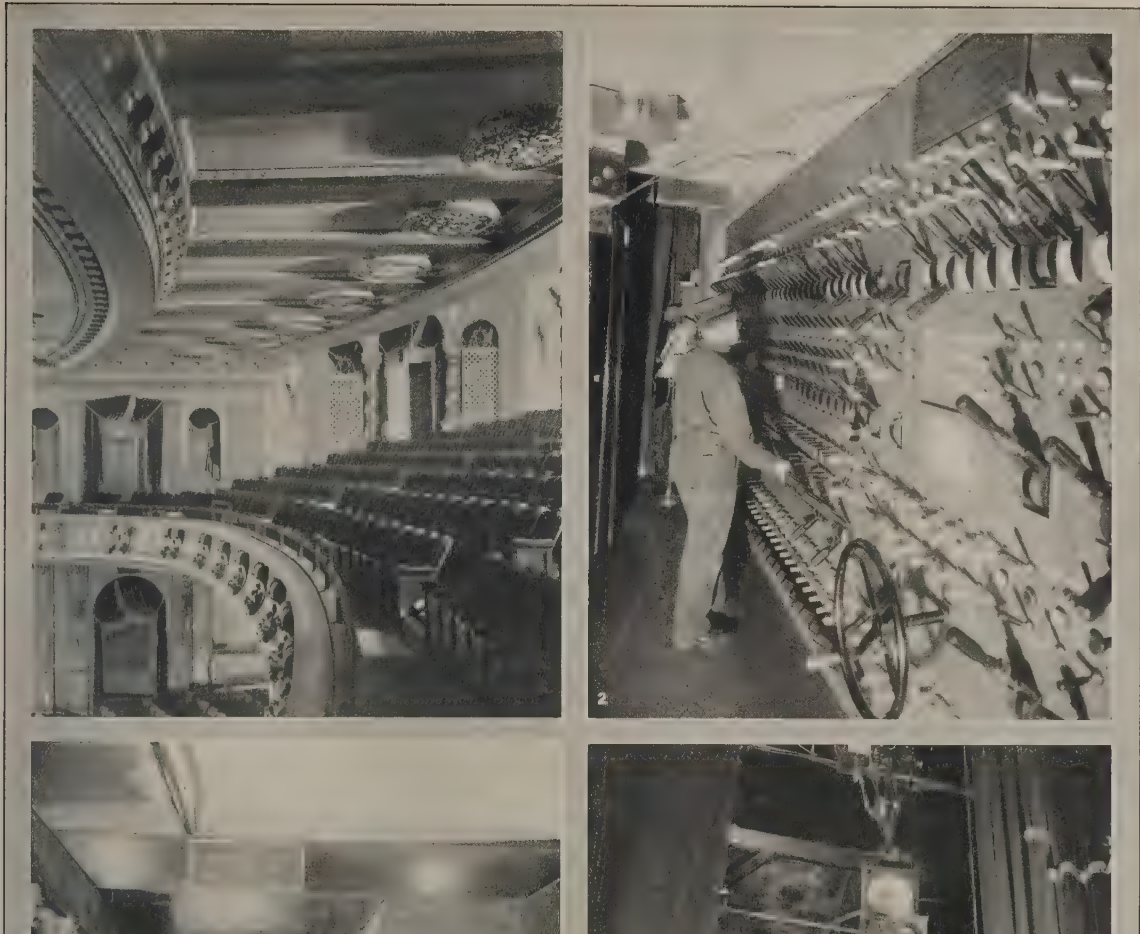
(L. SI.)

STAGE LIGHTING

The function of coloured light in the theatre is to stimulate the imagination and excite the emotions of the audience. In this use it is parallel to the function of music. If the audience is in a receptive mood—fertile soil to receive and react to the impressions and atmosphere—there are two great mediums with which to achieve these effects: light and music.

Assuming that the director is familiar with the possibilities as well as the limitations of every piece of equipment used in stage lighting, he has to consider the colours at his disposal; the emotional values attributed to each; the relative strength of each colour; the effect obtained by their isolation, succession or combination. He may use coloured lights upon a stage as a painter uses his brush and paints. He can tell a complete story with lights. By the employment of the appropriate colours he can interpret the rise and fall of the emotional scale, using lights to emphasize or heighten the emotional climax.

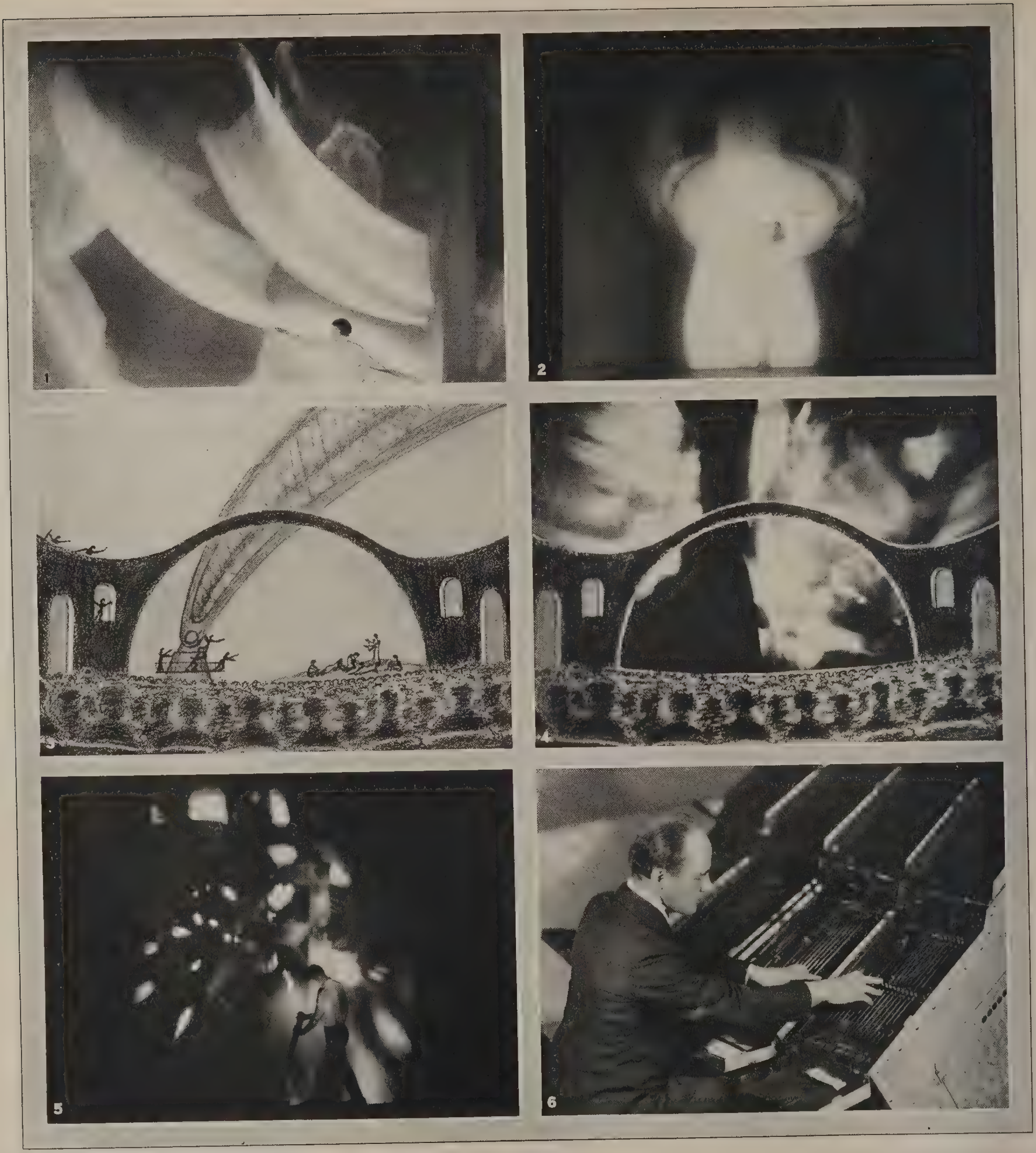
Considered from the most elementary aspect, light may be said to have two primary purposes: brought upward, or brightened, it elevates, inspires and stimulates; taken down, or subdued, it creates a depressing, quieting or narcotic effect in the same proportion. With various shadings, gradations and combinations of colours, a certain mood may be produced in an audience. Each colour possesses a property which will create that mood or contribute to its creation.



PHOTOGRAPHS, (1) TEBBS AND KNELL, INC., (2, 3, 4) ALBERT ROTHSCHILD

MODERN LIGHTING APPARATUS (ROXY THEATRE)

1. Mezzanine in Roxy theatre with lighting effects that are used to reflect the mood of the stage presentation. 2. Roxy theatre switchboard, 8 ft. high and 22 ft. long, with over 1,000 switching levers and 500 dimmers. 3. The rector room of the Roxy theatre where rector dimmers and contactor switches are placed. The rector plates run up to a capacity of 15,000 watts each, and each switchboard dimmer to 3,600 watts. 4. Spotlights placed on the bridges at each side of the stage, an effective means of creating angle lighting



BY COURTESY OF THE CLAVILUX LABORATORIES

COLOUR LIGHTING AS A VITAL ELEMENT IN MODERN STAGE DESIGN

1. Dancing with visual accompaniment. The dancer moves in silence with the rhythmically changing light forms as the only accompaniment
2. Changes in form, motion and colour of the luminous column, which seemingly envelops the dancer, follow the progress of the dance
3. Theatre for the use of light-settings. Screen and dome merge to form a huge surface for projected scenery. Only the base upon which the actors stand is real, the rest of the steel structure being projected from the keyboard
4. An example of the complete change in mood of stage and auditorium accomplished by the light-keyboard in a few seconds
5. Projected setting for a play. The lever which the actor grasps is actual, but the machine with its turning wheels is built up and controlled from the light-keyboard
6. The light-keyboard in the orchestra pit from which a player controls all visual possibilities by moving the small sliding keys. These, through relays, actuate the remote optical and electrical units

For example, red will excite, will create a premonition of impending danger; or it may be used to achieve a sinister effect. Amber and white added to the red will eliminate the more formidable aspects of the colour and create an effect of speed and action. Yellows and reds with a supplementary white will create a sustained mood, and serve to establish a definite atmosphere. Blue creates suspense. The audience becomes keyed to a mood. It becomes interested in the succeeding action. A mixture of shades of this colour will create a subdued mood, or even depression. Purple will impart an atmosphere of majesty, of power, of magnitude. Toned amber will contribute to the effect. The use of the primary colours, red, blue and green, will create a mood of passion; of primary emotions; of strength and virility.

Thus we see how each individual colour can either definitely express a mood or be used in conjunction with another or other colours to achieve a particular mood. The intensity, proportion and quality of the colours may be modified to suit the finer gradations of the mood.

An audience cannot be thrust into the atmosphere of a particular colour, or transferred from one mood to another too abruptly. The speed or tempo must be judiciously timed to correspond with the character of the mood. Otherwise the ultimate purpose of the lighting is apt to be defeated. For this purpose, the dimmers on the switchboard, which bring up or take off the lights at the required rate of speed, demonstrate their usefulness.

The relation of coloured light to music follows the same general principles of emotional interpretation. It is altogether possible to take a musical composition and interpret it by means of light, by establishing an accompanying atmosphere; to interpret the variety of moods; to mark the changes in tempo, quality and volume; to heighten or emphasize the climaxes. The analysis of colour as indicated above will serve as a guide to the interpretation of the emotional qualities of the music. A brief specific application of the theory will explain this.

The orchestra has tuned up and is ready to start the overture. It is necessary to secure the attention of the audience; to concentrate its eyes and ears on the orchestra. The mechanical equipment is used to accomplish this end. The major illumination is to be thrown on the orchestra. The house lights are brought down. The musical composition to be played provides the atmospheric theme, so to speak, of the lighting. With the spotlights in the ceiling or dome of the auditorium we may throw the desired light or colours on the orchestra itself. The other lights in the ceiling may be selected in colours necessary to establish the opening character of the music. Behind the orchestra is the stage curtain, an ideal background for the light interpretation of the music. A combination of spotlights or colours may be used for this background.

By means of this picture of light, the attention of the audience is focused on the orchestra, and a suitable atmosphere is created for the music. As the composition progresses the colours may be modified, added to, changed, or intensified in accordance with the tempo, the spirit, the volume of the music. We co-ordinate the colour scale with the changing music until we reach the climax. With the approach of the finale and the marshalling of all the musical forces, the lights expand accordingly. If the subdued nature of the composition requires it, the lights are likewise diminished. The closing chords find both the music and the lights finishing in perfect co-ordination.

The stage picture, which is often a visual interpretation of the music, provides further means of establishing and co-ordinating the mood of the audience. Just as a composition has a definite theme or character, so the corresponding lighting of the music must have a theme. Once having determined the light theme, so to speak, it should be followed throughout the sequence to sustain that particular mood. The light that is visible to the audience is reflected light, and its purpose is to simulate reality. Thus, it is necessary to achieve, or approach as nearly as possible, a natural lighting, or a lighting that is consistent with the character of the subject or scene, and an effort should be made to emphasize the natural colours of each particular subject or scene, which provides a guide for the kind of lighting.

Costumes, materials, natural settings, may also supply the keynote for the lighting, and may be accentuated or subdued to fit the particular needs of the director.

It is often undesirable to create a specific light theme. The music or subject may not be indicative of any particular atmosphere or mood. In that case, a certain freedom in the application of colours and light may be applied.

In projecting lights, there is also the quality to be considered. Light may be hard or soft, and the resultant effects naturally are dependent on this important factor of quality. By straining the light through a filter, a diffused quality is produced, which is very effective in the establishment of atmosphere. It is also important to retain the neutral character of the background or auditorium. The lighting of this background must not conflict nor detract from the stage picture or music picture to be created. The maximum utilization of the different types of lighting equipment will be of further assistance in the creation of moods and atmosphere. Many different types of equipment constitute the lighting tools used in the modern theatre, but they can be condensed into two general classes: (1) general lighting, (2) localized lighting.

Modern Lighting Equipment.—The general lighting equipment consists of footlights, border lights and strip lights. Localized lighting equipment includes bunch or flood lights, incandescent spotlights and carbon arc spotlights. The localized group can further be divided into fixed units and portable units.

Lighting units placed in the foremost part of the stage may be used to illuminate the stage curtains and drapes as a musical setting, or to furnish general illumination in the foreground of the stage. Another set of units at the back of the stage is generally used for the lighting of the cyclorama or backdrop.

General illumination, furnished on the stage from overhead, is the function of border lights. The stage is divided into entrances, and over each entrance, spanning the width of the stage and about 7 ft. apart, these border lights are suspended and so arranged that they can be raised and lowered at will. High wattage lamps are placed in individual reflectors and are divided into colour groups, wired similarly to the footlights. Colour screens of glass or gelatine are used in border lights.

Bunch or flood lights are made in many forms, and are used to light a given area to a higher intensity, or to flood painted scenery with a diffused, an unmodified or a coloured light. Some flood lights are made so that they can be suspended. The spotlight may be used to focus the attention of the observer to any particular performer or group, or to any one part of the scene. There are innumerable points in the theatre where these spotlights can be placed, not only on the stage but out in the auditorium as well. This, however, is a very dangerous form of lighting, and must be applied with great discretion.

Bridges spanning the whole width of the stage are suspended at various places, and are mounted with a number of incandescent and arc spotlights. From them shafts of light may be directed to parts of the stage that require particular illumination. Bridges are also suspended on each side of the stage, extending from the proscenium arch toward the rear wall. They are built on two levels and are equipped with a number of bunch lights, incandescent spotlights and arc spotlights. The proscenium spotlights, which are nearest the proscenium arch, can also be supported on these bridges.

The unique, the grotesque, or stylized mood may be obtained by lighting at angles. Lights may be focused from any direction on the desired object. The effect is generally interesting and unconventional.

It must not be forgotten, however, that the function of light in the theatre is to stimulate the imagination. In visionary lighting—the realistic appearance of dreams, apparitions and similar creative pictures—the imaginative thought is transposed to actual vision. Ceiling and side-lights are manipulated to create the illusion and the reality—food for the audience's imagination.

There are other mechanical devices to create the illusion—the simulation of various natural phenomena—rain, waterfalls, ripples, snow, etc. It is also possible to give the illusion of motion and depth to a scene. All are created by the manipulation of lights and colours. Modern equipment has made rapid strides in the development of stage lighting, both from the mechanical and artistic standpoint, and there is every indication that in the near future it will take a much more prominent part in stage and musical interpretation than ever before.

The beauty and magnitude of this branch of the interpretative art lies in the fact that there are no limitations—no specific rules for the director to follow. He may use his ingenuity and his imagination to the full extent. It is a field where the pioneer and experimenter will reap his reward in the beauty of his creation. (*See* also THEATRICAL STAGE EQUIPMENT; THEATRE, MODERN TENDENCIES; THEATRE, DEVELOPMENT OF; THEATRICAL PRODUCTION; COLOUR MUSIC; LIGHT; THEATRICAL STAGE DESIGN.)

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VISUAL ACCOMPANIMENT IN LIGHT

With the new use of light as an independent medium for aesthetic expression through form, motion and colour and the consequent beginning of an art of light (*see* COLOUR MUSIC), a promising field is opening up to artists and experimenters whose work in the new medium will, without a doubt, deeply affect the older art forms, particularly music and the arts of the theatre.

Visual Accompaniment to Music.—From Castel (1688–1757) up to the present day a considerable number of experimenters have attempted to assign a permanent colour to each step in the musical scale, but the results in actual performance have been without scientific or aesthetic justification, partly because the claim that a physical correspondence exists between sound and light vibrations has been permanently disproved by the physicist, and partly because only formless colours were employed and the absence of form and motion, the two most important factors in all visual experience, proved too great a handicap.

The only reasonable solution seems to be the complete liberation of the visual artist to compose, in form, motion and colour, a visual accompaniment to an already written musical composition and of the musician to compose similarly in melody, harmony and rhythm a musical setting to a silent visual composition with all the freedom he now has in setting a poem to music.

One of the first attempts in this direction was demonstrated by Leopold Stokowski and the Philadelphia Orchestra and Thomas Wilfred and his clavilux (*q.v.*) in Carnegie Hall, New York in Jan. 1926. For each of the four movements of Rimsky-Korsakov's "Scheherazade" Wilfred had composed a mobile visual setting which he played on a large white screen erected between the orchestra and the auditorium. Each musical motif had a corresponding mobile form and colour motif and these were blended and interwoven as the music was played. It was here demonstrated that an aural crescendo can effectively be accompanied by a visual diminuendo and also that the so-called cool colours (blue, turquoise and green) introduced in definite forms in certain rapid motion progressions, can well be used with an aural climax which invariably would have suggested "red" had only formless colour been employed. Form and motion alone have also been used in mobile white, grey and black accompaniments to music.

Visual Accompaniment to the Drama.—The art of light also opens up fascinating possibilities in the use of mobile light-settings of abstract, symbolic or even realistic nature which will fold themselves around the action of a play, opera, pantomime or dance as closely as music around a poem—so delicately blended and changed that the spectator, while aware of the unusual emphasis it would give to every scene, would seldom be conscious of the lighting itself.

But before such possibilities can be touched upon it will be necessary to revise the entire lighting system of the theatre. Even the most elaborate of the present day equipments are still manipulated by the electricians from large cumbersome switchboards, generally so placed in a corner of the stage that the several operators are unable to see the results produced. This switchboard should be replaced by a light-keyboard placed in the orchestra pit or in a modified prompter's box under the front part of the stage from which the light-artist can control all visual possibilities by the sweep of a hand over tiny low voltage keys. Furthermore, a standardization of lighting units and keyboards must be arrived at in order to permit the playing of a written light-score in any theatre without the necessity of transporting the heavy and delicate equipment as is now the practice.

Having the manuscript of the play before him and using the white cyclorama or backdrop as a painter's canvas the scenic artist at the light-console can then proceed to illuminate the actors and the necessary material units, at the same time building up, from special projectors, mobile visual settings in apparent space surrounding the action and recording it all in a suitable notation below the lines of the play. Settings projected in light have been used for many years, generally painted in colour upon glass or mica disks which were then rotated in the focal plane of a powerful stereopticon, but only on rare occasions have these been executed by the scenic designer as an integral part of the setting. They have mostly consisted of detached "effects" such as drifting clouds, water ripple, etc., superimposed upon already painted drops, and the results have lacked co-ordination and depth.

Adolphe Appia, the first important pioneer in stage lighting, writes in his *Die Musik und die Inscenierung* (1899) about the forest scene in "Siegfried": "We must no longer try to create the illusion of a forest, but instead the illusion of a man in the atmosphere of a forest. When the forest trees, stirred by the breeze, attract the attention of Siegfried, we, the spectators, should see Siegfried bathed in the moving light and shadows and not the movement of rags of canvas agitated by stage tricks."

With the invention of the clavilux the projection and control of three-dimensional form in motion has become possible and this instrument was used in the production of Ibsen's "The Vikings" at the Goodman theatre, Chicago, in March 1928. Each of the four acts began and ended in complete darkness and out of this forms and figures were lifted only as they were meant to occupy the attention of the spectator. The second act, a nocturnal banquet of vikings in a Norse hall, was lit entirely from a battery of instruments in the central fireplace, and mobile firelight, slightly stylized, followed the action, constantly bringing out areas of importance while subduing all else, increasing and decreasing in intensity and tempo and retarding only once into a static glow to intensify a moment of suspense. The light conditions changed so constantly during the entire act that the player was unable to lift his hands from the light-keyboard for a single moment. The ride of the dead warriors to Valhalla, generally obtained in opera by moving lantern slides, was here done as an abstract essence of blackness galloping toward light amid flashes of steel and blood.

Thus lighting, having assumed equal importance with music in the theatre, will need a new type of creative artist whose main task will be the fusion of the movements of actors and groups with the space surrounding them in such a way that the two come to form a mobile, at all times perfect, frame around the spoken word. The lighting of static settings and the more or less independent "flooding" and "spotting" of the actors will give way to the one difficult problem: *the aesthetic treatment with light of mobile form in space.*

The New Stage.—It is probable that such progress will greatly simplify the mechanical requirements of the stage of to-day, at the same time permitting such freedom as the gradual change from one scene or act to the next without a break or a single mechanical operation. The new stage in its simplest form would then merely consist of a raised platform in front of a large white surface. No proscenium or curtain would be required as the proper use of light would frame each scene and darkness mark the beginning and end of each chapter of the play, the conventional division into acts and scenes no longer being necessary. Such a stage has been evolved by the American designer, Norman Bel Geddes.

It will be well for those who are to build the theatres of the future to reflect over Appia's prophetic words, uttered in the closing years of the last century: "An object or an actor takes on a plastic quality only through the light that strikes it, and the plasticity can only be of artistic value when the light is artistically handled." (*See* also LIGHTING AND ARTIFICIAL ILLUMINATION: *Lighting in Practice.*) (T. WI.)

STAGGER PLAN. The great congestion of transit facilities in some of the larger cities of the United States, due to a uniformity of opening and closing hours, has led to the adoption of a so-called stagger plan. The acuteness of the problem in the city of New York is mainly due to the large number of persons involved, to the fact that business areas are highly concentrated as the result of tall buildings and to the fact that travel is confined largely to two directions, owing to the shape and geographical location of the island which forms the centre of New York's business activity. The department of health, feeling that the congestion of the transit facilities constituted a menace to health, conducted a survey to determine the feasibility of "staggering" or varying the opening and closing hours of firms employing large numbers of persons. As the result of this survey, a plan was determined upon and a considerable number of organizations voluntarily agreed to shift their opening and closing hours in conformity with the recommendations of the health department. Some of the larger companies found it desirable to divide their employees into groups, one group arriving at 8.30, another at 8.45, another at 9, another at 9.15 and another at 9.30. Each of these groups leaves at correspondingly different times in the afternoon. The groups are chosen in such a manner as to be co-ordinate with the flow of work in the organization. In addition to relieving congestion on the transit lines, this also tends to relieve congestion in the halls and elevators of the company's building. The movement was in 1928 still in the embryonic stage. (O. G. S.)

STAHL, FRIEDRICH JULIUS (1802–1861), German ecclesiastical lawyer and politician, was born at Munich on Jan. 16, 1802, of Jewish parentage. At the age of nineteen he entered the Lutheran church. He was professor of law at Würzburg, and of ecclesiastical law and polity at Berlin. Stahl early fell under the influence of Schelling, and at the latter's insistence, began in 1827 his great work: *Die Philosophie des Rechts nach geschichtlicher Ansicht* (an historical view of the philosophy of law), in which he bases all law and political science upon Christian revelation, denies rationalistic doctrines, and, as a deduction from this principle, maintains that a state church must be strictly confessional. This position he further elucidated in his *Der christliche Staat und sein Verhältniss zum Deismus und Judenthum* (The Christian State and its relation to Deism and Judaism). As synodal councillor Stahl made use of his influence to weaken the Evangelical Union (*i.e.,* that compromise between the Calvinist and Lutheran doctrines which is the essence of the Prussian Evangelical Church) and to strengthen the influence of the Lutheran Church. (Cf. *Die Lutherische Kirche und die Union,* 1859.) Frederick William IV. supported Stahl in his ecclesiastical policy, and the Prussian Evangelical Church would probably have been dissolved had not the regency of Prince William (afterwards the emperor William I.) supervened in 1858. Stahl retired into private life and died at Brückenau on Aug. 10, 1861.

STAHL, GEORG ERNST (1660–1734), German chemist and physician, was born on Oct. 21, 1660, at Anspach. Having graduated in medicine at Jena in 1683, he became court physician to the duke of Weimar in 1687. From 1694 to 1716 he held the chair of medicine at Halle, and was then appointed physician to the king of Prussia in Berlin, where he died on May 14, 1734. In chemistry he is chiefly known in connection with his doctrine of phlogiston (*see* CHEMISTRY, *History of*), the essentials of which, however, he owed to J. J. Becher; and he also propounded a view of fermentation which in some respects resembles that supported by Liebig a century and a half later.

STÅHLBERG, KAARLO JUHO (1865–), Finnish statesman, was born on Jan. 28, 1865. At the beginning of his public career, he held alternately university and administrative posts until he became a member of the Diet in 1904 and of the Finnish Government in 1905. He resigned in 1907 and in the following year was appointed a professor of administrative law. At the outbreak of the World War, the government was Finnish in name only, being composed entirely of Russian officials. Ståhlberg was then president of the Diet and he had to act as the chief public representative of Finnish opinion. He firmly withstood the increasingly oppressive tendencies of the Imperial Russian Government. After the Russian revolution of 1917 Finland became an independent republic, and in 1919 Ståhlberg was elected to the presidency and as the candidate of the Progressive and Socialist parties he had to fight the unconcealed hostility and distrust of the conservative parties. He pursued, nevertheless, a conciliatory and mitigating policy, and when the time of the next presidential election approached, the country almost unanimously desired him to accept re-election. He refused, however, and retired on the expiration of his presidency.

STAINED GLASS, a term that is generally understood to refer only to glass windows that have been coloured by such methods as the fusion of metallic oxides into the glass, the burning of pigment into the surface of white glass, or the joining of white with coloured pieces of glass.

ORIGINS

The origin of stained glass is obscure. It probably came from the Near East, the home of the glass industry, and mosaic windows of glass set in plaster work, which we know from the 17th century in Egypt and elsewhere, are probably of great antiquity. But it is not likely that the art goes farther back than the 9th century; it is doubtful if before that time glass was made in a sufficient variety of colours to suggest and produce coloured designs. The art would most naturally spread first to Italy, and Venice may have been a centre as early as the 10th century. An Italian panel in the Victoria and Albert Museum, tentatively ascribed to the 13th or 14th century, is fully Italian and Romanesque in style and suggests a native tradition. Actually the earliest reference to stained glass in the accepted sense of the term (that is, windows not merely coloured, but pictorial also) is in a manuscript which records that Adalbéron, bishop of Rheims from 969 to 988, rebuilt the cathedral and redecorated it with windows representing various stories (Richer, vol. ii., lib. 3). An earlier reference, in a 9th century life of St. Ludger, certainly relates to coloured windows, but it is not clear that they were pictorial. Mâle gives, as the earliest mention of leading, a reference to the *Miracles of Saint Benoit* where it is related that in the last years of the 10th century the church of Fleury-sur-Loire was set on fire and it was feared that the leads of the windows would be melted. Which are the earliest windows extant is a matter of dispute, but the evidence, both literary and stylistic, seems to favour certain figures of prophets in Augsburg cathedral, which may date from the middle of the 11th century.

TECHNIQUE

A stained-glass window is a translucent mosaic held together by lead; that is the simplest conception of its technique. Actually other considerations come into play in the design and execution of a window. The lead is not merely a connecting medium, but in all good design plays a part of its own; it outlines the main constituents of the design, giving definition and rhythm to the masses of colour. From the account given by Theophilus, we can derive a very accurate notion of the technique as practised when the art first came to its perfection in the 12th century. The general scheme for the glazing of a church was, of course, the care of the clerics, and we may assume that the artists among them, the illuminators, would prepare the first drawings. One such series of drawings, the Guthlac Roll, is preserved in the British Museum (Harley Roll, Y 6). But the actual cartoon for the glass was drawn on one end of a whitewashed board supported on trestles. The vacant space at the other end was used for laying out the glass and for the general business of glazing. The cartoon was marked to indicate the various colours, and the next step was to shape a piece of glass to the outline required by the design. This was done, firstly and roughly, with a hot iron and then more carefully with a tool known as the "grozing iron," a flat piece of iron with a notch at one end, rather like a modern spanner. This must have been a slow and laborious process, but the grozing iron seems to have continued in use until about 1500, when the modern method of diamond cutting began to be employed. The next step, in a fully developed stained-glass window, was to paint the glass with details which the bare design of glass could not give. At first the use of paint was confined to an opaque brown (grisaille, *q.v.*), used, not as colour, but as a means of outlining the design in further detail, reinforcing the effect of the leads. This pigment consisted of powdered glass mixed with a metallic oxide (probably iron), to which was added sufficient gum to make the mixture adhere. If "high lights" were desired, the whole surface of the particular piece of glass was covered with a thin coating of this paint and the lines scratched through with a pointed stick. Shading effects were produced by stippling with a brush. The glass, having been painted, was next fired in the kiln, to fuse the enamels to the glass. In mediaeval times the glass was fired in a pan, which was filled to the top with alternate layers of glass and whiting. When the glass was fused sufficiently, it was brought out and cooled and then rearranged on the glazing table. The next step was the leading. This was (and still is) done by means of strips of lead, in section like the letter H, but with a thicker cross-bar to represent the "core" of the lead; the upright strokes represent the "tapes." At first the leads were cast, but in the 17th century the lead vice was introduced. This is a kind of mangle, with two toothed wheels like coins with milled edges, between which a strip of lead is squeezed, the soft metal emerging in the form already described. Sometimes the wheels had the glazier's name engraved on them, which thus became impressed on the lead as it passed through the machine, and these names are occasionally found on old leading. When the leads, cut to the required length and shape, had been inserted between the pieces of grozed glass, they were next soldered together at the points of junction, and cement or putty was rubbed into the crevices between glass and lead. The window was then ready to move into place, where it was fixed by means of copper wires soldered to the leads and attached to iron saddle-bars let into the masonry. Larger windows were made in smaller units and these units fitted into an iron framework or "armature" which itself often formed a geometric design contributing to the general effect of the window.

From the 12th to the 15th century the technique of stained glass remained practically unchanged, though one minor innovation had a great effect on the character of design. This was the invention, early in the 14th century, of a yellow stain derived from a solution of silver. It formed a very thin film on the glass and was therefore very transparent; on clear glass it varied in tone from pale lemon yellow to deep orange; but it could also be applied to blue glass to produce a brilliant green. Its effect on design was far-reaching and will be noticed when we come to the history of the craft. In the 16th century the technique of glass-painting became more scientific; the glass itself was thinner and smoother and more transparent; two layers of different colours could be put together to produce a third colour; if these layers were fused together, one layer could be ground away or "abraded" (and by a later process "eaten" away by fluoric acid) to give delicate effects beyond the reach of a leaded mosaic. Finally, towards the middle of the 16th century, the art of painting in enamel on glass appeared, perhaps as a result of economic causes which made a scarcity of pot-metal. Hitherto glass had been coloured throughout its substance and was known as "pot-metal," though to obtain sufficient translucency in a dark colour like ruby the glass was "flashed," that is to say, clear glass whilst still pliant was dipped into molten coloured glass, and so received a translucent film of the desired colour. But now ground glass was mixed with various metallic oxides (copper for green, cobalt for blue, manganese for purple, and so on) and the design was then painted on to a clear sheet of glass and fused on. For some time this technique was continued with the old technique of leaded pot-metal; but in the 17th and 18th centuries the old technique disappeared, and the art of stained glass was virtually dead.

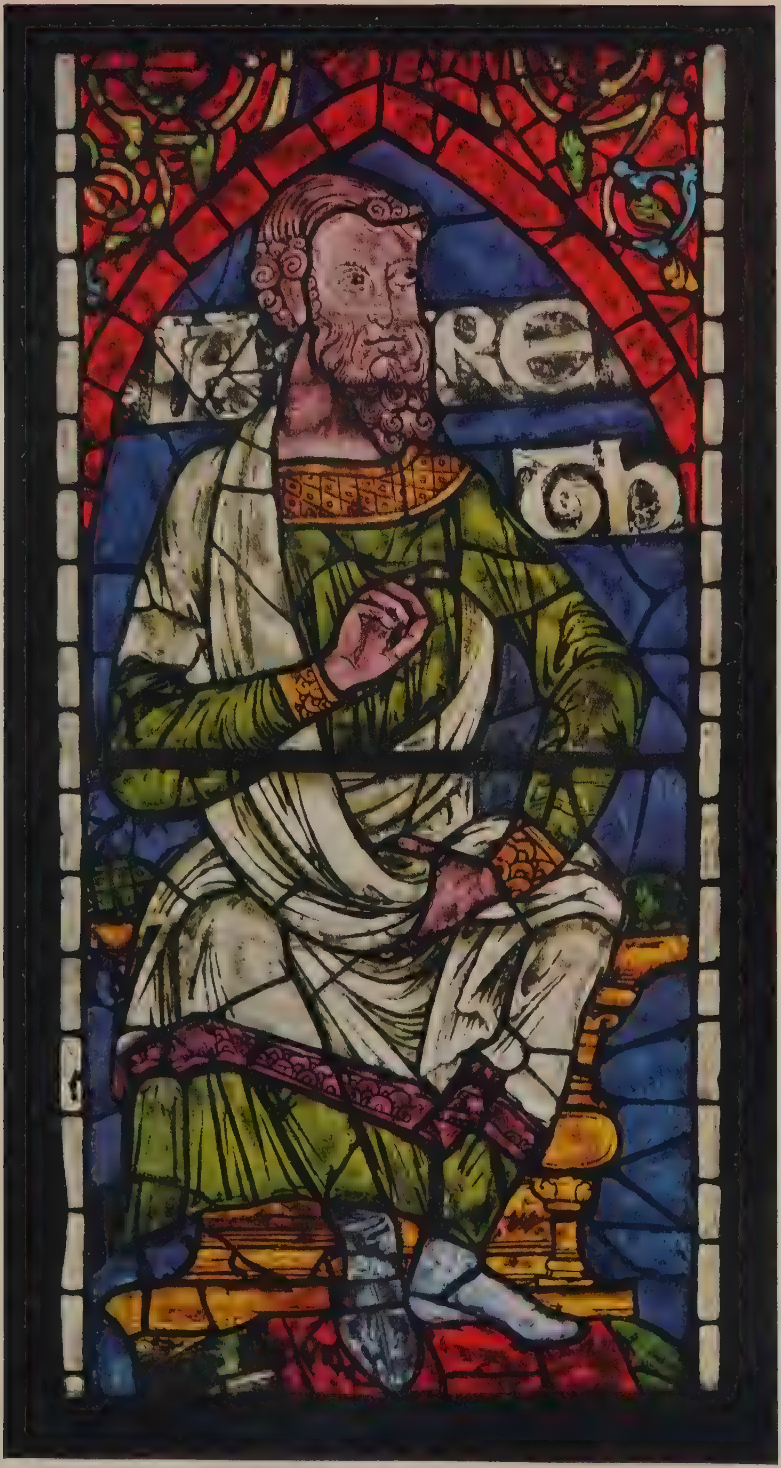
HISTORY

Eleventh and Twelfth Centuries.—The windows at Augsburg, ascribed by Fischer to the middle of the 11th century, have already been mentioned. To the end of the 11th century belongs a window at Le Mans (France) painted with the Ascension. For the 12th century we have in England a figure from a Tree of Jesse in the minster at York, and at Canterbury there is a magnificent series representing the genealogy of Christ which may be dated about 1180. At Chartres there are more important and extensive examples—in the west window is a Tree of Jesse design which is undoubtedly the best surviving stained glass of this century; also the beautiful figure of the Virgin and Child known as La Belle Verrière. Other considerable specimens of 12th century glass exist at Angers, Saint Denis, Châlons-sur-Marne, Bourges, Strasbourg, Poitiers and Le Champ (Isère). The earliest of these windows, such as those at Augsburg and Chartres, are strongly Romanesque in character. The windows at Canterbury come at the end of the Romanesque tradition. They still preserve the monumentality so characteristic of Romanesque design, but the figures are far removed from the rigorously schematic treatment of the Augsburg prophets; there is the first flush of humanism in their bold features. There is a sense of movement in their limbs; a sense of vigour in the formal draperies. The colouring of this Canterbury glass is still typical of the 12th century; the bare flesh is cut in pink glass, whilst the rest of the design is a quiet harmony of blues, pale green, white, brown and yellow, arranged in fairly broad masses with no effort towards "jewel-like" quality. The architectural settings are rudimentary, in most cases representing a simple column on each side of the figure, with an arch spanning the head.

It is probable that most of the early windows were of the single-figure, monumental character of the Augsburg and Canterbury examples. But about the middle of the 12th century a new type of window came into being which consisted, instead of a single representative figure, of a medallion (or several medallions) painted with pictorial subjects, such as incidents from the life of Christ, or from the life of some saint. This change was accompanied by various subsidiary developments. The necessity of telling a story in a series of medallions led to the decorative arrangement of these medallions within an "armature" or iron framework which was itself a subject for pattern, and very beautiful designs were evolved, showing a skilful counterplay of circles, lozenges, quatrefoils and squares, with their appropriate borders and interspaces. This development in its turn necessitated larger windows and this necessity had a profound effect on the development of Gothic architecture itself. A third development was in the actual colour of the glass. The pictorial treatment called for a more detailed and more varied play of colour, and the technical resources of the glass-maker were equal to this demand. The result was that kaleidoscopic or jewel-like glow of colours with which stained glass is always popularly associated. It is in glass of the early 13th century that this property is supremely evident.

Thirteenth Century.—With these early 13th century medallions we first become fully conscious of the part played by the actual painting in stained glass. It is true that the earlier figures had a broad effective scheme of drawing, but with the 13th century medallions a fine dramatic sense of line was developed and continued in force throughout the century. And with the sense of line came that superb sense of dramatic composition illustrated in so many of the medallions of this period at Canterbury, Lincoln, Chartres, Sens, Bourges, Le Mans, Rouen, Cologne, Marburg and Klosterneuburg (near Vienna). The highly stylicized motives of the decorative borders of the 12th century were no longer in keeping with this dramatic mode, and as the century advances we accordingly get a naturalizing of these motives. The formal acanthus leaves of classical inspiration give place to more natural plant motives, to scrolls of oak and vine; these coil with a more organic and vigorous movement, until eventually, in the 14th century, the artists begin to copy directly from their own observation—from the ivy and the wild strawberry.

Towards the last quarter of the 13th century, a greyer mood seems to have descended on our glass-painters. It may be that they were required to give more light in the churches, or that the supply of ruby glass, always somewhat precarious, gave out. Whatever the reason, there developed in the latter part of the



ENGLISH STAINED GLASS

"The Patriarch Jared." 12th century window in the south transept of Canterbury Cathedral. As in much of the mediaeval glass in England, the bare flesh is cut in pink glass, while the rest of the design is a harmony of blues, pale green, white, brown and yellow, arranged in fairly broad masses

13th and early 14th centuries the technique generally known as *grisaille* painting. It implies the use of large areas of clear quarries painted in black or brown enamel with simple and unobtrusive patterns of foliage. Grisaille work at this period is of two kinds: it may consist of geometrical patterns of quarries, often outlined in coloured bands, on which are painted designs of foliage, often in imitation of a trellised plant, or it may be used in combination with subject medallions. The best instance of this latter method is perhaps seen in the windows of the Chapter House at York, which, though now much decayed and obscured, are supreme examples of grisaille work.

These characteristics of 13th century stained glass are general wherever the main stream of Gothic art (*q.v.*) flowed. Distinctions of nationality need not, and indeed cannot, be made. In point of time the medallion windows at Canterbury perhaps come first; then, closest in time and style, come the similar windows at Sens; Chartres comes next and is very impressive in its quantity and scale; at Bourges and Rouen there is glass very similar to that of Chartres; the glass at Lincoln and Beverley in England must be placed somewhere before the middle of the century. But back again in France we find a more distinctive school developing in Paris during the second half of the century, in connection with the building of the Sainte Chapelle and the extension of Notre Dame. The distinguishing feature of this latter style was the general use of a background of trellis-work in blue and red glass, which, in the mass, has a rather unpleasant purple effect. This style scarcely penetrated to England, though an example may be seen in the east window of the south transept of Christ Church, Oxford.

Fourteenth Century.—Midway in the 14th century comes the Black Death, and this catastrophe marks the end of the pure Gothic tradition, in this as in all other arts. Its most marked effect was perhaps reflected in the break-up of the inter-community of Christian art. No doubt other forces, economic or political, were operative too; but the disorganization caused by the Black Death among artists and craftsmen all over Europe resulted in the formation of more limited and more local schools. Onward from 1350 the styles of England, France, Austria and Germany diverge more and more from each other. And within all these countries the local differentiations between various centres are often very marked. The disorganization not only affected traditions, but even more so technique. It seems that the ability to manufacture some of the brilliantly coloured kinds of glass was lost at this time, never fully to be recovered until the 19th century. There was also a Franciscan ban on pictorial windows, which no doubt had some influence in this direction, during the 14th century. But the glass-painters were not slow to react to the new situation; the invention of yellow stain early in the century had provided them with one new resource; and the growing taste for line design, as witnessed in the grisaille glass already mentioned, led to the full exploitation of clear white glass. When once the use of white glass had been forced on the glass-painters, its aesthetic value was appreciated. It may be also that the resultant effect on the lighting of the churches was appreciated, and that the glass-painters began consciously to aim at a clearer effect. Architectural developments kept pace with, and even aided, this changing colour-scale. The windows grew higher and wider, the tracery more intricate, demanding of the glass-painter an effect that was not too heavy for the expanse to be filled, or too clumsy for its delicacy.

Further developments were due not so much to economic factors as to a change in spirit. The 14th century saw the full emergence of that movement towards humanism which had found its protagonist early in the 13th century in St. Francis of Assisi. The tendency towards naturalism which we have already seen creeping into the decorative motives of stained glass was a far wider phenomenon, and involved all art and literature. The new spirit of Franciscan naturalism only manifested itself in plastic art by slow degrees, but it culminated in the Renaissance. It involved a transformation of Christian iconography, and the glass-painter, along with other artists, now deserted the fixed types of early Gothic art for the living types before him. Subjects are now given a contemporary setting; for his figures, his costumes and his architecture the painter looked around him and found models before his eyes. A playful freedom of line gradually developed; as the brush-stroke grew lighter, it grew easier. The features are rendered with more grace and verve; there is almost an excess of curve and curl in eyes and lips and locks. An individualization of the features begins to creep in; we begin to feel the presence of real people, friends and contemporaries of the glass-painter, no longer abstracted, no longer idealized. The folds of the garments lose their angular restlessness and sweep and sway in graceful curves. We get, too, the entry of fashion. The garments in the 12th and 13th centuries are formal and of classical derivation, except in so far as they are ecclesiastical or military. They continue to be somewhat non-committal during the first half of the 14th century, but with the growth of naturalistic treatment and the revival of figure-subjects we get the unmistakable evidences of contemporary fashions. The representation of costume then becomes a matter of course, and is of great assistance in the precise dating of stained glass.

But the most typical and expressive development of ornament is seen in the canopy. This form of architectural ornament no doubt originated in the 12th century, when an architectural unit—generally an arch—was introduced to indicate a building or interior scene. This simple unit became more elaborate during the 13th century, but remained essentially illustrative in intention. Then we get as an early characteristic of the 14th century, the elaboration of this detail into purely ornamental features. The architecture is given the value of pure decoration. At first this is rendered in one dimension, and slender pillars and fretted pinnacles, interchanged in colour, form a simple and effective setting for the figures within the framework. But as the architecture itself becomes more elaborate, its representation in the glass develops. By the end of the 14th century we find an elaborate use of perspective. In the 15th century the spirit of play breaks out even here, and the niches are peopled with angels and coy minstrels. As the century advances the canopies grow more complex, though more representational.

Fifteenth Century.—With this development of the architectural features of stained glass ornament is perhaps bound up a curious retrogression during the 15th century—the abandonment of natural plant motives for stylicized diapers. Artists forsook the carefully observed ivy, oak and vine, and introduced instead such dreary motives as that usually described as the "sea-weed pattern"—an elongated, shapelessly indented leaf, generally painted in reserve on a blue or ruby glass, and seemingly kept as "stock" to be used whenever the design required an indeterminate background. It was a step towards that still more slipshod expedient—the stencilled diaper background of the 16th century. The borders, which had always been an integral part of stained glass design, develop in conformity with the general trend. But their aesthetic function becomes less obvious and they gradually lose decorative value. In the 12th century the border had been the essential framework of the design, enclosing within its definite pattern the otherwise unconfined design. In the 13th century the border existed as a foil for the sequence of separate designs. Then, in the 14th century, when the subject-panel became isolated from its background, the border became a purely decorative feature, contributing a separate unit to the general aesthetic effect; in the 12th century the border framed the design—in the 14th it edged the frame of stonework, its naturalistic form suiting this purpose admirably. Then in the 15th century, with its strange efflorescence of canopy work, the border tended to lose all aesthetic justification; it existed merely as a strip dividing the design from the stonework, and providing, as it were, a transition from one to the other. In this rôle it naturally tended to become more formal in character. Already in the 14th century the typical border of creeping foliage had been varied with alternations of devices such as crowns, chalices, heraldic badges, grotesque animals, small figures of angels, etc.; an exceptional example is to be seen in the famous Bellfounders' window in the north aisle of the nave, York minster, where the border consists of bells (outer lights) and musical monkeys (centre light). The 15th century saw some recovery of the sense of colour. Coloured glass of a variety of colours, but too even and flat in tone to be quite satisfactory, became available on the Continent and was largely imported into England. Already in 1408 the east window at York minster, made by John Thornton of Coventry, is full of a new vitality and gaiety. The covenants for the execution of the glass in the Beauchamp Chapel, Warwick, which are dated 1447, specifically provide for glazing the windows "with Glasse beyond the Seas, and with no Glasse of England; and that in the finest wise, with the best, cleanest and strongest glasse of beyond the Sea that may be had in England." This window was carried out by John Prudde, one of the greatest of English glass-painters, and the result is versatile in the extreme, the colours, jewelled and counterchanged to the utmost limits of ingenuity, blazing with the greatest richness imaginable.

In Germany also, the development was in consonance with the richness and complexity of late Gothic art in general, and here the development may be particularly associated with the name of Hans Wild, whose principal works date from about 1470 to 1480. His most famous window is in the cathedral at Ulm, and shows great boldness and original fantasy in the use of foliage motives. The window becomes a luxuriant trelliswork of flowering plants and pinnacles in the depths of which the human figures tend almost to disappear.

One characteristic of this period is the development of heraldry in glass. We have practically no knowledge or records of the use of heraldry in stained-glass windows previous to the 14th century, though there are three 13th century shields in the apse windows of Westminster Abbey which serve to indicate an early use of heraldic glass. We know from records that these shields were originally placed in the aisle windows, which were of grisaille. But the particular circumstances which brought heraldic glass into general use are hardly consistent with the spirit of early Gothic art. One of the characteristics of the 14th century is the introduction of the personal element into the windows. Donors began to desire their portraits within the design of their window; memorials to the immediate dead began to assume a representational form. At first no attempt at faithful portrayal could be made; the mode and technique of glass-painting at that time forbade it. The shield of arms had therefore the very definite use of identification. But it was soon realized that heraldry had an aesthetic value of its own, and its use multiplied. Glass proved to be especially suitable to the rendering of the formal patterns of the shields, and the brilliancy doubly attractive in this personal emblem. The ground of the shield, which was usually filled in with a diaper pattern, gave the glass-painter an opportunity to exercise his skill in brushwork and his fertility in the invention of decorative motives. The technique of scratching a design with a point through a dense ground of colour, always a pleasant technique in glass-painting, was encouraged by this development. The glass-painter kept pace with the herald, and did not hesitate to attempt the utmost elaboration of curved shield and exuberant mantling. With the Renaissance heraldic glass took on a more restrained appearance—at least, in England, where the common use of the garter and the wreath tended to confine the design within sober limits. Elsewhere, especially in Switzerland, heraldic glass became, during the course of the 15th and 16th centuries, the most typical use of glass-painting.

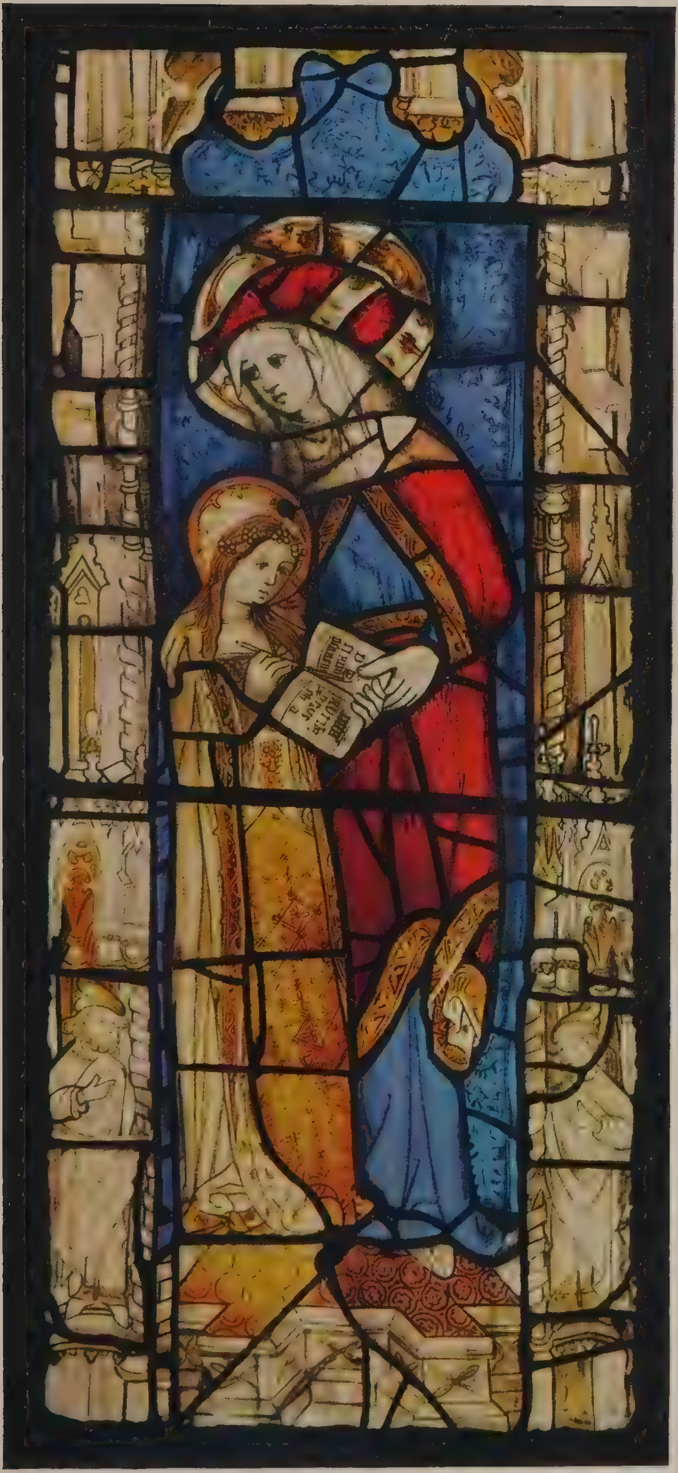
The 15th century saw a great growth and intensification of the individualism we have already noted as arising in the 14th century. Such a development naturally gave rise to the dominance of artists of unusual talent, and to the formation of schools dependent on such artists. A distinct style became established as a local tradition and sometimes persisted over two or three generations. Such schools were formed all over Europe, and particularly in the great ecclesiastical cities. In England, for example, definite schools can be associated with York, Coventry, Canterbury, Winchester, Oxford, Gloucester, Wells, Lincoln, Norwich and Westminster.

The different styles are not always easy to distinguish, and the "schools" are rather in the nature of empirical groupings based on the density of distribution.

Towards the end of the 15th century England suffered a general invasion of foreign artists and craftsmen, a growing influx that reached its culmination early in the next century with the arrival of Torrigiano and Holbein. At this time, in the Netherlands, the art of stained glass had reached a development which, in accomplishment and modernity, was far ahead of the insular style in vogue among English glass-painters. The wool and cloth trades flourished in spite of the wars. The new merchants, earnest Lollards as they were, were eager to turn their wealth to some good purpose, and thus they made the 15th century an age of church building and charitable foundations. And these merchants, moreover, were men of some culture, whose business had brought them into contact with foreign luxuries—particularly those of the Netherlands. When, therefore, they required glass for the beautifully furnished churches which they began to construct in various parts of the country, they demanded glass in keeping with their luxurious tastes, and for this they turned to the men from the Netherlands. In answer to the demand these men came across and, in accordance with the regulations, established themselves within a recognized sanctuary such as the liberty of St. Thomas in Southwark, and assumed English names. As time went on, they became a menace to the existence of the London Company or Gild of Glaziers, and a continual series of disputes between the Gild and the foreigners marks the beginning of the 16th century. But the proper tradition of glass-painting was entirely lost. In the middle ages stained glass thrived as an art subordinate to, or in community with, architecture. With the Renaissance, and the shifting of the dominant emphasis of artistic effort from architecture to painting, the glass-painter found himself in a dilemma. He had to adapt his art to the new conditions, or suffer from the general neglect of arts subordinate to architecture. He attempted to save himself by adopting the aesthetics of painting, and the history of stained glass henceforth is the history of this false step and of all the disastrous consequences.

Sixteenth and Seventeenth Centuries.—But whilst this false aesthetic was developing, there grew up in France and the Netherlands a full-blooded Renaissance style of glass-painting which makes the first half of the 16th century a distinctive epoch in the history of the art. It is a development of the pictorial treatment of the windows on the largest possible scale; the window is regarded as one large canvas; the intersecting mullions are ignored. On this canvas the coloured glass is spread in generous masses and heightened by all the resources of line and shade. The windows gleam with everything that is rich and ornate in colour, design and subject. The glass is thin, but this fault is counteracted by the breadth of the treatment. The Netherlandish type is well represented in England by the work of imported artists, of whom Barnard Flower is the most important. This artist came from the Netherlands, probably encouraged by Henry VII., who made him king's glazier in 1505. Flower executed the whole of the windows for Henry VII.'s chapel at Westminster, and was entrusted with the contract for King's College chapel, Cambridge, but died before he had completed more than four of the windows. It is probable that among the work which may be attributed to Flower are the windows of Fairford church in Gloucestershire, perhaps the most complete unit of stained glass remaining intact in England. King's College chapel, begun by Flower after designs probably by the Flemish artist, Dirick Vellert, was completed by a mixed company of English and Flemish glaziers.

In France, Rouen was the great centre of glass-painting, and that city still offers an incomparable display of the glass of this period, though many other towns, such as Evreux, Châlons-sur-Marne, Dreux, Beauvais, Auch, Troyes and Montmorency, are famous for their windows. In the Netherlands, the most important windows of this period are found in Antwerp, Hoogstraten, Brussels, Liége and Amsterdam, whilst the windows at Gouda, painted by the brothers Dirk and Waiter Crabeth and their pupils, towards the end of the 16th century, are of extraordinary range and completeness. In Germany important schools existed at Strasbourg, Augsburg, Munich, Freiburg-im-Breisgau, Nurem-



ENGLISH STAINED GLASS

"St. Anne Teaching the Virgin." From the east window of All Saints church, York, dated about 1440. The colouring is simple though rich in quality, a characteristic of English glass of this period. St. Anne wears a ruby cloak and bonnet and a blue gown. The Virgin's dress is white, ornamented with a pale yellow pattern, and the background of figures and canopy is blue covered with a diaper. All other parts are white with some yellow stain

berg, and above all at Cologne, the general character of all of which was not essentially different from that of the dominant Flemish or French type. In Italy the period is mainly associated with the name of Guglielmo de Marcillat (1467–1529, sometimes erroneously called William of Marseilles). Windows known to have been made by him exist at Arezzo and Rome, and a very typical example from the cathedral of Cortona, dated 1516, is in the Victoria and Albert Museum. At Florence, where there are also important earlier windows in the cathedral which are said to have been designed by Ghiberti and Donatello, other windows in the style of Marcillat may be seen in the church of Santa Croce. The building of the cathedral at Milan caused an important school of glass-painting to develop there, and the work of Cristoforo de Mottios and Nicolo da Varallo carried out during the second half of the 15th century is of great beauty. The Milan school continued in full activity during the 16th and 17th centuries. In Spain, especially at Seville, León and Avila, magnificent windows of this period exist, but they are in all cases the work of Flemish glass-painters.

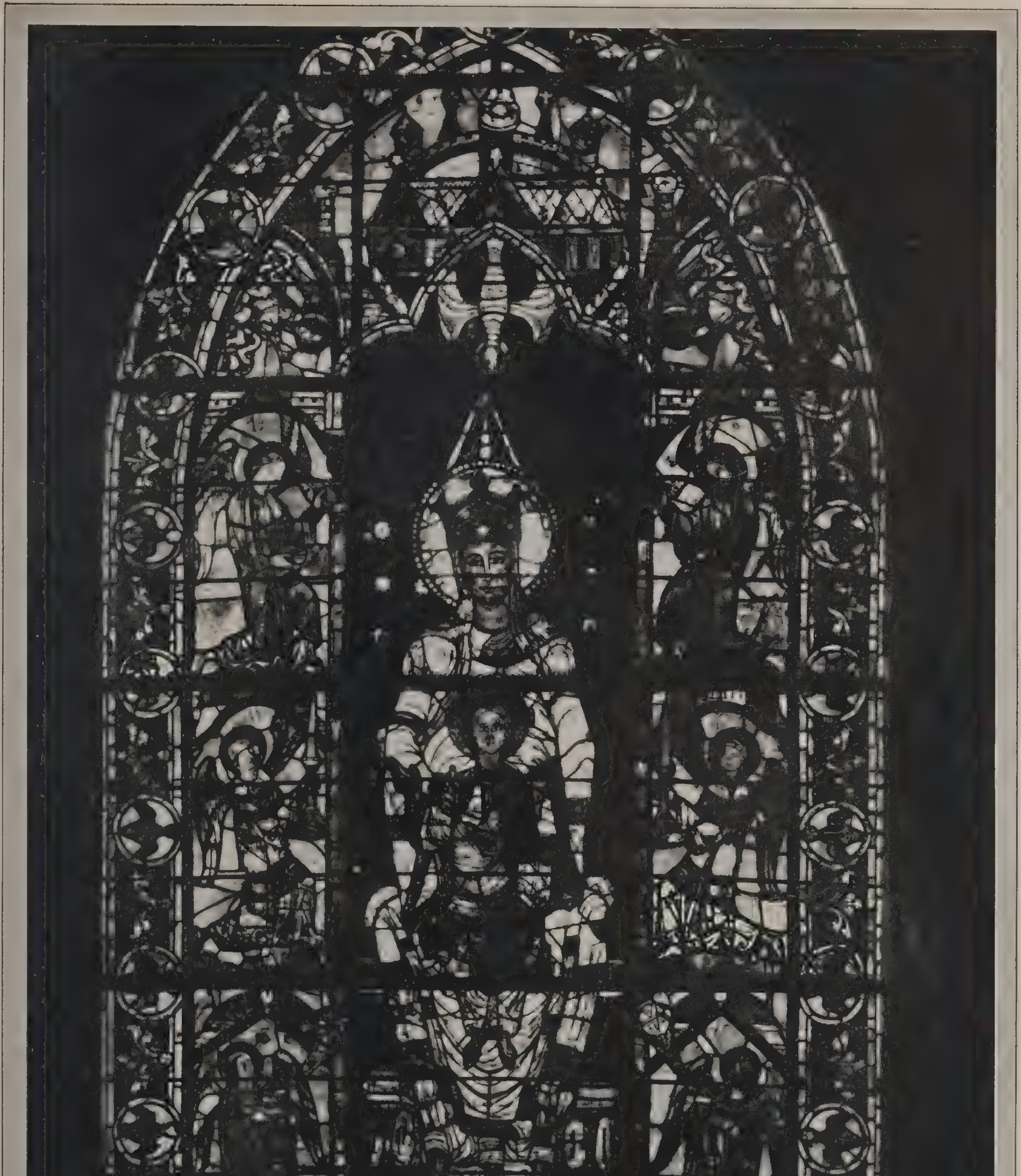
In the 17th century we find the highest level of glass-painting in Switzerland, though actually that level had been surpassed in its own country during the 16th century, when Holbein and Burgkmair were leading designers of the panels typical of that country. But the real significance of Switzerland in the history of glass-painting is that there alone was evolved an appropriate technique of enamel-painting. For various reasons of a social kind, glass-painting in that country had acquired a more domestic character; it actually became part of the furniture of the people, and a panel for the window of a room was as natural, and even more usual, than a picture for the wall. Glass-paintings thus became intimate and portable—a kind of *Kleinmalerei* comparable to the development of *Kleinplastik* in sculpture. Within the limits of this littleness, the art of enamelling glass developed an appropriate technique. It was, indeed, the technique of painting—of translucent painting—but then the Swiss panel *was* in all essentials a painting. To the same category belong the roundels painted in grisaille which were produced in large quantities during the first half of the 16th century. In these types of glass-painting the specific problems of distance and architectural harmony did not enter into the question; everything was made for nearness and intimacy. And on this scale stained glass was inappropriate, ungainly and without effect.

The same observations might be made of the Dutch and Flemish glass-paintings of the 16th and 17th centuries, which illustrate the enamel technique in both its good and bad aspects, and it was through these, rather than the Swiss, that the new style penetrated to England. Abraham and Bernard van Linge (who flourished about 1620–40 and painted many windows in Oxford and elsewhere) were the chief of these immigrants, but they were ably imitated by native artists such as Henry Gyles of York (1645–1709), the Price and the Peckitt families of the same city, and by artists like Francis Eginton (1737–1805) and James Pearson (d. 1805), who carried the art right on to the threshold of the 19th century. At their best, the achievements of the glass-painters in this *genre* have a miniature delicacy and a perfection of means beyond reproach. But it must be realized that we have entered on a new art, with its own aesthetic, and we must beware of any confusions of judgment in this respect. The unfortunate truth is that in England (and elsewhere in Europe) it was the glass-painters who were guilty of confusion. Social custom never called upon them for a domestic art comparable with Swiss glass-painting, but nevertheless they attempted to apply the methods of the domestic glass-painters (but without their technical skill) to the quite different needs of ecclesiastical buildings. The result was generally ludicrous, and always inappropriate. The crowning example of this misalliance of two inconsistent arts is to be found in the window designed by Sir Joshua Reynolds for New College chapel, Oxford, which was actually carried out by a china-painter.

The art of glass-painting in England during the 17th and 18th centuries does not offer sufficient material for any comparative criticism or positive judgment. We see nothing but scattered individuals, each expressing his own wayward fancy, displaying some ingenuity, supplying some passing need, but achieving nothing of significance.

Eighteenth and Nineteenth Centuries.—The Gothic revival that came as an offspring of the Romantic movement of the late 18th and early 19th centuries was not without its effect on the art of stained glass. The styles and methods of the early Gothic period were reconstructed, but devoid of all inner reason or inspiring sentiment. The art thus reduced to sterile formulas was easily commercialized, and factories for the manufacture of windows, any size, any subject and colours to taste, sprang up all over Europe, but especially in Germany. From this state of things the Pre-Raphaelites and William Morris (*qq.v.*), largely inspired by Ruskin, revolted, and whatever faults we may impute to them, we must nevertheless acknowledge that they made a feeling for design once again a vital force in the social life of England—and, indeed, eventually of Europe. We cannot enter here into the general character of Morris's achievements, but the basic fact upon which all his ideals rested was an intense aesthetic appreciation of mediaeval art. As much, perhaps, can be said of the initiators of the Gothic revival, though we may suspect that as an aspect of romanticism their enthusiasm sprang from a sense of the remoteness, the strangeness, and the mysterious gloom of this earlier art rather than from any real understanding of its rational basis or religious significance. But Morris had a more logical appreciation of the Gothic, and his attitude was as free from insincerity as it was devoid of any desire to imitate. He realized that without the spirit, the form could not exist, and his real greatness and overwhelming importance in the history of modern craftsmanship springs entirely from the fact that he attempted to evolve a style and invent a technique appropriate to the expressions of his age. Burne-Jones designed his first cartoons for stained glass as early as 1857, and the St. Frideswide window in Christ church, Oxford, dates from 1859. These early windows were carried out by Messrs. Powell of the Whitefriars Glasshouse, but from 1861 Burne-Jones worked exclusively for Morris. Stained glass was included in the first exhibition of the work of Morris, Marshall, Faulkner and Company in 1862. But the work of this period is weak in design and uncertain in technique. No attempt had been made to work out the proper function of the leads in the design, and the enamels are either poor in quality or badly fired. But even so, there was a certain freshness of attitude and a revolt against the dead conventions of the time. But as the demand for stained glass increased, so more thought was given to these matters and the improvement was rapid. In Morris's fully developed style, as in the cathedral at Birmingham, there is little to complain of in the technique of his glass. Time has yet to show whether the materials will weather so well as the 13th century materials, but in this matter Morris was at the mercy of other people; he did not make his own glass, but obtained the best he could find in the market. In other technical matters Morris need not fear comparison with any age. His selection and disposition of colours is admirable, and he was not afraid of using new colours to achieve effects unknown to previous ages. In the use of leads to emphasize design he is masterly, and we must go back to the 13th century for an adequate comparison. The best examples of windows by Morris and Burne-Jones are to be found in Christ church, Oxford (the St. Cecilia and St. Catherine windows, 1874–75 and 1878), the "Judgment" window at Easthampstead (1875), the two windows in Salisbury cathedral (1879), the east window of St. Peter's, Vere street, London (1881), a window representing the Resurrection at Hopton (1882), the well-known windows in the cathedral at Birmingham, perhaps the finest of all (1887), and (perhaps the most important in London) the windows at Holy Trinity, Sloane street. What is reputed to be one of the finest examples of their work (1882) is a window at Biarritz in France, representing the marriage at Cana. In addition to all the work designed for churches, and confined in the main to Biblical subjects, Burne-Jones and Morris made a good deal of stained glass for domestic or secular purposes. In their choice of subjects for this profane glass, they perhaps unduly confined themselves to the romantic and literary

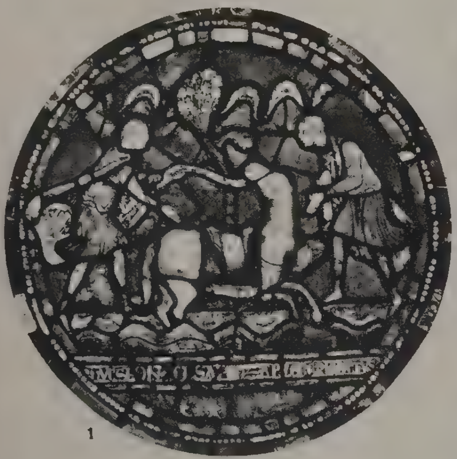
	12th century and earlier	13th century	14th century	15th century	16th century	17th and 18th centuries
England	Canterbury, York, Lincoln, Lanchester, Bradbourne, Dorchester Abbey	Canterbury, York, Lincoln, Beverley, Salisbury, Waterperry, Chartham, Westwell, West Horsley, Aldermaston, Upper Hardres	Oxford (Merton College and Christ Church), Wells, Gloucester, York, Hereford, Tewkesbury, Winchester, Ludlow, Deerhurst, Durham, Eaton Bishop, Arlingham, Notgrove, Fladbury, Edgeworth, York, Carlisle, Westonbirt, Chetwode, Beer Ferrers, Exeter, Norbury, Hereford, Selling, Stanford, Mancetter, Selby, Waterperry	Great Malvern, Gloucester, Little Malvern, York, Warwick, Coventry, Ludlow, Margaretting, Leicester (Museum), Long Melford, Hessett, Blakeney, Levrington, Martham, Canterbury, Norwich, Gresford, Windsor, St. Neots (Cornwall), Llandrynog, Norbury, Cirencester, Bristol, Battlefield, Durham, Thornhill, Almondbury, Orchardleigh, Westwood, Ettington, Bledington, Barkway Ash, Oxford (Bodleian Library), Ockwells Manor, Winchester, Berkhampstead, West Wickham, Stamford, East Harling, Bury St. Edmunds, Combe	Fairford, Cambridge (King's College), St. Margaret's, Westminster, The Vyne in Hampshire, Basingstoke, Winscombe, Llanrhaidr, Stoke D'Abernon, Gilling	Lydiard, Tregoze, York, Oxford, London (Lincoln's Inn Chapel, St. Andrews, Holborn), Guildford, Ashtead, Stoke Poges, Southwell, Hagley
France	Le Mans, Châlons-sur-Marne, Poitiers, Le Champ (Isère), Angers, Aubazine, Bonlieu, La Bénisson-Dieu, St. Denis, Lyon, Normée, Pontigny, Strasbourg, Varennes, Vendôme	Reims (Cathedral), Rouen Le Mans, Semur-en-Auxois, St. Sulpice-de-Favières, Châlons-sur-Marne, Montiers-Hubert, Bourges, Soissons, Strasbourg, Poitiers (Cathédrale and Ste. Radegonde), Chartres, Séez, Sens, Troyes, Lyons, Clermont-Ferrand, St. Martin-au-Bois, Orbais l'Abbaye, Tours, Châteauroux, Vendôme, Angers, Auxerre, Beauvais, Brie-Comte-Robert, Essomes, Dijon (Notre-Dame), Wissembourg, Paris (Notre Dame, Ste. Chapelle), St. Julien-du-Sault, Gassicourt	Angers, Avioth, Beauvais, Chartres (Église-St. Pierre), Evreux, Colmar, Dol, Clermont-Ferrand, St. Dié, Embrun, Limoges, Lyon, Mulhouse, Carcassonne, Mussy-sur-Seine, Narbonne, Niederhaslasch, Albi, St. Pierre-sur-Dives, St. Quentin, Rouen (St. Ouen), Séez, Semur-en-Auxois, Strasbourg, Vieux-Thann, Tonnerre (Hôpital), Toul, Toulouse, Troyes, Villeneuve-sur-Lot, Westhoffen	Rochefort (Rhône), St. Romain-au-Mont-d'Or, Wissembourg, Villefranche-sur-Saône, Walbourg, Châlons-sur-Marne, Abbeville, Riom, Aigueperse, Alençon, Le Mans, Saint-Saens, Le Bourget, Ambierle, Villeneuve-sur-Lot, Vieux-Thann, Ambronay, Argentan, Saverne, Sélestat, Solignac, Verneuil, Obernai, Beaujeu, Bernay, Paris (Ste. Chapelle, St. Séverin), St. Quentin, Rouen, Beaune (Hospice), Bourges, Saint-Lô, Saint Nicolas-du-Port, Chartres, Thann, Carentan, Carcassonne, Metz, Strasburg, Chamelet, Ceyzériat, Séez, Coutances, Embrun, Évreux, Moulins, Eymontiers, Lantic, St. Léry, Lisieux, St. Martin d'Estréaux, St. Omer, Quimper	Alençon, Ambronay, Angers, Autun, Grand-Andely, Montmorency, Argentan, Troyes, Bayonne, Autun, Auch, Chantilly, Châlons-sur-Marne, Brou, Brissac, Champigny-sur-Vende (Chateau), La Ferté-Milon, Vic-le-Comte, Limours, Rigny-le-Ferron, Conches, Pontoise, Saint-Julien-du-Sault Triel, Saint-Firmin, Lisieux, Rouen, Bourges, Paris (St. Gervais) Gisors, Villy-le-Maréchal, Moulins, Limours, Pont-Audemer, Montreuil, St. André-d'Apchon, Andrésy, Aumale, Auxon, Baignon, Bannalec, Bar-sur-Aube, Bar-sur-Seine, Baux, Beaumont-le-Roger, La Baussaine, Beauvais, Bécherel, Bernay (La Couture), Bignan, Blanzy-le-Château, Blénod, Bordeaux (St. Michel), Bourg, Bourg-Achard, Bourgtheroulde, Brienne-le-Château, Brienne-la-Vecille, Chailly, Chambéry, Champeaux, Chartres (St. Aignan), Châtillon-sur-Seine, Davenay, Dijon (Notre-Dame), Ecouen, Elbeuf, Epernay, Falaise, Fécamp, La Ferté-Bernard, Flavigny, St. Firmin, Les Ifs, St. Julien, Limoges, Lombez, Louviers, Metz, Nogent-le-Roi, Paris (St. Étienne-du-Mont, St. Germain-l'Auxerrois, St. Gervais, St. Médard, St. Merri), Pont-Audemer, Pont-de-l'Arche, Pont l'Évêque, St. Quentin, Quimper, Rennes, Rigny-le-Ferron, Riom, Roanne, St. Saens, Sablé, Sens, Tours, Vendôme, Verneuil, Villefranche-sur-Saône, Vincennes (Château), West-Capelle	Auch, Bourges, Caudebec, Charmes, Ecouen, Guingamp, Malestroit, Le-Mesnil-Aubry, Neuville-sur-Saône, St. Nicolas-de-la-Taille, Orleans (Ste. Croix) Paris (St. Étienne-du-Mont, St. Eustache, St. Germain l'Auxerrois, St. Germain-des-Près, St. Gervais, St. Médard. St. Merri, N. D. des Blancs, Manteaux, St. Nicolas du Chardonnet), Pont-de-l'Arche, Quillebeuf, Rouen, Savianges, Toulouse, Troyes Versailles (Château)
Germany and Austria	Augsburg, Goslar, Helmstedt, St. Magdalena, Weitensfeld	Metz, Naumburg, Cologne, Soest, München-Gladbach, Marburg, Merseburg, Haina, Bücken-an-der-Weser, Heimersheim, Heiligenkreuz, Bonn (Museum), Nuremberg, Coblenz, Friesach, Heiligenkreuz, Vienna, Stift Ardagger, St. Ruprecht ob Murau, St. Michael bei Leoben	Marburg, Esslingen, Freising, Cologne, Soest, Nuremberg, Lübeck, Erfurt, Regensburg, Herford, Altenburg, Markterlbach, Coblenz, Metz, Limburg-an-der-Lahn, Rothenburg-ob-der-Tauber, Prague, Klosterneuburg, Gurk, Lieding, Wels, Vienna, St. Florian, Wiener-Neustadt, St. Leonhard-im-Lavanttale, Graz, Gars, Strassengel, Pram	Ulm, Augsburg, Regensburg, Munich, Blutenberg, Soest, Freiburg, Dortmund, Xanten, Lüneburg, Tübingen, Straubing, Erfurt, Metz, Ingolstadt, Rothenburg o.d.T., Nuremberg, Stendal, Werben, Northeim, Halberstadt, Altötting, Friedberg, Cologne, Judenburg, St. Leonhard-im-Lavanttale, Tamsweg, Friedersbach, Göttweig, Wels, Nonnberg, Laxenburg, Wiener-Neustadt, Stifts Zwettl, Klosterneuburg, Vienna, St. Florian	Metz, Cologne, Nuremberg, Straubing, Xanten, Kyllburg, Ingolstadt, Wilsnack, Schwerte, Treves, Ansbach, Münster (Westphalia), Hanau, Immenhausen, Herford, Munich, Freiburg i.B. Landsberg, a.L., Augsburg, Tölz, Salzburg, Wiener-Neustadt, Steyr	Schwerin, Brunswick
Italy		Assisi	Milan, Orvieto, Assisi, Florence, Siena	Florence, Lucca, Pisa, Milan, Pavia, Prato. Assisi, San Miniato, Arezzo, Saronno, Siena, Bologna, Val d'Ema, Grosseto, Venice (SS. Giovanni e Paolo)	Milan, Florence, Rome (Santa Maria del Popolo), Perugia, Val d'Ema, Calcinaio (near Cortona), Arezzo, Monte San Savino, Bologna, Lucignano, Siecina, Siena	Milan
Netherlands			Tournai	Lierre, Diest, Tournai, Mons	Brussels, Herenthals, Gonda, Antwerp, Bruges, Diest, The Hague, Liége, Hoogstraeten, Lierre	Antwerp, Brussels, Diest
Spain			Leon, Toledo, Gerona	Leon, Burgos, Avila, Toledo, Oviedo, Barcelona, Gerona	Leon, Granada, Segovia, Barcelona, Avila, Tarragona, Toledo, Cervera, Astorga, Gerona, Seville	Seville, Segovia
Switzerland		Zurich (Museum)	Königsfelden, Zurich (Museum)	Basle, Zurich, Wettingen, Hilterfingen	Basle, Berne, Zurich, Wettingen, Lucerne	Zurich, Wettingen



BY COURTESY OF E. HOUVET

STAINED GLASS CATHEDRAL WINDOW

"La Belle Verrière," one of the stained glass windows of Chartres Cathedral, France. The figure of the "Virgin and Child," is strongly Romanesque in character. Work of the 12th century



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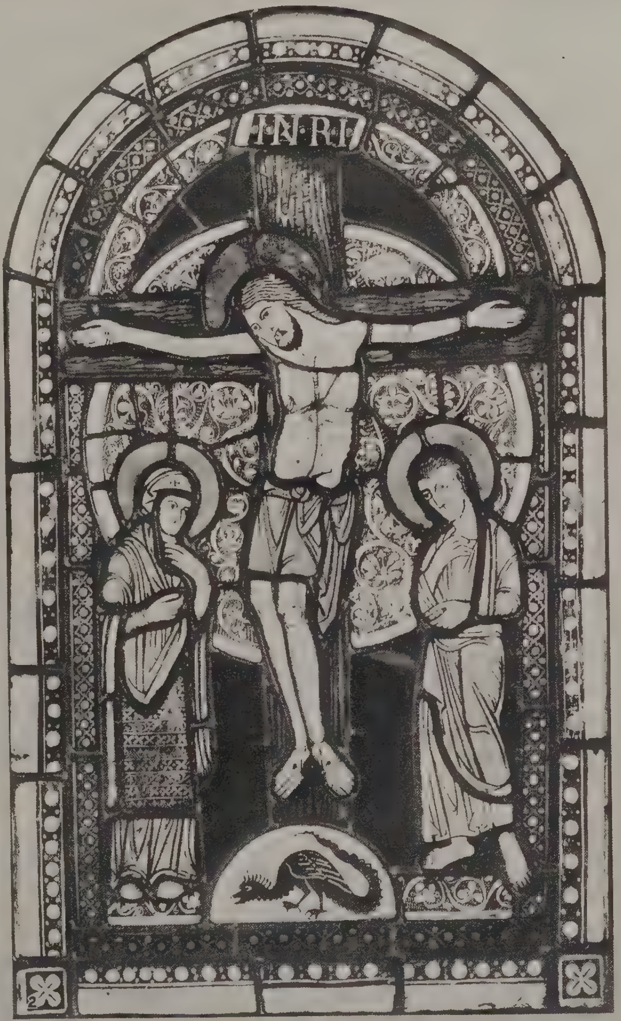

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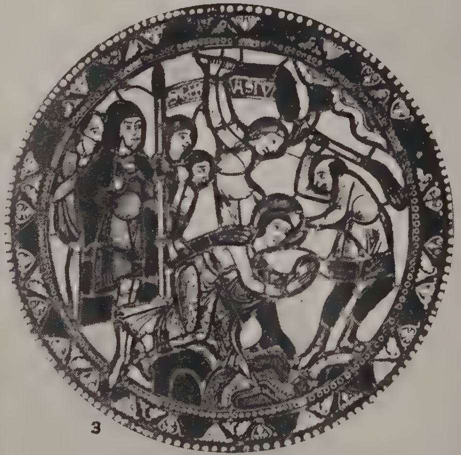

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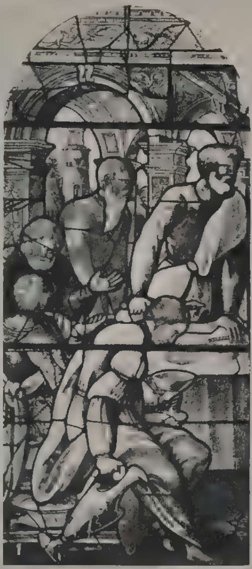
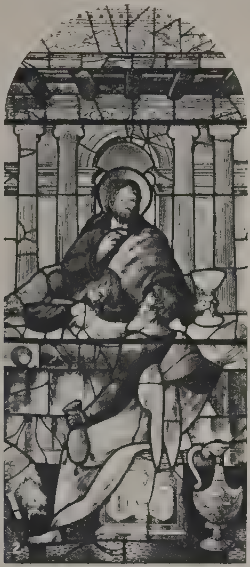
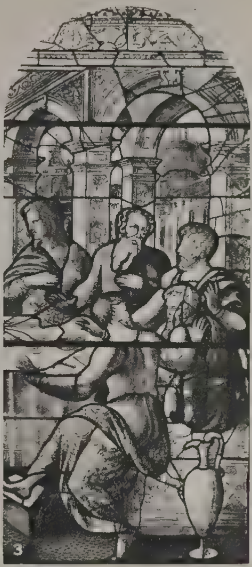
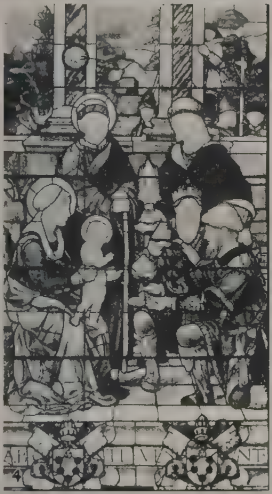
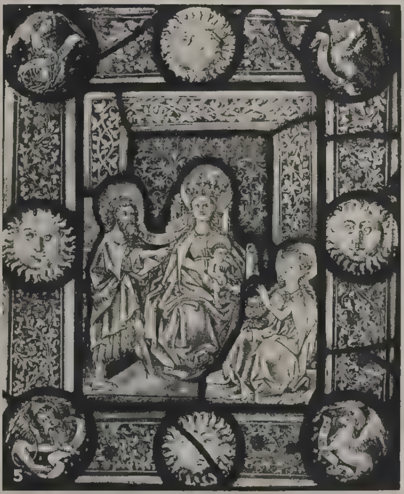
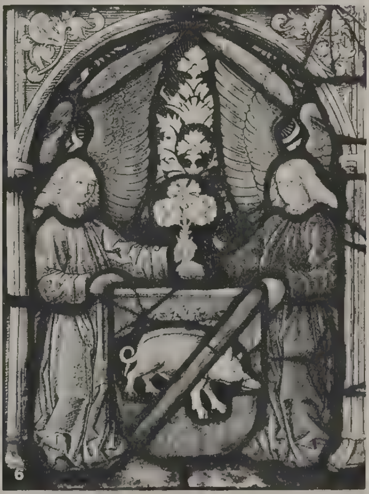
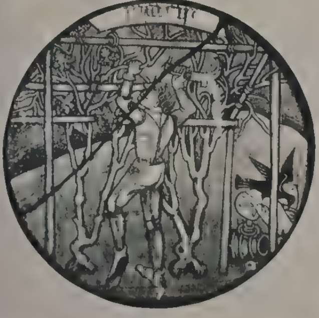
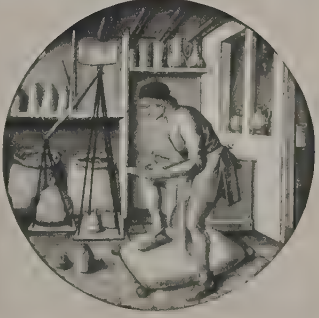
BY COURTESY OF (1) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM, (2) JULIUS BARD; PHOTOGRAPH, (3) LEVY AND NEURDEIN

STAINED GLASS OF THE 12TH AND 13TH CENTURIES

1. Medallion from a series illustrating the story of John of Roxburgh. In Trinity Chapel, Canterbury Cathedral. English, 13th century
2. "The Crucifixion," work of 12th century. German (Rhenish). Now in the Schloss Museum, Berlin
3. Medallion from a series illustrating the life and deeds of Saint Gervais. In Le Mans Cathedral. 12th century, French

PHOTOGRAPHS, (1, 2, 3) BY GRACIOUS PERMISSION OF HIS MAJESTY KING GEORGE V; BY COURTESY OF (4-8) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM

EXAMPLES OF 15TH AND 16TH CENTURY STAINED GLASS

1, 2, 3. Panels depicting scenes of "The Last Supper." French (Rouen School); dated 1542

4. "The Adoration of the Magi," by Guglielmo de Marcillat, Italian. About 1516. From Cortona Cathedral, Italy

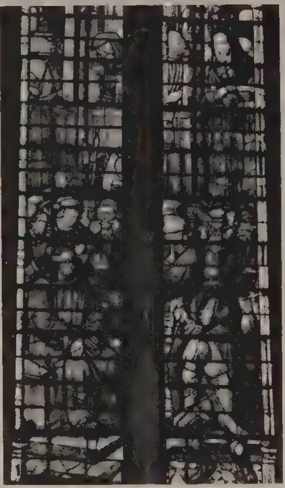
5. "The Virgin and Child," 15th century, German

6. A heraldic panel, Swiss, 16th century

7. "The Month of March," Roundel, from a series of the Labours of the Months. English, 15th century

8. "A Merchant in his Warehouse." An example of Flemish stained glass about 1530

STAINED GLASS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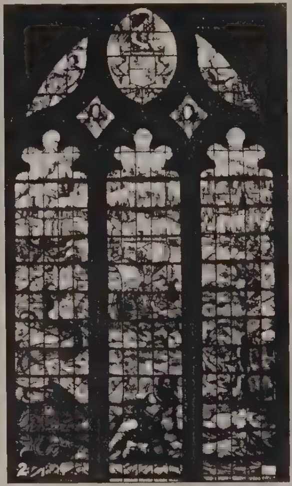
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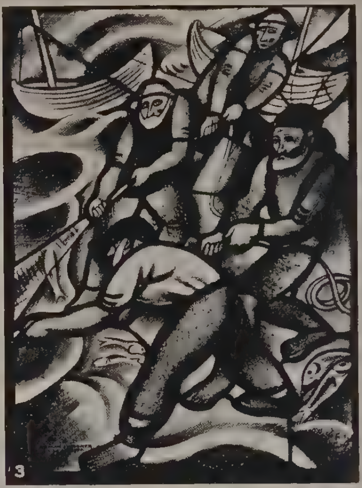
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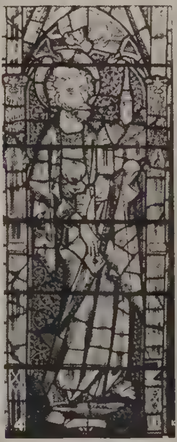
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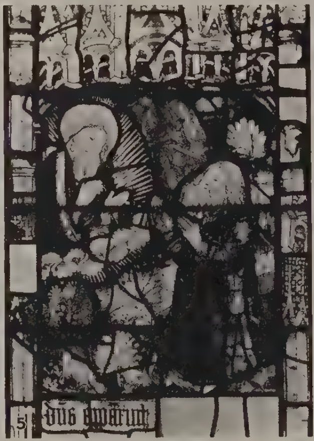
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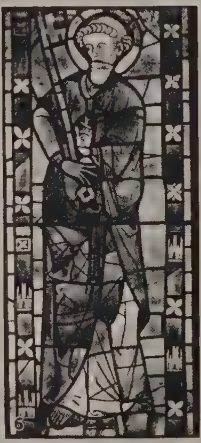
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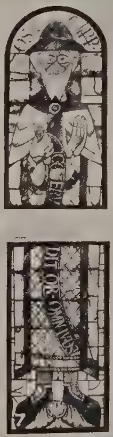
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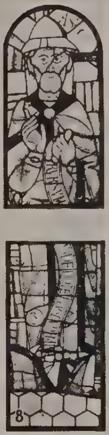
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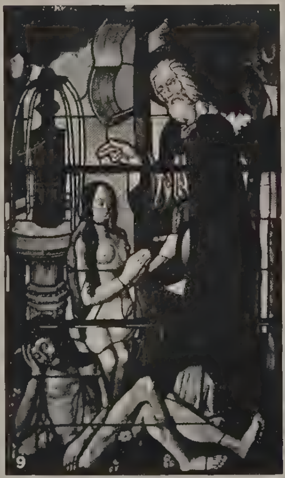
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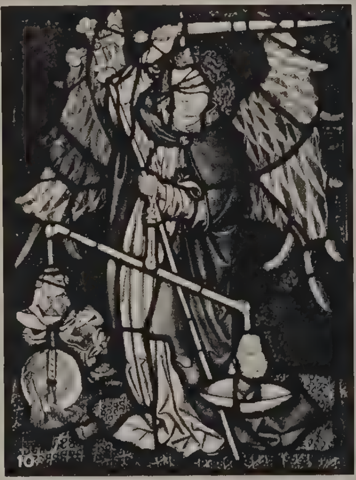
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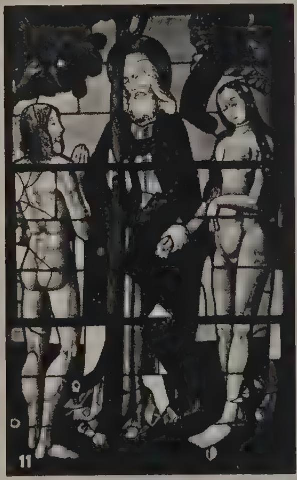
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BY COURTESY OF (6, 10) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM, (9, 11) COLLECTION ARCHIVES PHOTOGRAPHIQUES; PHOTOGRAPHS, (1, 2, 4, 5) SYDNEY PITCHER, (3, 7, 8) PUHL AND WAGNER

1. "The Mocking of Christ," English, early 16th century. In King's College Chapel, Cambridge. 2. "Jonah and the Whale," by Abraham Van Linge. In University College Chapel, Oxford. Dated 1635. 3. "Fishing." Example of modern German stained glass, Seewald, executed by G. Heinersdorff. 4. "St. Peter," English, middle 14th century. In Gloucester Cathedral. 5. "God Appearing unto Abram." English, middle 15th century. In Great Malvern Priory. 6. "St. Peter." French, second half of 13th century. From Sées Cathedral, Normandy. 7 and 8. "Prophets." German, 11th century. In Augsburg Cathedral. 9. "The Creation of Eve," in the Cathedral, Chalons-sur-Marne. French, middle 15th century. 10. "St. Michael," German, 14th century. 11. "The Institution of Matrimony" another stained glass window at Chalons-sur-Marne

predilections of their circle; but here again we cannot criticize their stained glass without entering into a discussion of their whole point of view. It is perhaps sufficient to say that it lacked the immediacy and the reality which we are entitled to expect from any contemporary expression of ideals.

The principles which William Morris established and followed give us an adequate criterion for the criticism of modern stained glass. It is sad to confess how little these principles have been followed in England itself. There is no longer any vital contact between the glass-painters and the significant artists of the day. And in all directions there is a relapse into a servile and lifeless imitation of mediaeval mannerisms, due to a natural disregard for those self-sacrificing ordinances which Morris observed. It seems that only the complete filling of every window in every old church will ever terminate this atrocious vandalism. There might be some satisfaction in the prospect if it were certain that that would put a stop to what is known in the trade as "period work"; but these *pastiches* of the art of other epochs find their way into practically every new church that is built, and the only hope of any reform would seem to lie in the final triumph of those principles for which William Morris stood. For these principles are not altogether dead; they have merely migrated, and on the Continent, especially in Germany, there is a school of glass-painting which is not only modern in intention, but is inspired by all that is vital and significant in modern art.

Like the stained glass of William Morris, this modern continental stained glass is both religious and secular. The work of Jan Thorn-Prikker and of Karl Schmidt-Rottluff has given to the symbols and images of Christianity a new intensity and realism for which there is no parallel this side of the Renaissance; and the abstract designs in which these glass-painters have experimented seem to open up infinite possibilities for this art of pure colour and light. These artists work under the direction of Gottfried Heinersdorff for the Berlin firm of Puhl and Wagner. In France, interesting experimental work is being done, for example, by MM. Mauméjean of Paris and Hendaye. Stained glass, which dominates all other arts in this matter of colour, would seem to be peculiarly fitted for those experiments in abstract design and harmony which have been distinctive of a certain phase of modern art. The difficulty in all contemporary glass-painting of a non-ecclesiastical kind, is not so much to extend the possibilities of the art in the direction of design and actuality, but rather to find a function for the art itself. For that we must look, with whatever faith we can summon, to those manifestations of civic and commercial enterprise for which our age is distinguished. At Hagen, in Germany, the railway station has fine modern glass by Jan Thorn-Prikker; in Paris, the offices of a newspaper, *L'Intransigeant,* have windows with appropriate designs by Henri Navarre executed in leaded glass by Gaëtan Jeannin. But these are isolated instances of what seems to be the only chance of a revival of the art commensurate with its possibilities. There is nothing impossible in such a revival; the technical and material resources of the art are greater than they have ever been. All that is lacking is the desire; and to foster this we cannot do better than instil a wider consciousness of the unique and unrivalled beauties of the art as it has existed in the past.

(*See* Painting; Grisaille; Interior Decoration; Mosaic; Heraldry; Gothic Art; Renaissance; Genre; Architecture, Church; Glass.)

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STAINES, a town in Middlesex, England. Pop. of urban district (1921) 7,326. A British village was situated at the Thames on the main road from London, and the crossing was one of the earliest bridged. A grant of oaks from Windsor forest for the repair of the bridge is recorded in 1262. The existing bridge, from the designs of George Rennie, was opened in 1831, after three bridges had failed in the previous forty years. The name of Staines appears in the Domesday Survey, and is attributed to a stone marking an early limit of the City of London.

STAINLESS STEEL is a term used in a broad sense, particularly in America, to cover all "rustless steels" (*q.v.*) or iron alloys designed to resist atmospheric corrosion, attack by organic solutions, hot or cold acids or chemicals, or scaling at elevated temperatures. In the restricted sense the term applies as a trade name to cutlery steels containing not more than 0·70% carbon and from 9 to 16% of chromium patented in 1916 by the English metallurgist Brearley. Chromium is the principal alloying element in most stainless metals (in the broad sense used above). Stainless or rustless iron contains less than 0·10% carbon and usually from 12 to 18% chromium, the balance being iron. It is inherently stainless to atmospheric corrosion, resists most acids and chemicals fairly well, and can be fabricated and worked cold like mild steel. Most of the possible iron-carbon-chromium compounds up to 3% carbon and 60% chromium have been patented, in addition to the Brearley patent noted above, and many of them containing more than 20% chromium, either in the form of forgings or castings, are non-scaling, *i.e.,* will withstand oxidation at 1,100° C for weeks. Such are very useful for furnace parts or pots to withstand flame. High chromium steels containing considerable nickel, for instance 17% chromium and 8% nickel, are non-rusting and are austenitic (*q.v.*) in structure, very tough, may be hardened by cold work, and are being widely adopted by the chemical industry for processing equipment. Addition of silicon improves the resistance to scaling of this and plain chromium steels (gas engine valves, for instance, contain 8% chromium and 3% silicon). Other alloying elements are also used for special purposes. Superior resistance to hot or cold hydrochloric acid (until recently unobtainable by any but the noble metals) is given by an alloy of 20% iron, 20% molybdenum and 60% nickel. While the entire field of iron-carbon-chromium-nickel-silicon alloys is so big that the surface has barely been scratched, to say nothing of possible additions of tungsten, molybdenum, cobalt, copper, manganese, and aluminium, enough is known of the properties of various stainless alloys so that small pieces or large equipment which will corrode or scale no faster than 0·02 in. per year can now be furnished for nearly all commercial liquids or industrial atmospheres. (E. E. T.)

STAIR, JAMES DALRYMPLE, 1st Viscount (1619–1695), Scottish lawyer and statesman, was born in May 1619, at Drummurchie in Ayrshire. After seven years as regent of the University of Glasgow he resigned, going to Edinburgh, where he was admitted to the bar on Feb. 17, 1648. In 1649 he was appointed secretary to the unsuccessful commission sent to The Hague to treat with Charles II. by the parliament of Scotland, and was sent in the following year to Breda, where the failure of Montrose's expedition forced Charles to change his attitude and to return to Scotland as the covenanted king. Stair met him on his landing in Aberdeenshire. He refused in 1654 to take the oath of allegiance to the Commonwealth. Three years later (1657), Stair was appointed a commissioner of justice in Scotland, on the recommendation of Monk. After the Restoration he was received with favour by Charles, knighted, and made a judge in the court of session. He refused to take the declaration that the National Covenant and the Solemn League and Covenant were unlawful oaths, and, forestalling deposition, he resigned. The king, however, summoned him to London, and allowed him to take the declaration under an implied reservation. In 1669 a family calamity, the exact facts of which will probably never be ascertained, overtook him. His daughter Janet, who had been betrothed to Lord Rutherford, was married to Dunbar of Baldoon, and some tragic incident occurred on the wedding night, from the effects of which she never recovered[1].

In 1670 Stair served as one of the Scottish commissioners who went to London to treat of the Union. In Jan. 1671 he was appointed president of the court of session. In 1672, and again in 1673, he was returned to parliament for Wigtownshire. When the Test Act was enforced Stair, dreading a fate similar to that of Argyle (*q.v.*), went to London to seek a personal interview with the king; but the duke of York intercepted his access to the royal ear, and when he returned to Scotland he found a new commission of judges issued, from which his name was omitted. He retired to his wife's estate in Galloway, and occupied himself with preparing for the press his great work, *The Institutions of the Law of Scotland,* which he published in the autumn of 1681, with a dedication to the king. He repaired to Holland in Oct. 1684, and took up his residence, along with his wife and some of his younger children, at Leiden, where he published the *Decisions of the Court of Session between 1666 and 1671* and a small treatise entitled *Physiologia nova experimentalis.*

In his absence a prosecution for treason was raised against him and others of the exiles by Sir G. Mackenzie, the lord advocate, but it was dropped, owing to the appointment of his son, the master of Stair, who had made his peace with James II., as lord advocate in place of Mackenzie. Stair returned from Holland in the suite of William of Orange. In 1689 he was again placed at the head of the court of session. He was attacked by an anonymous pamphleteer, perhaps Montgomery or Ferguson the Plotter, in a pamphlet entitled *The Late Proceedings of the Parliament of Scotland Stated and Vindicated.* He defended himself by publishing an *Apology.*

Shortly after its issue he was created Viscount Stair (1690). The massacre of the Macdonalds of Glencoe (Feb. 13, 1692), for which his son, the master of Stair, was largely responsible, naturally reflected on him. On Nov. 29, 1695 Stair died in Edinburgh.

Stair's great legal work, *The Institutions of the Law of Scotland deduced from its Originals, and collated with the Civil, Canon and Feudal Laws and with the Customs of Neighbouring Nations* is important for the historical study of Scottish law. *See* J. Murray Graham, *Annals of the Viscount and First and Second Earls of Stair* (1875); A. J. G. Mackay, *Memoir of Sir James Dalrymple, First Viscount Stair* (1875); and Sir R. Douglas, *Peerage of Scotland,* new ed., by Sir J. B. Paul.

STAIR, a series of steps arranged one above the other, occasionally varied by platforms known as "landings." The total height of a stair is the "rise," the total horizontal distance between the top and bottom steps is the "run." A series of steps without a landing is called a "flight." The horizontal surface of a step is called its tread, and the vertical front its riser. The projection of the tread beyond the face of the riser is termed a nosing.

Long use has demonstrated that certain proportions of riser and tread are safe and easy. For interior stairs twice the height of the riser, plus the length of the tread, should be 23, all dimensions being in inches. A variant is that the sum of rise and tread should be between 17 and 17½ in.; a third rule specifies that the product of rise and tread, in inches, should be not less than 70 nor more than 75. In general, English usage advocates a slightly lower rise for a given tread than American usage, while in Europe the rise is frequently greater. For exterior stairs, the general usage is to keep the riser below 6 in., and the tread above 12.

It is uncertain what is the oldest stair in existence. On the sacred road up the mountain of Tai Shan, in Shantung, China, there are many great flights of ancient granite steps. In Egypt stairs in pylons exist which date from the second millennium B.C. Assyria has left massive stairs on the ziggurats (*q.v.*), which date from the 9th and 8th centuries, B.C.; and the palace terrace at Persepolis has a double flight of steps, of great beauty, which shows the skill of the Persians in the 6th century B.C.

Further west, stairs play an important part in the Cretan palaces, as in the palaces at Knossos and Phaistos (both *c.* 1500 B.C.). In Hellenic Greece the monumental stair was of less importance, due to the Greek love of informal and picturesque approaches. Thus in Athens the propylaea of the Acropolis was probably entered by a winding path and the present great flight of stairs, dating from the Roman period, is not part of the original design. In the post Alexandrian period there developed a new love of monumental grandeur, largely Asiatic in origin, which produced such magnificent stairs as those of the altar of Zeus at Pergamon (180 B.C.). A similar monumental sense distinguished Roman stairs. Those of the propylaea at Baalbek (time of Hadrian), over 100 ft. wide, are typical, and again and again stairs are made essential parts of great architectural conceptions, as in the temple of the Sun on the Quirinal hill at Rome, built by Aurelian (A.D. 273), some of the steps of which were taken, in 1348, to build the famous stairs of the Aracoeli on the Capitoline hill at Rome.

Although during the middle ages stairs were used more for utilitarian than aesthetic purposes, where they were necessary they received adequate treatment, usually more direct and informal and more picturesque than those of the Roman tradition. Thus at Le Puy en Vélay, in France, the 11th century cathedral, which was built on a hilltop, is approached by a magnificent stair that provides a superb foreground to the polychrome façade. The steps that mount up to and past the apse of the 14th century cathedral at Erfurt, in Germany, show the direct and beautiful relationship between the building itself and the stairs which is characteristic of the best Gothic usage.

The Renaissance produced a recrudescence of the tradition of Roman formality in stair design. Particularly magnificent are the stairs of the Baroque period, such as the so-called Spanish stairs at Rome in the Piazza di Spagna (1723–26), by F. de Sanctis, those of the Campidoglio, at Rome (begun 1547), by Michelangelo and the infinitely varied terrace stairs of the Italian villas. The inspiration of these Italian Baroque stairs was felt throughout Europe and is largely the foundation of stair design in modern city and garden planning. Thus the enormous stairs of the gardens of Versailles (1667–88), by A. Le Nôtre, owe much to the Italian precedent, and were themselves imitated widely all over Europe. Among modern stairs may be noted the extremely lavish stairs of the monument to Victor Emmanuel II., in Rome (begun 1885), by Giuseppe Sacconi, with the altar of the Patria; the broad flights leading up to the library of Columbia university, New York (1896), by McKim, Mead and White; Waterloo steps in London (1831–34), by Benjamin Wyatt and those of the Lincoln memorial at Washington, D.C. (1924), by Henry Bacon.

In the Orient, the stairs leading down to the river at Benares, in India, of various dates, combine monumentality and picturesqueness; a similar skill is shown in the design of large numbers of temple and palace steps throughout the peninsula. Further east the ruins of Angkor use wide flights of steps with magnificent effect in connecting the various levels of the terraced group. The Chinese have always been superb stair designers and builders, and there is hardly a temple or large house or palace which does not owe some of its effect to its stairs, either monumental and formal, like those of the Forbidden City or the Temple of Heaven, both in Peking, or winding and informal, as in Chinese garden design. Many of the temple stairs have, in the centre, an inclined plane running the entire height of the rise, richly carved with the symbolic dragon—the so-called spirit stairs by which the beneficent powers are supposed to enter. In Japan the tradition is much more informal, but the hilly nature of the country makes stairs an important feature of almost every temple layout. (T. F. H.)

STAIRCASE, a term for stairs accompanied by walls. The earliest staircases seem to have been built with walls on both sides, as in Egyptian pylons. Contemporary models of houses, dating back to the Middle Kingdom, show a staircase leading up the side of a court to a roof terrace, with continuous wall below. The origin of such stairs may have been earlier structures in wood, or even ladders cut out of logs. Egyptians may have used the self-supporting staircase in which each step is supported at its front by the step below and prevented from turning by having its end built solidly into a wall.

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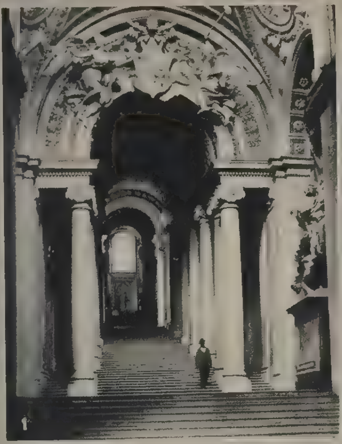
[1] Sir Walter Scott took the plot of his *Bride of Lammermoor* from this incident, but he disclaimed any intention of making Sir William Ashton a portrait of Lord Stair.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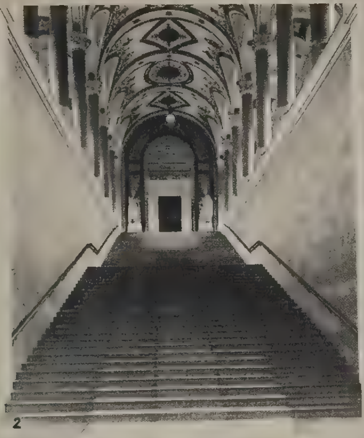
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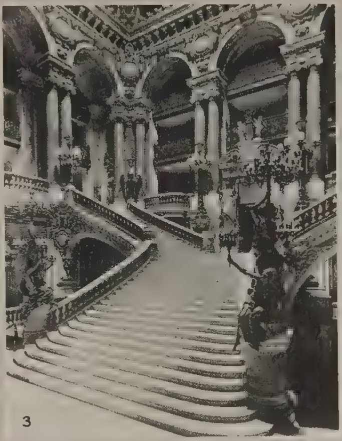
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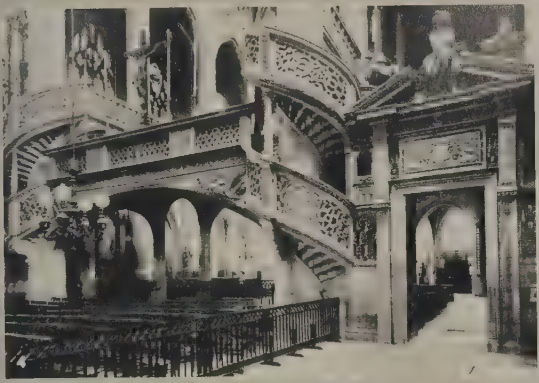

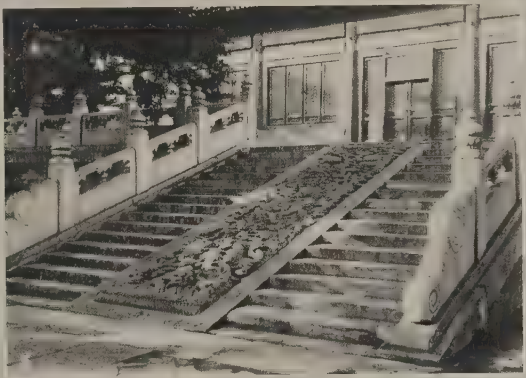

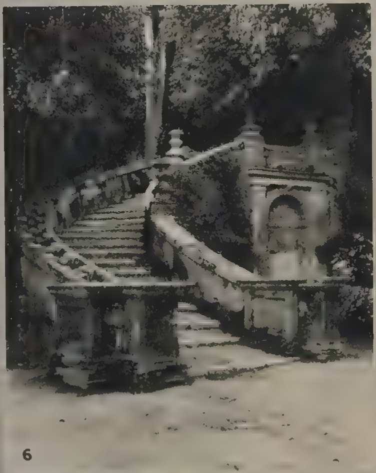
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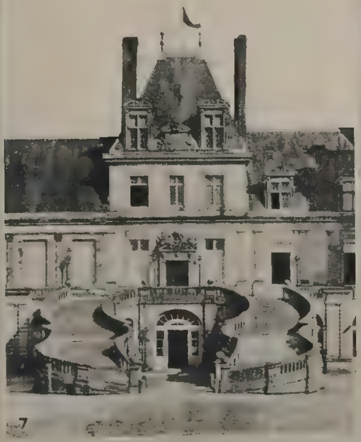
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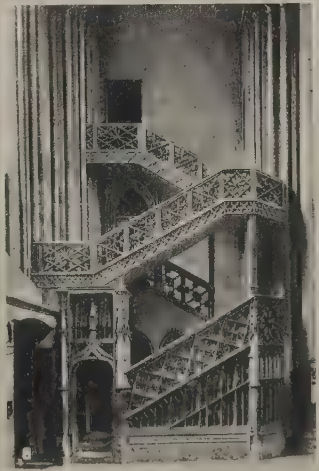

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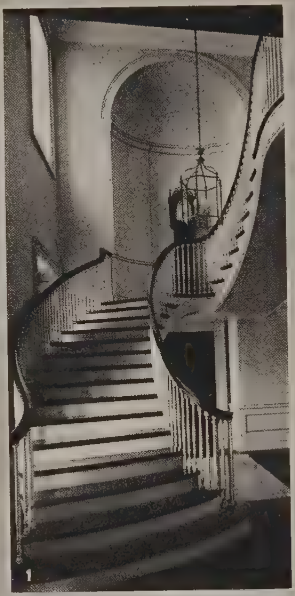
OLD WORLD STAIRCASES

1. The Scala Regia in the Vatican palace, designed by Bernini and built between 1663–66. Skillful use of exaggerated perspective by the progressive shortening of the columns makes it one of the most impressive of all monumental staircases. 2. The main staircase of the Bavarian State library, designed by Friedrich von Gaertner in the middle of the 19th century, has extreme simplicity as its key note. The contrast of plain wall and colonnade above gives an effective touch. 3. The gorgeous staircase of the Paris Opera, by Charles Garnier, 1861–74. 4. The spiral stairs leading to the jubé or choir loft, in the church of St. Etienne du Mont, at Paris, 1600–05, by Biard, reveal the rich and delicate charm so characteristic of the French early Renaissance. 5. The terrace stairs of the temple of Confucius at Peking have the characteristic Chinese marble balustrades and in the centre a flat ramp, lavishly carved with dragon shapes, to form a spirit way by which beneficent spirits could enter. 6. One of the picturesque and simple stairs in the famous gardens of the Villa d'Este connecting the many levels. 7. The horseshoe staircase in the palace at Fontainebleau, 1634, by J. du Cerceau, noteworthy for the daring Baroque curves of its plan and famous as the place where Napoleon took leave of his troops before going to Elba. 8. The staircase, of flamboyant Gothic, built in the transept of Rouen cathedral, 1477–79, to allow direct entrance to the chapter library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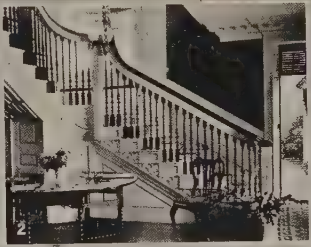
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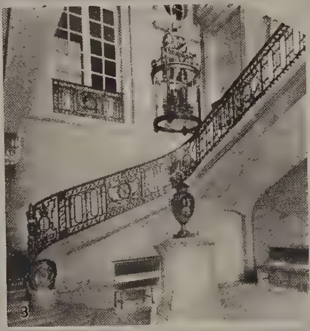
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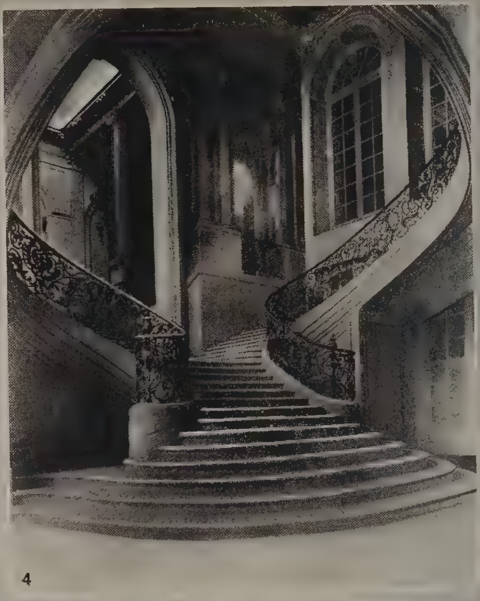
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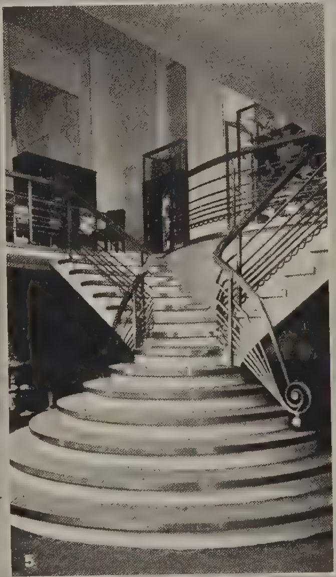
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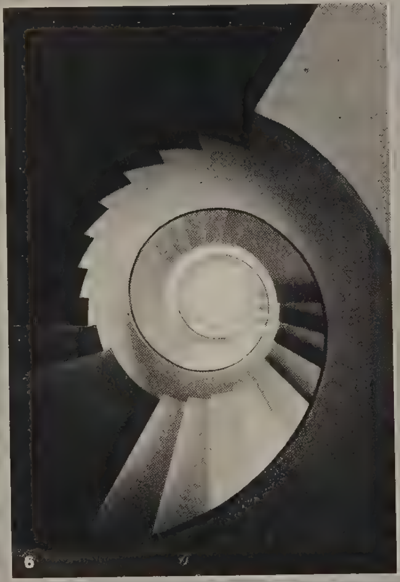
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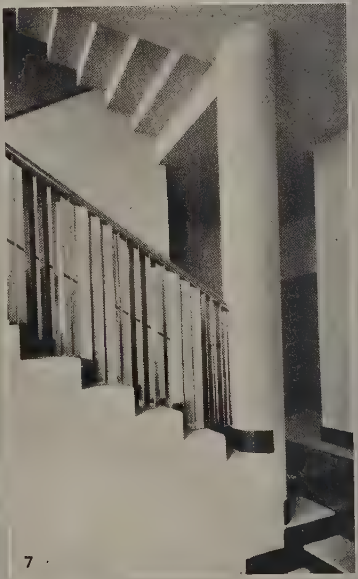
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RENAISSANCE AND MODERN STAIRCASES

1. Staircase by John Russell Pope in the Sloane house in New York, a characteristic modern interpretation of late Georgian delicacy and detail
2. The staircase of the third quarter of the 18th century, in the Moffatt-Yard-Ladd house in Portsmouth, N.H., characterized by the panels, bracketed ends and lavishly turned balusters, so typical of the developed American colonial
3. The famous stairs of the Petit Trianon at Versailles, though built by Gabriel in 1766 under Louis XV., show a simple delicacy and a use of straight lines characteristic of the style known as Louis XVI.
4. Much more typical of Louis XV. work is the lavish and monumental stairs of the Hôtel de Ville at Nancy, France, designed by E. Here, with iron work by Lamour
5. Modern freedom in design, the effort to combine many materials and to contrast straight and curved lines, characterize a stair designed by Patou in a Paris shop (La petite Jeannette)
6. The circular, concrete staircase in the Martel house in Paris, designed by R. Mallet-Stevens, an austere simplification of the more extreme types of modernism
7. In his Paris house, the same architect, Mallet-Stevens, combines concrete stairs with a railing of aluminium whose narrow aluminium supports, set at varying angles, catch varying reflections

Greece and Rome.—In classical Greece, interior staircases were common but unimportant; they were placed in out of the way corners, and often built of wood. In Rome, a new treatments for staircases became necessary. Many of the apartment houses indicated on the marble plan of Rome (*c.* A.D. 205), now in the Palazzo dei Conservatori at Rome, seem to have had stair towers built in the centre of a courtyard. The Colosseum (*q.v.*) at Rome (completed A.D. 80) has elaborate and practical entrance and exit stairs, by which the crowds could be readily handled. These, in general, are supported by sloping vaults and roofed by others. Similar staircases were common in the theatres.

Byzantine and Romanesque.—Merely inclined planes lead up within enormous buttresses at the ends of the narthex of S. Sophia (532) at Constantinople, so giving access to the galleries. In S. George at Salonica (late 5th century), a spiral staircase surrounds an open well. In the early Romanesque there is a growing use of the spiral staircase. To this development the great thickness of Romanesque walls and buttresses was particularly congenial, as it allowed the staircases to be built in solid masonry. Not only was the open circular well used, but the solid newel, in which each step had cut upon it a cylindrical form to act as part of the newel. This type of spiral staircase is still in use.

Gothic.—The Gothic spiral staircase was cut with the utmost cleverness. We have the radial stone cut in two levels, so that the ascent was twice as fast as by the ordinary method, thus allowing the radius to be remarkably decreased. Such circular staircases as lead up in the traceried turrets of the spire of Strasbourg cathedral in Alsace (1435) are miracles of daring design and delicate execution. The late Gothic period also produced a great number of beautiful interior staircases, like the "Stair of the Library" in Rouen cathedral (1477–79), which show that the possibilities of the staircase with straight runs were at last being realized. Of rich interior spiral staircases, the early 16th century staircase leading to the organ in S. Maclou, in Rouen, and the contemporary staircase to the jube (*q.v.*), or rood loft, of S. Étienne du Mont in Paris (in which a certain amount of Renaissance feeling is present) are noteworthy. In the larger houses the lack of communicating passages led to many staircases. Thus in the house of Jacques Coeur at Bourges (*c.* 1450), there are eight separate spiral staircases, whose exterior treatment, in rich, traceried towers, furnishes a great deal of the picturesqueness and varied beauty of such a building.

Renaissance.—During the Renaissance, despite such *tours de force* as Vignola's spiral stair in the palace at Caprarola (*c.* 1550), the general practice was to have important staircases run up in a straight flight, sometimes varied by landings, and sometimes with changes in direction between walls often crowned with a slanting vault. The most perfect developments of this type were made chiefly during the Baroque period. The magnificence of the huge interior flights of the Genoese palaces (*e.g.*, the "University," 1623, by Bianco) is famous. The Scala Regia is particularly remarkable in the artificial exaggeration of its perspective, through the gradual diminution of width and height as the steps ascend. In France the spiral staircase added by Francis I. to the château at Blois (1515–24) and the double circular staircase of the château of Chambord (begun 1519) are remarkable. The early Renaissance, however, produced its most remarkable results in the richly ornamented wooden staircases of Tudor and Jacobean houses. The usual arrangement was to have the staircase divided into comparatively short flights, at right angles to each other, around a central open well; the heavy newels at the corners were finished with urn-like finials at the top and carved drops at the bottom, the railing consisted of a large rail supported either by miniature arcades or square balusters, whose mouldings were often sloped to follow the stairs, and the whole was covered with intricate surface ornament of strap work. The staircase at Hatfield house (1611) is typical. The early Renaissance staircases of Spanish palaces are in most cases placed in one corner of the courtyard and run up between walls to a landing with a return flight that opens out onto the upper floor gallery. The walls, and sometimes even the treads and rises, are often cased in brilliant faience tiles. Even in staircases of more Italian type, with balusters, the richness of wall surface remains, as in the staircase of the hospital of S. Cruz at Toledo (1504–14), by E. de Egas. The climax of Spanish Renaissance monumental stair design is reached in the "Escalera Dorada" at Burgos cathedral (1519), by D. de Siloe, with its exquisite metal railing.

The developed classicism combined with the Baroque of the later 16th century to give a new trend to staircase design throughout Europe. Thus in France a gorgeous series of staircases was produced, of which the "Escalier des Princes" of Versailles is typical. The reaction to the lightness and gaiety of the Louis XV. period (*see* LOUIS STYLES) led to the development of many gracious and inviting house staircases of the type known as self-supporting, full of sweeping curves and with railings frequently of metal. In the Louis XVI. period the new, popular classicism restrained the exuberance of the earlier staircases but retained their graciousness and lightness; of these, one of the loveliest is that of the Petit Trianon at Versailles (1766), by Gabriel, with a beautiful iron railing. Meanwhile, the classic trend had expressed itself in England by the substitution of open string for closed string stairs, that is with the balusters coming down to the top of each tread, rather than being supported on a slanting member, or string, which received the ends of the treads. This at once made for a more interesting treatment at the ends of the steps, and led, eventually, to the development of the bracketed step end, in which scrolls and leafage of great richness were carved under the end of each riser. Moreover, the fact that English stairs were largely of wood inspired the design of turned balusters and newels of great variety. During the last half of the 18th century, a growing trend toward lightness and delicacy of design led to the substitution of plain, tapered shafts in place of elaborate balusters, and the use of stairs rising in continuing curves instead of straight flights and landings. The same development took place during the 18th century in the colonial work of North America. Thus certain of the earliest houses, like the Capen house at Topsfield, Mass. (1683), have closed strings and heavy newels of Jacobean type, while the Lee mansion at Marblehead, Mass. (1768), has a magnificent open string staircase, whose steps have panelled and scrolled ends, and whose twisted balusters are as rich as any contemporary work in England. The curved staircase of the Valentine museum at Richmond, Va. (1812), is typical of the later delicacy.

Modern.—During the middle and the third quarter of the 19th century, staircase design reached its lowest ebb, not only in England and France, but throughout Europe, except in the case of those monumental and official buildings on the Continent whose design never fell a victim to the current taste. Closed strings again became the fashion and balusters and newels of gargantuan proportions and bulbous and meaningless elaboration. Yet one of the most gorgeous and effective staircases in the world dates from this period, that of the Paris Opéra (1861–74), by Charles Garnier.

Two elements have vastly affected modern staircase design, steel and reinforced concrete. The use of steel has led to simple plans of straight runs and railings delicate and straightforward in design, with newels usually accented, as in the Jacobean wooden stairs. Reinforced concrete, on the other hand, is a material so flexible that the most daring curves and fantastic sweeps become structurally sound. Probably the most brilliant example of this modern type of staircase design is in the new portion of the Galeries Lafayette at Paris (1926), by F. Chanat, a conception of dizzying lightness, with modernist iron railings.

STRUCTURAL DESIGN

Stone and Marble Staircases.—Modern stone and marble staircases are of two main types. In the first the actual exposed treads and rises form, themselves, the structural elements. In the other type the treads and rises are supported upon a separate structural base which may consist of a masonry vault, a steel framework or a reinforced concrete slab. In the first class, in which the steps themselves are structural, the staircase is usually built into a wall at one side. Each step rests for a small distance upon the step below and is built into the wall for a distance sufficient to make the weight of the wall above prevent it from turning.

The undersides of the steps, where exposed, are frequently cut to form an inclined surface, following the slope of the stairs, and may be decorated with panelling or carved or other ornament. This type of stair can be used both for straight and curved runs, and is particularly applicable to monumental entrance halls, where the stair, in a triple run with two landings, or in a continuous, curved sweep, fills a recess opposite the door. In such staircases the railing is usually of metal with the uprights securely dowelled into the ends of the steps. Stairs somewhat similar can be built with the ends of the steps built into the walls on both sides, where a monumental run rises between two walls.

Wooden Staircases.—These can be divided into two classes, closed and open string stairs. In both the essential support is given by rough timbers called carriages, which follow the slope of the stairs and are cut roughly to the shape of the under side of the steps. In the case of closed string staircases both sides of the staircase are finished by a sloping, straight-sided plank, approximately an inch and a half thick, on the inner faces of which grooves are cut, whose upper and outer faces exactly fit the top and side of the tread and riser; the under and inner sides are, however, sloped, so that wedges may be driven in to force the tread and riser boards into position and hold them with perfect rigidity. Similar wedges are driven in between the rough carriages and the under sides of treads and risers. To give additional strength, the treads and risers are, themselves, rebated together, so that a small, projecting strip of the tread fits into a groove in the bottom of the riser, and a similar strip on the top of the riser fits into a groove on the bottom of the tread. The projecting portion of the tread is moulded and an additional small cover mould placed below to cover the joint.

In the open string staircase the strings at the end are cut to the shape of the steps, and the vertical cuts are usually mitred at 45°, so that the ends of the risers, also mitred, may form with them an invisible joint. In the ends of the treads dove-tailed sockets are left to receive the dove-tailed ends of the balusters; a moulding, exactly similar to the nosing, is then applied across the end of the step, and covers the bottom of the balusters. At times, bracketed and carved pieces are mitred at the ends of the risers and applied over the face of the string. It is this type of staircase that was the rule during the Georgian period in England and in the developed American colonial and early republic work. Where an open string stair is built against a wall, it is usually finished at the wall end by a closed or housed string, similar to that described, forming a base-board for the wall.

The structural strength for a wooden staircase is usually furnished by framing a heavy member, called a header, at the top and bottom of every run; to these headers the rough carriages are spiked, and the newels, if they exist, firmly fastened. The newels themselves are designed to receive the finished stair strings, and also the finished string member that is occasionally used at the edges of a floor in the stair-well opening. In staircases similar to those of the early 19th century in England and America, in which newels did not exist, except at the bottom, and in which stair rails and balusters were of the most extreme attenuation, and the whole frequently laid out with complex curves, strength was achieved by the most exquisite workmanship, whereby the careful framing of every part made the finished staircase an independently rigid structure. Frequently the curved plan itself furnished a certain amount of lateral rigidity. In modern staircases of this type additional strength is obtained by inserting iron or steel bands into the hand-rail; occasional balusters may be of steel, well fastened to the string.

Steel Staircases.—These have become almost universal in modern fireproof buildings of all types, except where unusual monumental effect is desired, and the design of steel staircases is largely standardized. They consist of a steel string on each side, which takes the form of a plate or channel of sufficient rigidity to carry the weight.

Iron spiral staircases are usually formed of cast iron members, each of which forms a tread and riser, and has at its inner end, a collar arranged to slip over a vertical pipe or cylindrical bar forming the central newel. Such spiral staircases are rigid independently of any wall, and are frequently used in open spaces, such as those existing in power houses, gymnasiums and the like. Reinforced concrete, sometimes finished as artificial stone, is used for stairs and permits of infinite variety of form.

Moving Staircases.—In many places where continuous transit between floors is necessary, as in large shops, underground railway stations and the like, moving stairs, sometimes known as escalators, are much used. These are of two types. In one, an endless belt carries on its surface links or blocks of sufficient roughness to act as treads. This endless band, at top and bottom, rotates around wheels or pulleys, motor-driven. At the bend the band disappears through the floor into a slot armed with steel arms, so designed as to occur one in each groove between the raised portions of the treads. Another continuous band on each side, geared to the same speed, serves as a hand-rail. The other type has a similar mechanical basis, but the belt, instead of carrying directly upon its upper surface blocks to form the treads, is designed to motivate actual continuous horizontal treads with risers radially shaped, so that at top and bottom the treads slide up on the risers into a continuous moving plane. Moving handrails are furnished as in the other type, and in addition, a moving band angularly across the top and bottom, to remove automatically any dropped objects. Moving stairs of the second type are always entered and left at the side, those of the other type directly at top and bottom.

Legal Regulation.—As stairs form one of the most necessary methods of exit from a building, their design has formed one of the most important portions of the building legislation of modern municipalities, especially in the case of public, commercial, industrial and educational buildings. Although there is much variation in the detailed requirements of different cities, the methods of regulation are almost the same and state: (1) where fireproof stairs are required; (2) the number of staircases; (3) size; (4) design. Thus, in addition to the universal requirements for structural solidity, the attempt is generally made to furnish at least two stair exits to any large, enclosed, upper floor area; and where fire risk and the danger of panic are unusually great, as in the case of theatres, to demand sufficient stairs to allow the building to be emptied in a very short time, without disorder. Widths of stairs are frequently determined in accordance with the number of people using them. In New York, for instance, each staircase must be designed to contain all the people of the floor area it serves, on the basis of one person to each 21 in. of width and each one and one half treads. Design is controlled by specifying the relationships of tread and riser, the distance apart and size of landings, whether or not curved stairs are allowed, etc., and often, because of the smoke danger, requiring exit stairs to be enclosed in a fireproof tower, with fireproof, self-closing doors at all entrances.

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STALACTITES are pendent masses formed where water containing mineral solutions drops very slowly from an elevation. (Gr. σταλακτός, from σταλάσσειν, to drip.) They are seen, for example, beneath bridges, arches and old buildings where water percolating through the joints of the masonry has dissolved very small quantities of the lime present in the cement and mortar between the stones. On exposure to the air part of the water evaporates and the solution of calcium carbonate becomes supersaturated; a deposit of this substance ensues and as the drop continues to fall from the same spot a small column of white calcite very slowly grows downwards in a vertical direction from the roof. In the same way stalactites of ice (icicles) are produced in frosty weather as the water dropping from eaves of buildings, elevations, branches of trees, etc., very gradually, freezes. Other minerals often occur in stalactitic growths; thus we find in mines and in the cavities of mineral veins stalactites of limonite, opal, chalcedony and gibbsite. These are never of great size, usually not more than 2 or 3in. in length, and probably the method of origin is exactly the same as that of the larger and more common stalactites of ice and calcite.

The conditions essential to the perfect development of stalactites appear to be (1) a very slow trickle of water from a fissure; (2) regular evaporation; (3) absence of disturbance, such as currents of air. Hence, ice stalactites form most readily on calm cold nights, and stalactites of ice or calcite are seen in greatest perfection in the interior of caves.

In limestone caves stalactites form in abundance as glimmering white columns covered with a thin film of water. The great caves, such as those of Adelsberg (in Styria), Jenolan (Australia), the Mammoth Cave (Kentucky), the Causses district in France, and the grottoes of Belgium, are divided into chambers which are richly festooned with stalactites, and fanciful names are given to various groups according to their similarity to different objects, natural or artificial. Ice caves of considerable size occur in the Arctic and Antarctic regions, and are draped with ice stalactites often wonderfully like those of limestone caves.

Where the water drops upon the floor of one of these caves evaporation still goes on and if the air be perfectly still the drop will always land on the same place and a pillar of deposit, called a stalagmite, will rise vertically, till in course of time it meets and joins with the stalactite above. As the stalactites thicken, they assume tapering forms with irregular surfaces. Large stalactites may be 3 or 4ft. thick, but in that case they are usually due to coalescence of adjacent ones. Single stalactites 2ft. in diameter are not rare. From data obtained by measurement of the rate of growth at the present day it has been estimated that as much as 200,000 years may have elapsed since certain thick stalactites began to grow. Caves are of great antiquity but there is, of course, no certainty that the conditions have remained uniform. Sir Archibald Geikie records that stalactites 1½in. in diameter had formed beneath a bridge in Edinburgh which was 100 years old; in caves, however, the rate of formation is rarely so great as this. Inscriptions on stalactites in the Adelsberg cave after 30 years had been covered with a scarcely perceptible film of new deposit. In one of the Moravian caves a stalactite, about as thick as a goose quill, was broken across in 1880, and in 1891 it had grown 3 or 4cm.; from careful observations it has been calculated that one of these stalactites, 7ft. long, may have been formed in 4,000 years. The stalagmitic crust on the floor of caves is usually mixed with blocks which have fallen from the roof, sand, mud and gravel carried in by floods, and the bones of animals and men which have inhabited the cave if it had an accessible entrance.

Stalactites also occur in the interior of the lava caves found in Hawaii, Samoa, etc. Often the upper surface of a lava flow has cooled to form a crust, while the interior is still perfectly fluid, and it sometimes happens that the liquid basalt has made its escape, leaving great cavities below the hollow roof of the lava. The interior of these caves is covered with a black shining film of glassy basalt, and black stalactites of lava hang downwards. Their surface is sometimes changed to brown or red by the action of the acid vapours which filled the cave after the lava retired. These stalactites are tubular, with bluntly rounded ends, and probably their mode of growth is somewhat analogous to that of icicles.

STALACTITE WORK, in architecture, one of the most general characteristics of all of the Mohammedan styles, consisting of a series of little niches, bracketed out one above the other, or of projecting prismatic forms in rows and tiers, connected at their upper ends by miniature arches. Its infinite varieties may be classified into three groups, the first consisting of those basically niche-shaped, in which the concave curve is the most important feature; the second group includes those in which the vertical edges between the niches are the most important feature, being set at all sorts of angles and having generally prismatic forms; the last group consists of elaborately intersecting, miniature arches. The first two groups occur commonly in Syrian, Moorish and Turkish work and in their simpler forms, in Persia; the last group is typically Persian and is found also in Mogul work in India.

Stalactites are of comparatively late development in Muslim art, the earliest buildings in Syria, Egypt and north Africa showing no traces of them. They seem to appear suddenly all over the Muslim world toward the beginning of the 12th century. Thus simple forms are found in the mosque at Ani in Armenia, built between 1072–1110, and they are common in Algiers and Sicily during the course of the century, as in the gate at Chella (1118–84), and in the building known as La Ziza at Palermo (1154). In Egypt the stalactite appears in panels flanking the main entrance of the El Akmar mosque at Cairo (1125–50). They reached their highest development in the 14th and 15th centuries, becoming the normal decoration for the heads of door niches and the bracketing under cornices and minaret galleries. The richest examples of the prismatic type are to be found in Moorish work in Spain, especially in the intricate wood and plaster ornament of such palaces as the 14th and 15th century Alhambra in Granada and the 14th century Alcazar at Seville. In Turkey, a peculiar type of faceted crystal shape is found and the form became the most common capital decoration.

STALIN, JOSEPH VISSARIONOVITCH (DJUGASHVILLI), general-secretary of the Russian Communist Party, was born in 1879, son of a Georgian peasant shoemaker. Young Joseph secured an education through being selected for a course at a Russian religious seminary. However, he was expelled for "unreliability." At 17 he joined a Social Democratic group and agitated among the workers of Georgia.

For organising demonstrations in Batoum in 1902 he was imprisoned, and in 1903 was exiled to Eastern Siberia for three years. In Jan. 1904 he escaped and returned to his political activities, frequently changing his pseudonym. He evaded arrest until 1908, when he was again exiled to Vologda province for three years. He escaped once more in 1909, returning to Baku and renewing his activities, but was speedily arrested and sent to Solvichegodsk for six years. Inside a year he escaped to St. Petersburg, but was arrested a third time after a few months and sent back to Vologda province for a further three years. He escaped in Dec. 1911, was again exiled in April 1912, but was once more in St. Petersburg (Leningrad) in September.

In March 1913 he was arrested and exiled to Turukhansk in Northern Siberia, where he remained until Feb. 1917. He was responsible for the Bolshevik campaign for the State Duma in 1913, directing the Bolshevik group in that Duma from outside, and in 1912–13 acting as one of the editors of the Bolshevik journals "Sviezda" (Star) and "Pravda" (Truth). He belonged to the central committee, and in the Soviet Government he became commissar for nationalities. Stalin fought against Yudenitch, Denikin and the Polish army, in 1919 and 1920 he was commissar for workers' and peasants' inspection, and from 1920 to 1923 was a member of the revolutionary military council. As general secretary of the central committee of the Russian Communist party, after Lenin's death he became the most powerful figure in the U.S.S.R., and held his position when his policy was assailed by other Communist leaders, securing the exile of Trotzky and other opponents.

His *Leninism* was translated (1928) into English.

STALIN, a town in the Ukrainian S.S.R. Pop. (1926) 105,739. In 1870 a British subject named Hughes received a concession from the Russian government to manufacture iron rails. His company started operations on the site of the present Stalin, formerly known as Hughesovka (Yuzovka). British, French and Belgian capital was freely invested in the development of the industry from 1880 up to 1914. The close conjunction of the Donetz coalfield to iron and manganese deposits made the industry very profitable. Following the 1917 revolution the industry was depressed, but from 1924 onwards progress has been rapid and the population of Stalin was doubled between 1923–6.

STALINGRAD, a province of Russia, lying on both banks of the lower Volga. Area 85,167 sq. kilometres. Pop. (1926) 1,406,927. It is a low-lying area, and the banks of the Volga for some distance on either side of the river are below sea-level. The soils on the left bank of the Volga river are salt steppe; on the right, as far as the Don river, they are light brown and grey steppe, with salt efflorescences, while west of the Don is a fertile black-earth region. The climate is continental and the rainfall scanty and variable from year to year. The province lies in an area subject to terrible recurrent famines due to failure of rainfall, and rapid desiccation has been in progress for some time. In years of sufficient rainfall, the harvest is fairly good. The chief crops are summer wheat and winter rye; millet, sunflower seed, barley, oats and potatoes are grown in less quantity and vineyards are profitable in the south. Maize cultivation is steadily increasing. Irrigation is the only hope for the district. Experimental stations are working at Stalingrad and at Tingutin.

The most favourable region is the alluvial strip near the Volga and Akhtuba rivers, which is particularly wide near the town of Stalingrad. Here the temperature remains above freezing point for nine months in the year and the combination of alluvial soil, warmth and moisture makes grain, fruit and vegetable growing very profitable. Poplar trees attain a remarkable growth in ten years, and fruit trees bear for five years in succession. The nearness of the oil wells facilitates the use of internal combustion motors for irrigation purposes, and cheap and convenient routes for export are available. The drawback is the frequent change in direction of the main watercourses and their connecting channels, which may convert a fertile garden into a waste of river mud, or even wash it entirely away. Dikes are being built to lessen this danger. Sheep, cattle, pigs and horses are bred, and in 1926 had made rapid progress towards restoration to pre-War level. The 1921 famine, particularly disastrous in this region, following on the civil war centring round the town of Stalingrad, had reduced their numbers catastrophically. There is also some camel breeding in the district. Stalingrad is becoming a centre for timber but apart from Stalingrad (*q.v.*) there are no industrial areas in the province. The chief peasant occupations supplementing agriculture are fishing, flour-milling, oil-pressing, tanning, leather, fur-dressing, textiles and felt making and the making of pottery and household and farm implements. Lake Elton, one of the most productive sources of salt in Russia, is situated in the trans-Volga part of the province, but has no rail connection. The Don approaches the Volga very closely near Stalingrad, and the Soviet Government in 1928 embarked on a scheme to construct a canal linking the two rivers. The canal should be open for navigation by 1935.

The region was occupied in the 5th century by the Finno-Turkic Bulgars, who were in the 10th century driven northward by the Khazars, a closely related tribe. Later the region formed a part of the empire of the Tatar Golden Horde, one section of which was incorporated in the khanate of Astrakhan. The Russians in 1557 conquered Astrakhan and in 1589 erected the fort of Tsaritsyn on the site of the present town of Stalingrad, but the real absorption of the region into Russia involved a century of struggle with the nomads of the Volga during which there were perpetual Nogai, Kalmuck and Kirghiz raids on the Russian settlements. In the reign of Catherine II., the Russian peasants, the Cossacks and the dissatisfied native tribes rebelled under the leadership of Pugachev (1773–75) and fighting was fierce in the region between Kazan and Stalingrad. After the 1917 revolution, there was much disorder in the region, and considerable opposition to the Bolshevists, which was, however, finally overcome.

STALINGRAD (formerly Tsaritsyn), a town of Russia, the administrative centre of the province. Its position at the point where the Volga most nearly approaches the Don gave it great importance as a transhipment centre and after the construction of the railway links with the Don at Kalach and with the railway systems of Moscow and Leningrad, its growth was rapid. The town manufactures metal goods and machinery, has a naphtha-refining factory, 20 sawmills, a chemical factory, a brewery, a confectionery industry and mineral oil works. A tractor factory with an output of 10,000 tractors per annum was under construction in 1928. There are municipal electricity, water, tram and bus services. Pop. (1926) 143,243; (1897) 55,186.

A fort was erected here in 1589, after the fall of Astrakhan, to prevent the raiding of settlers by Kalmucks, Kirghiz and Circassians, often joined by Cossacks and runaway serfs. The town took part in the rising in favour of the false Demetrius, and was captured by Stenka Razin in 1670. In 1773–75 it took a part in the rebellion of Pugachev. After the revolution of 1917, Stalin held the town and it was renamed in his honour.

STALL, literally a place where one may stand, and so applied to a separate division in a stable, shed, etc., in which a single horse, cow or other domestic animal may be kept, to a separate booth, bench or table in a market or other building, or in the street, on which goods are exposed for sale and in England to the higher-priced seats on the ground floor of a theatre. In cathedrals, monastic churches and the larger parish churches the stalls are fixed seats enclosed at the back and separated at the sides by high projecting arms, and placed in one or more rows on the north and south sides of the choir or chancel. In a cathedral the canons and prebendaries have each a stall assigned to them. In the chapels of the various knightly orders the stalls are assigned to the members of the order, thus, in St. George's Chapel, Windsor, are the stalls of the Knights of the Garter, in Henry VII.'s chapel in Westminster abbey are those of the Knights of the Bath, adorned with the stall plates emblazoned with the arms of the knight occupying the stall, above which is suspended his banner.

Architecturally considered, the stalls of a cathedral or church are a marked feature of the interior adornment. They are richly carved, and are frequently surmounted by canopies of tabernacle work. The seats generally can be folded back so as to allow the occupant to stand upright or kneel; beneath the seat, especially in monastic churches, is fixed a small bracket, a *miserere* (*q.v.*), which affords a slight rest for the person while standing. Among beautiful specimens of carved stalls may be mentioned the Early Decorated stalls in Winchester cathedral (1296); the Early Perpendicular ones in Lincoln minster (*c.* 1370); the early 15th-century canopies in Norwich cathedral (15th century), and the towering corner-stalls with their ornate carving filled with figures, in Amiens cathedral (1508–20).

STALLBAUM, JOHANN GOTTFRIED (1793–1861), German classical scholar, was born at Zaasch, near Delitzsch in Saxony on Sept. 25, 1793, and died at Leipzig, where he was rector of the Thomasschule, on Jan. 24, 1861. His reputation rests upon his work on Plato, of which he published two complete editions.

See C. H. Lipsius in the *Osterprogramm of the Thomasschule* (1861); R. Hoche in *Allgemeine deutsche Biographie*, vol. xxxv.

STALYBRIDGE, municipal borough, Cheshire, England. It stands on the river Tame, in a hilly district. Pop. (1921), 25,216. The whole district is very densely populated. Stalybridge is one of the oldest cotton towns, the first cotton mill having been erected in 1776.

STAMBOLISKY, ALEXANDER (1879–1923), Bulgarian statesman, was born at Slavovitsa, in southern Bulgaria, Sept. 1, 1879, the son of a peasant landowner. After studying at the village school and later in the neighbouring town, he attended the agricultural college of Halle in Germany. On returning to Bulgaria, aged 18, he took up journalism, and in 1902 became editor of the organ of the newly-formed Agrarian League. Six years later he was elected to the Sobranye, where he led the Agrarian party.

He now began to organise the peasant masses, who form 80% of the total population of Bulgaria, into agricultural associations. In 1911, when the Grand Sobranye met at Trnovo to amend the Constitution, his first conflict with King Ferdinand occurred. After the treaty of Bucharest (1913) Stambolisky and the Agrarians were unmerciful in their criticisms of Ferdinand's policy, though deterred from extreme measures by the fear of external complications. Stambolisky's opposition to Ferdinand came to a head in 1915 during the negotiations that preceded Bulgaria's entry into the World War. Stambolisky strongly backed the Entente in spite of the King's anger, pressure from the Government and the growing influence of the Central Powers. Summoned before the King, Stambolisky threatened him with personal violence if he should fight against the Allies, reminding him that he had a crown to lose. Ferdinand ordered his arrest. He was tried by court-martial and condemned to penal servitude for life.

In Sept. 1918, when the resistance of the Bulgarian troops began to slacken, Ferdinand released Stambolisky, who left for the Macedonian front. He returned at the head of the insurrectionary troops and their arrival at Sofia resulted in Ferdinand's abdication and flight. A partisan of the new ruler, King Boris, Stambolisky became a member of the Cabinet in Jan. 1919 and Prime Minister in Oct.; as head of the Government he went to Paris and signed the Treaty of Neuilly in the same year. In Feb. 1920 he dissolved the Sobranye, and the following month was returned to power at the head of a homogeneous Agrarian majority. From 1920 to 1923, the Agrarians under Stambolisky ruled Bulgaria with a rod of iron. They had the Radoslavov Cabinet, which had brought Bulgaria into the World War, condemned to death by popular vote. Stambolisky also carried measures based on the interest of the peasants (*see* BULGARIA), and declared: "Sofia, that Sodom, that Gomorrah, may disappear. . . . I shall not weep for her." Through his influence post-War Bulgaria loyally carried out the terms of the Peace Treaty, won the esteem of the Allies, and secured a reduction of reparations. Stambolisky also made persistent efforts to improve Bulgaria's relations with Yugoslavia, with which country he concluded an agreement at Niš (1922). His ultimate ideal was probably some kind of federal South Slav State, embracing Bulgaria.

The overthrow of the Government by a military faction on June 9, 1923, was caused partly by dissatisfaction with Stambolisky's domestic policy and partly by the influence of the Macedonian party. The change of régime took place in one night, the Agrarian Ministers being arrested in their homes. Stambolisky, pursued by an armed detachment to his native village of Slavovitsa, escaped and fled across the mountains, hoping to reach the frontier. After being followed by soldiers for three days, he was eventually surrounded and shot on June 12. A formidable personality, attractive in many ways, and made of finer clay than the average Balkan statesman, Stambolisky has been called a modern Rienzi. Tall and broad, his demeanour was fierce and his movements ungainly; his rough-hewn face was crowned by a mass of black hair; he impressed everyone with his strength and the sincerity of his advocacy of a "Green International," to unite the peasants of all countries. Stambolisky published *Authority, Anarchy and Democracy;* and *What a Politician ought to be.*

STAMBOLOV, STEFAN (1854–1895), Bulgarian statesman, was born on Jan. 31, 1854, at Trnovo, the ancient Bulgarian capital, where his father kept a small inn. Under Turkish rule it was impossible to obtain a liberal education in Bulgaria, and young Stambolov, after attending the communal school in his native town, was apprenticed to a tailor. During the politico-religious agitation which preceded the establishment of the Bulgarian exarchate in 1870, a number of Bulgarian youths were sent to Russia to be educated at the expense of the Imperial government; among them was Stambolov, who was entered at the seminary of Odessa in order to prepare for the priesthood. He was expelled for his association with Nihilists, and, making his way to Rumania, he entered into close relations with the Bulgarian revolutionary committees at Bucharest, Giurgevo and Galatz. In 1875, though only twenty years of age, he led an insurrectionary movement at Nova Zagora in Bulgaria, and in the following year organized another rising at Orekhovitza. In the autumn of 1876 he took part as a volunteer in the Serbian campaign against Turkey, and subsequently joined the Bulgarian irregular contingent with the Russian army in the war of 1877–78. After the signature of the Berlin Treaty in 1878 Stambolov settled at Trnovo, where he set up as a lawyer, and was soon elected deputy for his native town in the Sobranye, of which he became president in 1884. The revolution of Philippopolis, which brought about the union of Bulgaria with eastern Rumelia, took place on Sept. 18, 1885, and it was largely owing to Stambolov's advice that Prince Alexander decided to identify himself with the movement. War with Serbia followed, and Stambolov served as an ordinary soldier in the Bulgarian army.

After the abduction of Prince Alexander (*q.v.*) (Aug. 21, 1886) Stambolov, who was then at Trnovo, established a loyal government at Trnovo, issued a manifesto to the nation, nominated his brother-in-law, General Mutkurov, commander-in-chief of the army, and invited the prince to return to Bulgaria. These measures resulted in the downfall of the provisional government set up by the Russophil party at Sofia. On the abdication of Prince Alexander (Sept. 8) Stambolov became head of a council of regency, with Mutkurov and Karavelov as his colleagues; the latter, however, soon made way for Jivkov, a friend and fellow townsman of the first regent. Stambolov frustrated the mission of General Kaulbars, whom the Tsar despatched as special commissioner to Bulgaria; suppressed a rising organized by Nabokov, a Russian officer, at Burgas; quelled military revolts at Silistria and Rustchuk; held elections for the Grand Sobranye, despite the interdict of Russia, and eventually secured the election of Prince Ferdinand of Coburg to the vacant throne (July 7, 1887). Under the newly-elected ruler he became prime minister and minister of the interior, and continued in office for nearly seven years.

The aim of his foreign policy was to obtain the recognition of Prince Ferdinand, and to win the support of the Triple Alliance and Great Britain against Russian interference in Bulgaria. He gained the confidence of the Sultan, and obtained concessions for the Bulgarian episcopate in Macedonia (*see* MACEDONIA). With the assistance of Austria-Hungary and Great Britain he negotiated large foreign loans which enabled him to develop the military strength of Bulgaria. He was still the despot. Major Panitza, after a conspiracy, was shot at Sofia in 1890; four political opponents were hanged at Sofia in the following year, and Karavelov was sentenced to five years' imprisonment.

His mood was emphasized by the assassination of his colleague, Beltchev, in 1891, and of Dr. Vlkovitch, the Bulgarian representative at Constantinople, in 1892, and eventually proved intolerable to Prince Ferdinand, who made him resign in May 1894.

He was now exposed to the vengeance of his enemies. On July 15, 1895, he was attacked and barbarously mutilated by a band of Macedonian assassins in the streets of Sofia, and succumbed to his injuries three days later. His funeral was interrupted by disgraceful riots, and an effort was made to perpetrate an outrage on his remains. No attempt was made to arrest his murderers; two persons, however, arraigned for the crime in 1896, were subjected to almost nominal penalties. (J. D. B.; X.)

STAMFORD, a town of Lincolnshire, partly in Northamptonshire. Pop. (1921) 9,882. It formerly possessed 14 parish churches, but now has only six. There are some remains of the 7th century Benedictine monastery of St. Leonard's and a west gate of the Carmelite monastery (1291). To the south of Stamford, in Northamptonshire, is Burghley house, the seat of the marquis of Exeter, a fine quadrangular mansion dating from 1587, containing a noteworthy art collection.

Apart from the tradition preserved by Henry of Huntingdon that the Saxons here defeated the Picts and Scots in 449, Stamford (*Staunford*) is a place of great antiquity. The Danes built a fort here on the north bank of the Welland, round which a town existed when in 922 King Edward fortified the opposite side of the stream. It passed again into Danish hands and was one of the five boroughs recaptured by Edmund Aetheling in 941. The priory of St. Leonard was a cell of Durham, and a charter of Edgar dated 972 mentions a market and a mint. In the reign of Edward the Confessor Stamford was a royal borough governed by 12 lawmen. The Norman castle, built before 1086, was thrice besieged by Henry II., but only yielded in 1153. Henry III. gave the town a charter in 1256.

Stamford was known for its monastic schools, and in 1333 was chosen as the headquarters of the students who seceded from Oxford, and an Early Decorated gateway remains of Brasenose Hall. The attempt to establish a regular university was prohibited by royal authority. The defeat of the Yorkists here was followed by the decay of the castle in the reign of Richard III., and the history of the place later centred round the family of Cecil.

See E. C. Mackenzie-Walcott, *Memorials of Stamford, past and present* (1867); J. Drakard, *The History of Stamford in the County of Lincoln, comprising its ancient progressive and modern state* (1822); C. Nevinson, *History of Stamford* (1879); *Victoria County History: Lincoln.*

STAMFORD, a city of Connecticut, U.S.A., on the Boston Post road. Pop. (1920), 35.096 (30% foreign-born white); 1928 local estimate, 44,000. The city lies around a broad bay (2 m.

across at the entrance and 1½ m. wide), from which two tidal inlets extend. The city still has the charm of a New England village. It is a residential suburb, with 90 trains daily to and from New York. It is also an important industrial centre. The town of Stamford (known for the first year by the Indian name of Rippowam) was settled in 1641 by 29 persons who seceded from the Wethersfield church and came under the New Haven jurisdiction. In 1662 it submitted to Connecticut. The borough was incorporated in 1830 and became a city in 1894.

STAMITZ, JOHANN WENZL ANTON (1717–1757), the eldest and most important of a family of Bohemian musicians famous in the 18th century. He was born at Deutschbrod on June 19, 1717. He was a solo violinist at the coronation of the emperor Charles VII. (1742), and in 1745 the elector took him to Mannheim as director of the chamber of music. Stamitz and his successors are known as the Mannheim school. Although Phillip Emanuel Bach in Berlin and the young school in Vienna were arriving at similar results, it seems certain that Stamitz was the real pioneer, who not only demonstrated the dramatic value of the "working-out" section of the first movement of a sonata or symphony, but, by incorporating the minuet, definitely established the four-movement form. In addition he demanded of the orchestra a greater independence from the different instruments, singling out the much neglected viola. He died at Mannheim on March 30, 1757. His works include 27 concertos, sonatas and solos for violin; several sets of symphonies, and harpsichord music. Johann's brother ANTON THADDAEUS STAMITZ (1721–1768) was a 'cellist at Mannheim.

Much confusion has arisen between Johann and his eldest son CARL STAMITZ (1746–1801), who sometimes used the name Johann, while the father was frequently called Johann Carl or Carl Johann. He produced an opera, *Der verliebte Vormund,* at Frankfurt and another, *Dardanus,* in St. Petersburg. He died at Jena in 1801. His more elaborated 70 symphonies are chiefly written for larger orchestras than his father's.

An introduction with details of the family, by Hugo Riemann, is included, together with a thematic catalogue of 45 symphonies and 10 orchestral trios, in Series III. i. of *Denkmäler deutscher Tonkunst in Bayern,* and other compositions of Johann and Carl are found in Series VII. i., XV. and XVI. of the same work. *See* also Grove, *Dictionary of Music and Musicians;* Riemann, *Lexikon;* Eitner, *Quellen-Lexikon;* R. Sondheimer, *Die formale Entwicklung der vorklassischen Sinfonie* (*Allgem. Musikztg.* Jan. 1922); P. Bekker, *Musikgeschichte* (1926) p. 126 *et seq.*

STAMMERING or STUTTERING, a spasmodic affection of the organs of speech in which the articulation of words is suddenly checked and a pause ensues, often followed by a repetition in rapid sequence of the particular sound at which the stoppage occurred. There are many grades, from a slight inability to pronounce with ease certain letters or syllables, to a condition in which the muscles, not only of the tongue and throat and face, but even of those of respiration are involved in spasm.

In normal speech exquisite co-ordination of muscular movement is necessary in larynx, cheeks, tongue, lips, involving also complicated nervous actions. It is when the co-ordination is not effected with sufficient precision that stammering results. Stammering rarely shows itself before the age of four or five years, and often it develops in a child in a feeble state of health.

Stammerers, as a rule, find the explosive consonants *b, p, d, t, k* and hard *g* the most difficult to articulate, but many also are unable easily to deal with the more continuous consonants, such as *v, f, th, s, z, sh, m, n, y,* and in severe cases even the vowels may cause a certain amount of spasm. Usually the defect is not observed in whispering or singing.

The condition named *aphthongia* totally prevents speech, and may, at intervals, come on when the person attempts to speak; it is only temporary, and is usually caused by nervous excitement.

Stuttering may, it seems, be overcome in some cases by instruction in reading and speaking slowly and deliberately, carefully pronouncing each syllable. When feeling the tendency to stammer, the speaker should pause, and then by a strong voluntary effort attempt to pronounce the word. He should also be taught how to regulate respiration during speech, so that he may not fail from want of breath. In some cases aid may be obtained by raising the voice towards the close of the sentence. Sounds or combinations of sounds that present special difficulties should be carefully studied, and the defect may be largely overcome by a series of graduated exercises in reading. Intoning is often useful. Some maintain that benefit from such education is often merely temporary. In any case the psychical basis of stammering calls for the most pronounced attention in treatment. In very severe cases, where the seizures affect other muscles than those of articulation, medical treatment is necessary.

STAMP, SIR JOSIAH CHARLES (1880–), British economist, was born in London on June 21, 1880. Educated at the University of London, he entered the civil service (inland revenue department) in 1896, and became assistant secretary to the board in 1916. In 1919 he resigned from the service to join Nobel Industries Ltd., of which he was a director and secretary until he accepted the new post of president of the executive of the London, Midland and Scottish railway in 1925. Stamp sat on the royal commission on income tax (1919); on the finance arbitration committee for Northern Ireland (1923–24); on the committee on taxation and national debt (1924); on the Dawes Committee on German currency and finance (1924); on the court of enquiry into the coal industry (1925); and on the Paris committee of enquiry into the reparations question of 1929. He held many academic honours, and was created G.B.E. in 1914. He is the author of many books, e.g., *Wealth and Taxable Capacity* (1922, 2nd ed. 1923).

STAMP DUTY, a tax imposed in Great Britain on written documents which are evidence of legal rights involved.

The payment of the tax is denoted by a stamp which is impressed on or affixed to the document.

The Stamp Act of 1891 is still the principal act governing stamp duties. But new duties and increases have been authorized by successive Finance Acts. The revenue from the duty for the year ending March 31 amounted to £27,000,000.

In some cases, moreover, parties have no discretion to dispense with written evidence. For example, contracts for insurance (marine, life or general accident) must be expressed in the form of a stamped policy and failure to do this not only vitiates the contract but renders the parties liable to fines.

The sanction of the act is expressed in very wide terms. Except in criminal proceedings, an instrument executed in Great Britain, or relating, wherever executed, to any matter or thing done or to be done in Great Britain, is not to be given in evidence or to be available for any purpose whatsoever, and it is the duty of all judicial officers before whom an instrument is tendered in evidence to take notice of the absence or insufficiency of duty. Further, any person whose duty it is to enrol or record an instrument liable to duty is liable to a fine if he enrols or records an instrument insufficiently stamped. On the other hand, the stamp does not add to or warrant its legality, it merely makes it possible for the legality to be examined.

Classification of Duties.—Dutiable instruments may be classified broadly as follows:—

1. Instruments evidencing the creation of contractual rights—bills of exchange, bills of lading, charter parties, contracts of insurance, bonds and innominate contracts.
2. Instruments evidencing the transfer of property (real or personal) or the creation of rights in property—conveyances of realty, assignments of personalty, mortgages, leases, transfers of stocks and shares and bearer securities.
3. Instruments evidencing the grant of privileges—grants of dignities and honours (patents of peerage, etc.), admissions to learned professions, licences to practise as solicitors, notaries, etc.

For the year ended March 31, 1927, the yield of duty under the principal heads of charge was as follows:—

	£
Conveyances of land and property other than stocks and shares at £1 per cent.	6,000,000
Transfers of stocks and shares at £1 per cent.	6,000,000
Companies' share capital duty at £1 per cent.	3,500,000
Cheques at 2d.	3,250,000
Receipts at 2d.	2,250,000
Marine Insurance Policies and Bills of Lading	600,000

STAMPINGS, DROP: *see* PRESSED METALS.

STAMPS: *see* Post and Postal Service and Philately.

STANCIOFF, DIMITRI (1864–), Bulgarian diplomatist, was born at Sistov, Bulgaria, in May 1864, and studied at the Theresianum College, Vienna. In 1887 he entered the Foreign Office, Sofia, and was a member of the delegation entrusted with electing Ferdinand, in due course becoming head of the new King's political Cabinet. Afterwards he was successively Bulgarian representative at Bucharest, Vienna and St. Petersburg. He became Minister of Foreign Affairs in 1906 and was for a time Prime Minister after the murder of Petkoff. In 1908 he resigned and became Minister in Paris, where he remained until 1915 when he was sent to Rome. He was made a member of the Bulgarian Delegation to the Paris Peace Conference, and in 1920 was appointed Bulgaria's representative to the Court of St. James. Stancioff was Bulgaria's chief delegate to the first international Peace Conference in 1899 and was a permanent member of the International Court of Arbitration.

STANDARD. For the various meanings of this word *see* Weights and Measures; Physical Units, Units and Dimensions, Standards Department; Electricity and Time, Standard.

STANDARD, BATTLE OF THE, a name given to the battle of Aug. 22, 1138, near Northallerton, in which the Scottish army, largely composed of wild and undisciplined Highlanders and Galloway Picts under King David, was defeated by the English levies of Yorkshire and the north Midlands. The latter formed a single deep line of dismounted men in front of a chariot carrying the consecrated banners of St. Peter of York, St. John of Beverley, St. Wilfred of Ripon and St. Cuthbert of Durham. King David planned to use his nucleus of knights and archers to lead the way and open a gap in the English line, but the fierce pride of the clansmen compelled him to give them precedence. Their headlong onset was repulsed. Left isolated except for his bodyguard of knights, King David retired from the field.

See C. Oman, *Art of War in the Middle Ages*, vol. i. 390–396 (1924).

STANDARDIZATION, means setting up standards by which extent, quantity, quality, value, performance and service may be gauged. Instances are the mile, the hour, the pound, the bushel, and the dollar.

Many individual manufacturers have standardized their products to gain the advantages and economies of mass or volume production. Several of these manufacturers maintain standards departments in their organizations to supervise design and production with the view to effecting maximum interchangeability between parts entering into the finished product, by securing consistent uniformity in their size and other essential characteristics. The standards established by one company are sometimes, though not always, of interest to another company.

Standardization offers many advantages to manufacturers, distributors and consumers. "(1) Standardization stabilizes production and employment, since it makes it safe for the manufacturer to accumulate stock during periods of slack orders, which he cannot safely do with an unstandardized product. (2) It reduces selling cost. Possibilities of reduced costs are generally even greater in distribution than in production. (3) It enables buyer and seller to speak the same language and makes it possible to compel competitive sellers to do likewise. (4) In thus putting tenders on an easily comparable basis it promotes fairness in competition, both in domestic and in foreign trade. (5) It lowers unit costs to the public by making mass production possible, as has been so strikingly shown in the standardization of incandescent lamps and automobiles. (6) By simplifying the carrying of stocks, it makes deliveries quicker and prices lower. (7) It decreases litigation and other factors tending to disorganize industry, the burden of which ultimately falls upon the public. (8) It eliminates indecision both in production and utilization—a prolific cause of inefficiency and waste. (9) By concentrating on fewer lines, it enables more thought and energy to be put into designs, so that they will be more efficient and economical. (10) By bringing out the need of new facts in order to determine what is best and to secure agreement on moot questions, it acts as a powerful stimulus to research and development, and it is thus in decided contrast to crystallization resulting from fixity of mental attitude. (11) It is one of the principal means of getting the results of research and development into actual use in the industries. (12) It helps to eliminate practices which are merely the results of accident or tradition and which impede development. (13) By concentration on essentials and the consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely upon efficiency in production and distribution and upon intrinsic merit of product. (14) Standardization is increasingly important for the maintenance and development of foreign trade. (15) The efficiency of competing countries, increasing through national standardization programmes, is likely to stiffen competition between those countries. (16) Joint effort in bringing about standardization within and between industries almost invariably leads to better understanding and to beneficial co-operation along other lines—a step toward the integration of industries" (*Mechanical Engineering*, Aug. 1926).

Practically every major American industry has co-operated with its allied or related industries in standardizing products or commodities of mutual interest. This group movement is one of the outstanding post-War developments in America.

The American Engineering Standards Committee.—In order to make standardization on a national scale possible, a clearing house or co-ordinating agency has been established to bring about systematic participation by, and co-operation of, the many organizations and associations individually working on the general problem. This agency is the American Engineering Standards committee, a federation of 33 national organizations, including nine major engineering societies, 18 national industrial associations and six departments of the Federal Government.

Government Co-operation in Standardization.—The United States Government is interested in industrial standardization in two ways: first, as a purchaser, in the specifications for materials and apparatus, and secondly, through its service and research bureaux, in innumerable standardization questions. Thirty-three branches of the United States Government are officially represented on sectional committees of the American Engineering Standards committee. The bureau of standards of the Department of Commerce is acting as sole or joint sponsor for 13 projects; the bureau of mines, Department of Commerce, for seven; the forest service, Department of Agriculture, for two; and the public health service, Treasury Department, for one. In addition, the bureau of standards, for example, is officially co-operating through representatives on sectional committees on 69 projects. One or more branches of the Federal Government is participating in this way in practically all the work of the American Engineering Standards committee. The Department of Labour designates representatives on all sectional committees dealing with safety codes, and is publishing approved codes as Government documents. The State Governments are actively participating in the work, chiefly through national organizations of State commissions, the most active being the International Association of Industrial Accident Boards and Commissions and the Association of governmental labour officials. The highway and traffic commissions (which co-operate through the American Association of State Highway Officials and the regional conferences of motor-traffic administrators) and the railway and utility commissions also participate in this work.

The bureau of standards of the Department of Commerce is a national agency for standardization and industrial research. Because they carry Government approval, the standards developed in the course of bureau research often tend to become those demanded by intelligent buyers throughout the country. For example the Government specifications for cement and the tests therewith have become the commercially accepted standard. Again, the Government buys about $1,000,000 worth of electric lamps annually on specifications. The acceptance is based on bureau of standards' tests, which have become the standard of the country.

The Federal specifications board was organized under the bureau of the budget in 1921. It is composed of representatives of each of the purchasing units of the U.S. Government, the chairman of the board being the director of the bureau of standards, *ex officio*. Its purpose is to unify Government specifications and to bring them into line with the best commercial practice.

The Bureau of Standards at Washington has been reorganized to include commercial standards as well as research and testing. As to commercial standards, its service is mainly promotional in character. It helps to work out such standards and adds periodical audits of adherence, also co-operating with the United States bureau of foreign and domestic commerce in applying the standards to foreign commerce.

The American Marine Standards committee was organized primarily to promote simplification of practice and economy in the construction, operation and maintenance of ships and ports facilities. The underlying authority is vested in a membership enrolled from the marine and allied industries. In 1928 its field was confined to three divisions: hull details, engineering (machinery) details, and ship operation details and supplies. Progress of similar work abroad is closely observed by exchange of publications with foreign bodies.

Standardization for Design, Construction and Tests.—For the purpose of bringing to the user the best obtainable opinion on the merits of appliances, devices, machines and materials in respect to life, fire and collision hazards, and theft and accident prevention, the Underwriters' Laboratories (Inc.) was established and is maintained by the National Board of Fire Underwriters. The laboratories are conducted for service and not for profit.

One of the most widely circulated codes of the laboratories is its code for electrical appliances, which consists of standards for design and construction, and tests of devices and materials for use in electrical circuits for light, heat and power, and for the forms of supervision of such products marketed under inspection and listing by the Underwriters' Laboratories. The code is in loose-leaf form to facilitate revisions. The following standards are included and may be also obtained as separate pamphlets: armoured cables and cords; cabinets and cut-out boxes; cartridge-enclosed fuses; cut-out bases; electric ranges; electric signs; fixture wires; flexible cords; flexible non-metallic tubing; ground clamps; heater cords; knife switches; panel board; renewable cartridge-enclosed switches; rigid conduits; rubber-covered wires and cables; snap switches; soldering lugs. Additional standards are constantly under consideration and in preparation. Lists of inspected electrical appliances which have been examined and tested and found to comply with the standards of the laboratories are published semi-annually.

Standardization in Building and Housing.—The work on building and housing seeks to promote a wider application of the best standards for building materials and design to the $6,000,000,000 or more of new construction carried out each year. In this way it helps to widen the practical usefulness of the laboratory and field research work of the bureau of standards and of other scientific bodies, and to secure a more general adherence to approved specifications and simplified practice programmes for elimination of excess dimensional varieties.

The advisory building code committee has been most active and influential in this field. More than $3,000,000,000 worth of construction work is carried out each year under the conditions prescribed by local building codes, and each of the committee's reports gives concise recommendations suitable for inclusion in such codes.

Standardization of building codes took a prominent position in the public mind as a result of the activities of the United States Senate committee on reconstruction and production appointed in 1920. Salient facts brought out by this committee were that there was a wide diversity in building-code requirements; that this proceeded from unscientific methods in preparing codes, and that large savings appeared to be possible through more uniform requirements. These were facts already well known to many architects and builders, but their significance was thrown into relief by the twin evils of inadequate housing and stagnant building.

Practical attack of the problem was commenced in 1921 through the appointment by Secretary Hoover of a committee of seven architects and engineers of high professional standing to undertake thorough and impartial studies. The country needed homes. The local code requirements for such construction appeared to be in a chaotic state. No careful investigation had been made up to this time. Accordingly a subcommittee on plumbing was appointed by Secretary Hoover and this outlined a series of tests to be carried out at the bureau. These tests were continued over a period of more than two years and the principles deduced from them were incorporated in the subcommittee's report, *Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings*, published in 1924. The report contains a recommended code and a complete report of the experiments at the bureau of standards.

Purchasing and Standardizing Agencies.—General purchasing agencies have been established in a number of cities.

Among the municipalities, New York city has formulated and utilized the greatest number of purchase specifications, more than 1,600 specifications for 42 different classes of commodities having been prepared for this purpose. Practically all of the work of standardization is done in the department of purchase. Recommendations for standards are forwarded to the board of estimate and apportionment, which consists of the mayor, the controller, the president of the board of aldermen, and the five borough presidents. Standards adopted by this board are compulsory on all city departments.

In every one of the 48 States, standards for materials used in the construction and maintenance of roads and bridges have been established by the State highway commissioners. Much of the activity in this line of standardization can be attributed to the aid given to the States by the Federal Government for the building of the main highways of the country.

Pan-American Conference on Standardization.—The first Pan-American conference was held at Lima, Peru, from Dec. 23, 1924, to Jan. 6, 1925. The general purpose of the Lima conference was to prepare the ground for co-operation in standardization between the republics of the Western Hemisphere and to facilitate international commerce through standardization work. No attempt was made to undertake any technical work at the first meeting, but co-operative relations were established and means were provided for continuing study for future work. The conference was attended by representatives from 13 countries:—Brazil, Costa Rica, Cuba, Guatemala, Haiti, Mexico, Nicaragua, Panama, Paraguay, Peru, United States, Uruguay and Venezuela. It was the general opinion that standardization can be used by the Latin Americans in three ways: first in expediting and making more efficient their own industrial development; secondly in improving the effectiveness of their buying in foreign countries; and thirdly in the development of better methods for producing and marketing their own raw products. The formal resolutions of the conference, as an official body, recommended that there be a convention between the American States, providing for co-operation in standardization matters; the establishment in each country of one or more organizations dealing with standardization matters, either governmental or industrial or mixed, as each may deem best; the use for the present of the Inter-American High Commission as the channel of communication; and the gradual compilation of a technical vocabulary in Spanish, Portuguese, English and French.

The second Pan-American standardization conference was held at Washington, May 9 to 12, 1927. Seventeen of the American republics were represented at this meeting, the programme of which was confined to standards for use in the inter-American trade in coffee, cocoa, fruits, hides, certain oil-seeds and wool. The formal recommendations concerned the organization and development of the standardization work in the several countries; the establishment of appropriate agencies to fight plagues and pests affecting animal and vegetable production; the early acceptance of wool type sample standards; and the immediate development of uniform specifications for agricultural products and raw materials important in inter-American trade.

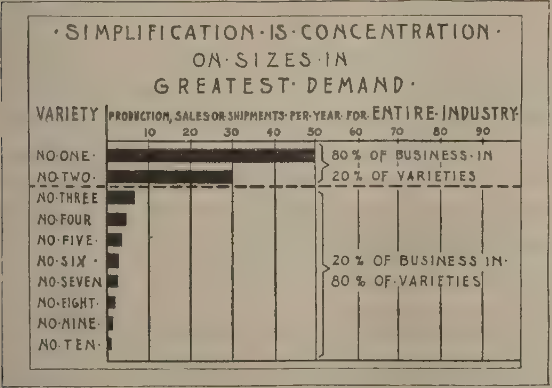
The following are among the recommendations in the report of the Hoover committee: Products should be standardized so far as is consistent with progressive development of manufacturing. Materials should be standardized to the fewest practicable kinds, sizes and grades. At least the details of equipment, including machines and tools, should be standardized so as to permit of the widest interchangeability and maximum usefulness consistent with improvements in design and invention. Performance standards should be developed as a valuable aid to planning and production control. Under the week-work system such standards are the basis of a just measurement of the individual worker's performance and of the adjustment of his wage rate to his capacity. Under the piece-rate system they are the basis of just rates. Without standardization of appliances, conditions, work content and method, no valid performance standard can be maintained. By constantly comparing actual performance with the standards and promptly investigating the causes of departure from standard, the manufacturer can quickly detect adverse conditions as they creep in, and can rectify them. (R. M. H.)

SIMPLIFIED PRACTICE OR SIMPLIFICATION

Another branch of standardization is the commercial elimination of unnecessary variety in sizes, dimensions, grades or qualities of common commodities. Its chief purpose is to reduce the economic waste resulting from the production and distribution of too many varieties of the same general class of goods. The wastes of over-diversification are unduly large inventories, increased cost to carry them, slower turnover, idle investment, heavy obsolescence and decreased profits. Advantages gained through simplification, by the manufacturer are decreased production costs and selling expenses, smaller inventories, faster turnover and consequently improved profits. Distributors likewise are enabled, through simplification, to reduce their inventories to the lines that sell well and thus to secure speedier turnover and better profits. Consumers benefit from simplification through lower prices, improvements in quality of product and in the service of supply.

Analyses of many different lines of products have shown to the U.S. department of commerce that usually 80% of the year's total business in any line of products is done in 20% of the varieties in which that line is offered. The remaining 80%, producing only 20% of the year's business, usually provides a fertile field for simplification.

During the World War, the United States organized its war industries board which, among other responsibilities, was charged with the restriction of production of non-essential goods, in order to divert to war purposes the material and labour represented in those goods. The conservation division of the board applied simplification to more than 300 commodity lines with enormous savings to industry. (*See* B. M. Baruch, *American Industry in the War*, U.S. Government Printing Office, 1922.) After the war, many of the industries which had participated in the Government's programme and had benefited by simplification, wishing to continue this waste-elimination programme, turned to the U.S. Chamber of Commerce. (*See* WAR CONTROL OF INDUSTRY.)



Early in 1921, Herbert Hoover, then president of the American Engineering council (the executive body of the Federated American Engineering Societies), organized a committee of 17 well-known industrial and management engineers to make a survey of waste in industry. The committee studied six major industries and found wastes ranging from 29% in the metal trades to 64% in the manufacture of men's ready-made clothing. Avoidable waste, according to the committee's evaluation, amounted to 41% in boot and shoe manufacture, 49% in the textile, 53% in the building and 58% in the printing industry. Among the outstanding causes for waste in these fields was the unnecessarily great variety in sizes, etc. The committee therefore suggested that the Federal Government call together representatives of trade associations in inter-dependent industries and form committees to effect simplifications in their commodities. (See *Waste in Industry*, McGraw-Hill Book Co., 1922.)

When Hoover became secretary of commerce he was requested by many business leaders to assist industries to apply simplification. Accordingly, he organized the division of simplified practice. In Nov. 1921, varieties of vitrified paving-brick were reduced from 66 to 11, which constituted the bulk of the output.

A general conference of brick producers, highway engineers, and officials agreed thereafter to concentrate on the 11 most popular sizes. In March 1922, a second conference reduced the number to 7; in Jan. 1928, only 5 varieties were listed. (See *Trade Association Activities*, Domestic Commerce series no. 20, U.S. department of commerce, 1927.) Meantime, simplification through group co-operation has been applied to 80 other commodities, with elimination of superfluous variety ranging from 25% in some instances to 99% in others, as shown in part in the following tables:—

Simplified Practice Applied to Construction Materials

Commodity	Varieties		
	Formerly	Now	Reduction
			%
Paving bricks	66	5	94
Asphalt	102	10	90
Steel reinforcing bars	40	11	72½
Metal lath	125	24	81
Woven wire fence	552	69	87
Asbestos millboard	10	5	50
Eave trough and conductor pipe	21	16	24
Concrete building units	115	24	80
Sand lime brick	14	3	78½
Roofing slate	98	48	51
Average reduction	..	..	71

Simplified Practice Applied to General Supplies and Furnishings for Homes, Hotels, Hospitals, Clubs, etc.

Commodity	Varieties		Reduction
	Formerly	Now	
			%
Bedsteads, springs and mattresses	78	4	95
Bed blankets	78	12	85
Sterling silver flatware	190	62	67
Tinware, galvanized japanned	1,154	873	24
Milk bottles	49	9	82
Milk bottle caps	29	1	96
Hotel china-ware	700	160	77
Restaurant china-ware	668	177	73
Dining car china-ware	700	113	84
Hospital beds	67	4	94
Steel lockers	65	17	74
Average reduction	..	..	76½

One manufacturer of electrical apparatus eliminated 49% of the items in his stocks. An important Western road reduced its stores, releasing $18,000,000 of otherwise idle investment.

A shoe manufacturer making 3 grades of shoes in 2,500 styles cut his varieties to one grade of 100 styles, thereby reducing his production cost 31%, direct overhead 28%, inventories 26% and cost to consumer 27%. This enabled him to increase his turnover 50%; women's shoes 22%; and men's 80%.

Simplification, now widely recognized in America, is also being studied, and to some extent applied, by business interests in other countries. Many economists regard the increasing application of simplification as a significant factor in the advancing standard of living, since the savings it yields are passed on to the ultimate consumer in higher wages and lower prices.

BIBLIOGRAPHY.—"Simplification," *Management's Handbook,* Sect. 17, p. 989–1034 (1924); U.S. Bureau of Standards, *Standards Year Book* (1927); Amer. Soc. of Mech. Eng., *Bibliography of Management Literature,* p. 58 (1927); U.S. department of commerce, *Simplified Practice —What it Is and What it Offers.* (R. M. H.)

FROM THE POINT OF VIEW OF THE CONSUMER

Let us agree at once and frankly with the social critics that standardized behaviour patterns, moving-picture plots, syndicated editorials, slavery to advertised styles, political speeches, educational rolling mills, are an unmitigated evil, but when it comes to the kind and the quality of the goods which the public buys, we enter a different, more limited field, and one where standards of workmanship have a definite and valuable place. Women should not wear identical frocks; but no aesthetic values are lost if a woman has standards to guide her in respect to the durability, the fullness of measurement, the fastness of dyes, the silk content of materials. Standards often improve a product because, due to stability of demand, the product can be built with more specialized and more precise tools, and with more research behind it, than is the case with small quantities and excessive varieties. For nicety of workmanship and exact adaptation to its function, the present-day lamp bulb, vacuum-tube or fine watch has no counterpart in handicraft industry. The U.S. Chamber of Commerce has estimated that one-quarter of all industrial effort in America is wasted because of irrelevant over-diversification of styles, types and sizes. This refers to the labour of approximately 5,000,000 people, and a full 25% in the cost of living. (S. CH.; F. J. S.)

STANDARD OF LIVING. The term "Standard of Living" has two distinct meanings. As used by the leading economists from Ricardo to the present day, it has a strictly technical meaning. It also has a loose, general and semi-popular meaning. In the strictly technical sense it means the scale of living which the average individual of any given group considers preferable to marriage, or which he must be sure of maintaining before he will marry and undertake the support of a family. In the loose and general sense it means merely the list of things which the average individual of any given class happens to be consuming at a given time and place. In the technical sense, it is a dynamic factor in determining the density of population, the labour supply, the rate of wages, and the possibility of future improvement of economic conditions. In the general sense it is merely a description of the way people are actually living in a given time and place. It is useful in determining what income is necessary in order to support a family according to a standard of living which the estimator deems necessary or satisfactory.

In the strictly technical sense, a man who will marry and beget children without any regard whatsoever to his ability to provide for the needs of wife and children, has, literally, no standard of living at all. It is safe to say that the only creatures who thus thoughtlessly mate and breed are those which, like plants and animals, lack the capacity for thinking of the future. A standard of living, in this technical sense, is something which goes with intelligence and foresight.

Similarly, those who will marry and undertake the support of families as soon as they feel able to provide the bare necessaries of life are said to have a low standard of living. Conversely, those who will not marry until they are reasonably certain of being able to afford a great many luxuries as well as all the necessaries and decencies of life, are said to have a high standard of living. Thus a standard of living is always relative and consists of the number of desirable things which the individual considers more desirable than the domestic satisfactions which come with marriage. A high standard of living may result either from a weakening of sex and domesticity or from a strengthening of the desire for other things, while a low standard may result either from exaggerated sexual and domestic desires or from weakened desires for other things.

It is obvious, to begin with, that standards of living, as thus technically conceived, have a profound influence upon the economic well being of nations and of classes within a nation. If the standard of living of every individual of a group, either territorial or occupational, is high, it insures the group against over-population. If, for example, no one would marry and undertake the support of a family until he was reasonably certain of being able to educate his children, to house them comfortably, and provide them with a motor car, it is reasonably certain that no children would be legitimately born except in families which could afford these things. Besides, such a country, in the absence of immigration, would never have any more people than could afford these things. Disasters and bankruptcies might reduce some to want, but normally there would be no want. On the other hand, if every one would marry and undertake the support of children as soon as he was able to provide a bare physical subsistence, it is certain that a great many children would be born in families which could only afford bare physical subsistence. In other words, wide spread poverty would be the normal state of large masses of people.

In the above characterization we have coupled both sex and domesticity as factors in a low standard of living. In a rather strict and narrow sense however, it is a relatively strong sexual desire rather than a high development of domesticity which characterizes a low standard of living. A highly developed domesticity would lead an intelligent person to desire not merely children, but the welfare of his future children. This would lead to some postponement of marriage until one could provide for their welfare.

The items which go to make up a high standard of living include other things than material articles of consumption. Those who will not marry until, as suggested above, they are reasonably certain of being able to educate their children, have a high standard of living. Such a desire to safeguard the welfare of their future children has the same effect on marriage rates and marriage ages as the desire for beefsteak and race track tickets. Even a high degree of thrift may be a mark of a high standard of living. He who will not marry until he can afford a sizeable insurance policy or bank account may be called a thrifty individual, but he also has a high standard of living. In such a case the desire for an insurance policy or a bank account has the same effect on the postponement of marriage as the desire for a motor car or an eight-room house and must be accounted as a part of a high standard of living. Certain it is that if no one would marry until he had an insurance policy or a bank account, no children would be legitimately born except in families which, at one time at least, had insurance policies or bank accounts. There would generally be no poverty except as the result of unforeseen disasters which dissipated savings and cut off incomes out of which savings were made.

It is well to remember that this balancing of sex against other desires is conditioned upon an economic system which imposes parental responsibility. If one did not have to pay the expenses of his own family, no other desires would have to be sacrificed when the procreative desires were gratified.

Different nations, and different classes within each nation may have different standards of living in the strict as well as in the general sense of the term. There are, however, no statistics available which throw any very direct light on these differences in the stricter sense. Some indirect light is thrown on the subject by an exceedingly valuable study by Baber and Ross on "Changes in the Size of American Families in One Generation" (University of Wisconsin Studies in the Social Sciences and History, No. 10, Madison, 1924). Tables are included which show that farmers and labourers tend to marry earlier than business and professional men; other tables show that on the average, more children are born of early than of late marriages.

Family budgets as evidences of the spending habits of people with different incomes, were the first records to be studied statistically with a view to determining standards of living. The most famous of these is that of Dr. Ernst Engel. The following table summarizes the general results of that study.

Items of expenditure	Percentage of expenditure of family income					
	$225–$300		$450–$600		$700–$1,000	
Subsistence	62·0	95·0	55·0	90·0	50·0	85·0
Clothing	16·0		18·0		18·0	
Lodging	12·0		12·0		12·0	
Heat and light	5·0		5·0		5·0	
Education, public worship, etc.	2·0	5·0	3·5	10·0	5·5	15·0
Legal protection	1·0		2·0		3·0	
Care of health	1·0		2·0		3·0	
Comfort and recreation	1·0		2·5		3·5	
	100·0		100·0		100·0	

From Ernst Engel, *Prussian Statistical Bureau Report No. 1857*, p. 145, Table I.

The only striking thing about this table is that it shows that as incomes increase the percentage spent for the basic necessaries decreases while the percentage spent for education, health, comfort, etc., increases.

A fairly clear idea of the comparative standard of living of different countries and at different times may be gained from a study of the relative cost of living. Changes in the cost of living in Great Britain from 1915 to 1926 have been calculated by the Ministry of Labour. The following table is a condensation of their findings:

*Index Numbers of the Cost of Living in Great Britain Calculated by the Ministry of Labour**

July, 1914=100

Date	Food	Housing	Clothing	Fuel and light	Other items	Total cost of living
1915	132	100	125	125	105	125
1916	161	100	160	135	120	145–150
1917	204	100	205	140–145	140	180
1918	210	102	320	175–180	180	200–205
1919	209	106	360	185–190	195	205–210
1920	258	115–120	425	230	220	252
1921	220	145	290	260	210	219
1922	180	153	240	190	195	184
1923	162	147	220	180–185	185	169
1924	162	147	225	185	180	170
1925	167	147	230	180	180	173
1926	161	150	220	195	180	170

*The figures are for July of each year.

A comparison of the changes in the cost of living in different countries is contained in the following table. These, together with the statistics of wages, furnish the best information available as to the standards of living of wage workers in those countries:

Cost of Living in Different Countries, **1914–1926*

1914=100

Year	Germany	Canada	France	United Kingdom	United States	Switzerland
1914	100	100	100	100	100	100
1915	..	97	..	125	105	119
1916	..	102	..	148	118	140
1917	..	130	..	180	142	180
1918	..	146	..	210	174	229
1919	..	155	238	215	199	261
1920	..	190	341	255	200	253
1921	..	152	307	222	174	209
1922	..	146	302	181	170	158
1923	..	146	334	171	173	167
1924	116·0	143	366	171	173	166
1925	143·3	146	390	173	178	165
1926	139·8	155	..	173	..	..

*From the *"Monthly Bulletin of Statistics, League of Nations,"* No. II. February, 1926. Page 67.

The changes in the cost of living have been compared with the changes in money wages in order to give the trend of real wages in various countries. *Cf.* the *International Labour Review*, 1927, Page 107.

A somewhat more elaborate study was made in 1909 by Robert Coit Chapin in his *Standard of Living in New York City*, page 70. The following is a brief summary of his more elaborate table:

Expenditures of Families in New York City

Income group	Rent, per cent	Carfare, per cent	Fuel and light, per cent	Food, per cent	Clothing, per cent	Insurance, per cent	Health, per cent	Sundries, per cent
$ 400–$ 499	26·8	2·6	5·6	40·8	13·0	1·2	3·1	6·9
500– 599	25·9	1·8	5·9	44·4	12·4	1·3	1·9	6·4
600– 699	23·6	1·7	5·8	44·6	12·9	2·0	2·1	7·3
700– 799	21·9	1·5	5·0	45·6	13·4	2·5	1·9	8·2
800– 899	20·7	2·0	5·0	44·3	14·0	2·2	2·7	9·1
900– 999	19·0	1·5	5·1	44·7	14·6	2·6	2·6	9·9
1,000– 1,999	18·1	1·8	4·5	44·7	15·5	2·5	1·5	11·4
1,100– 1,199	16·2	1·9	3·8	45·6	14·9	2·5	3·6	11·5
1,200– 1,299	19·8	2·2	3·8	45·0	15·2	2·2	1·3	10·5
1,300– 1,399	16·8	1·1	3·6	43·6	13·7	4·9	1·1	15·2
1,500– 1,599	16·3	1·2	4·1	36·8	16·8	2·3	7·4	15·1

Numerous other studies have been made, notable among which are those of Henry Higgs, "Workingmen's Budget," *Journal of the Royal Statistical Society*, 1893; Louise Bolard More on *Wage Earner Budgets*, N.Y. 1907; Frank Hatch Streightoff on *The Standard of Living among the Industrial People of America*, Boston, 1911; William C. Beyer, Rebekah P. Davis and Myra Thwing on *Workingmen's Standard of Living in Philadelphia*, N.Y., 1919, and a symposium by various writers on *Standards of Living; a Compilation of Budgetary Studies*, published by the Bureau of Applied Economics, Washington, 1920.

On the basis of these studies of actual budgets, various estimates have been made as to the money income necessary at existing prices to enable an average family to maintain a satisfactory standard of living. Of course something depends upon what the estimator considers a satisfactory standard. One of the best of these estimates was made by Robert Coit Chapin in 1909. His estimate was that in New York City in that year $900.00[1] was necessary. Various other estimates, based on different price levels and costs of living are tabulated by Paul Douglas in his *Wages and the Family*[2]. A summary of this tabulation follows:

Total Amounts Required to Support the Standard Family of Five According to Various Budgets

Year	City	Investigator	Amount of budget	
			Subsistence plus health and decency	Comfort
1913–15	Philadelphia	Cotton and Little	$1,070	..
1917	San Francisco	Peixotto	1,476	..
1918	Philadelphia	Beyer	1,637	..
1919	Washington	U.S. Bureau of Labor Statistics	..	$2,262
1919	Lawrence, Massachusetts	Nat. Ind. Conf. Board	1,658	..
1920	Cincinnati, Ohio	Nat. Ind. Conf. Board	1,692	..
1920	Chicago, Illinois	Council of Social Agencies	1,666	2,322
1920	San Francisco, Los Angeles, and Sacramento	Blum and Peixotto	..	2,292
1921	Philadelphia, Pa.	Beyer	1,847	..
1922	Anthracite region of Pennsylvania	Nat. Ind. Conf. Board	1,322	..

It is frequently asserted that because the well-to-do classes have a low and the poor a high birth rate, the difference in wealth is the cause of the difference in the birth rate. On the mere ground of probability it would be at least as likely that the causal connection is the exact reverse, or that the difference in the birth rate is the cause of the difference in prosperity. There are some rather strong reasons for believing that, *in the same economic class,* an increase of prosperity increases rather than decreases the birth rate. If, without first raising the standard of living, in the strictly technical sense, a given economic class is provided with larger incomes, the larger incomes are used as a means of earlier marriages and larger families.

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[1] Cf. *The Standard of Living Among Workingmen's Families in New York City*, p. 246.

[2] Chicago, 1925, pp. 7 and 8.

From Malthus to the present day, it has been recognized that a low standard of living among the working classes was the chief hindrance to the success of schemes of social betterment. Efforts to improve the condition of backward peoples are clearly frustrated by their enormous fecundity. During 40 years of British rule in Egypt, 1882–1922, the population doubled. This was made possible by irrigation and other economic improvements. Had the population not doubled, the lot of the masses might have been greatly improved. But with a low standard of living, the increased food supply merely resulted in a greater excess of births over deaths with no great improvement in the average well being. Similar results followed British rule in India, the French control of Algeria, the American occupation of the Philippines and Porto Rico. In every case, there has been a phenomenal increase in population, with no apparent change in the standard of living. The net result is, as Ross so expressively states,[1] *"The white race is today serving as a midwife to the blacks and the browns."*

If the standards of living of the blacks and the browns could have been raised while the productivity of their countries was being increased, the results would have been different. Instead of merely increasing the number of people living a miserable existence, white control would have lifted those people to a higher state of comfort. Similar results seem to follow from most so-called humane movements for the improvement of the condition of the lower classes of labourers within advanced countries. So long as the standard of living remains low and men will marry as soon as they are assured of sufficient income to satisfy the basic necessaries of life, any improvement in wages or employment is likely to result merely in earlier marriages and larger families with a consequent increase in the supply of labourers followed by a reduction of wages to the old level. On the other hand, if the reform can start with, or be accompanied by, a rise in the standard of living, this train of evil consequences will not follow. The real question, therefore, upon which the success of most schemes of social amelioration depends, is, Can the standard of living of the mass of the labourers be raised? For the more intelligent portion of the labouring classes the raising of the standard of living is not only feasible but offers the most effective means of social amelioration. For the less intelligent classes, those bordering on feeblemindedness, some more drastic method will have to be employed to prevent the overstocking of the labour market. (T. N. C.)

STANDARD OIL COMPANIES, American petroleum corporations which were formerly a single group operating throughout the world under the ownership of Standard Oil Company of New Jersey. In 1911 the United States Supreme Court ordered the dissolution of this company under provisions of the Sherman Anti-Trust Act and shares of 33 subsidiaries were distributed to stockholders of the company. Since that time there has been a gradually decreasing community of interest among the different units, and the ownership of the shares, originally in the same hands as the shares of the Standard Oil Company of New Jersey, has become widely diversified. In 1929 the largest interest in Standard Oil Company (N.J.) stock controlled but 11% of its shares, and this interest had disposed of all of its holdings in some of the other units. There was no officer or director holding a place in the management of two or more of the companies and each company has pursued an independent career. Many of the companies formerly aligned are engaged in spirited competition, one with the other. Notably, Atlantic Refining Company has gone into direct competition with Standard Oil Company of New York and Standard Oil Company of New Jersey, in the fields formerly reserved to those units. Standard Oil Company of New Jersey has recently entered the State of Pennsylvania, formerly occupied exclusively by Atlantic Refining, and is engaged in building up its own retail distributing organization in that State. Standard Oil of Indiana is in active competition both for production and retail business with several of its former associates. The Vacuum Oil Company is competing for lubricating oil business against all the other companies. The largest of the former members of the Standard Oil group now does but a very small percentage of the total business of the country.

Some of the principal Standard Oil Companies are Standard Oil Company (N.J.), Standard Oil Company (Indiana), Standard Oil Company of New York, Standard Oil Company of California, Standard Oil Company of Ohio, Vacuum Oil Company, Atlantic Refining Company, Prairie Oil and Gas Company. The first named is the largest of the former units, with assets of approximately $1,500,000,000. Its business is about half domestic and half foreign, the domestic business being done chiefly in the middle Atlantic States, which are best served by its seaboard refineries. This is now exclusively a holding company which owns numerous subsidiary companies that produce, transport, refine and market petroleum and its products. Prominent among these subsidiaries are Standard Oil Company of New Jersey, Standard Oil Company of Louisiana, and Standard Oil Company of Pennsylvania, all 100% owned. The holding company has a majority interest in Humble Oil and Refining Company, Beacon Oil Company, Creole Petroleum Corporation, Imperial Oil Ltd., and various other operating companies. It is a large operator of tankers, having the greatest private tonnage under the American flag.

Standard Oil Company of Indiana operates directly in eleven States in the middle west and through subsidiaries in many other areas where it competes with former units of the trust. It has total assets in excess of $500,000,000. Standard Oil Company of California is an important producing, refining and marketing company which is chiefly operating on the Pacific coast. It too operates a large number of tankers.

STANDARD PRICE: *see* PRICE MAINTENANCE.

STANDARDS, NATIONAL BUREAU OF. This United States body was established by act of Congress on March 3, 1901, and has for its functions the development, construction, custody and maintenance of reference and working standards, and their intercomparison, improvement and application in science, engineering, industry and commerce. The bureau is a part of the Department of Commerce. Its services are available without charge to the national and State Governments, and under certain conditions, tests and investigations are conducted for the public. In the case of tests for other than the national and State Governments, fees are charged which are paid in to the U.S. Treasury. The original staff of the bureau of standards numbered 14 persons. In 1928 there were about 850, of whom two-thirds were technically trained. The plant comprised 14 permanent buildings on a site of 43 ac. in the north-west suburbs of Washington.

The bureau serves as a clearing house for scientific and technical information and to this end co-operates with similar institutions abroad and with the research laboratories of American industries. Large industrial groups send representatives to work in the bureau's laboratories on problems of mutual interest, the results of which are published for the public benefit. The laboratory equipment is unusually complete and includes several small-scale manufacturing plants in which mill processes can be studied.

Scope.—The bureau's work falls into two major classes, the first comprising scientific and technical research and testing, and the second the establishment of commercial standards. Each of these major groups includes several divisions which in turn are made up of sections, the section being the working unit dealing with some specific class of problems. The research and testing group consists of the following divisions: electricity, weights and measures, heat and power, optics, chemistry, mechanics and sound, organic and fibrous materials, metallurgy and ceramics. The commercial standards group is composed of the following units: simplified practice, building and housing, specifications, commercial standards; and members of the staff cooperating with such organizations as the Federal Specifications Board and the American Marine Standards committee. In addition to these two groups there are divisions concerned with the administrative work of the central office, the operation of the bureau's plant and the construction of apparatus.

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[1] *Standing Room Only*, by Edward A. Ross, N.Y., p. 98.

Achievements.—Through conferences held during the past 23 years, practical uniformity in weights and measures has been secured throughout the country. In this connection it should be remembered that the Bureau of Standards has no police power.

Many contributions have been made to the art of radio communication, particularly as regards the fundamental data underlying the propagation of radio waves, and the measurement and control of frequency. Recently a new type of radio beacon has been developed by which aircraft are guided in fog and by which the pilot can tell when he is following the desired course.

Contributions have been made to the art of manufacturing railroad rails, car wheels, boiler plate and other metallurgical products. A means for greatly retarding the corrosion of duralumin, the light alloy used in the construction of aircraft, has been developed, and the plating of metals with chromium has been made a commercial success.

The bureau constructed the first altitude laboratory in the world for testing aircraft engines under flight conditions. In this laboratory the low air pressure and temperatures existing at high altitudes can be duplicated and the performance of the engine determined. The results obtained in this laboratory were of the greatest value in assisting in the design of aeroplane engines during the World War.

The bureau's polarimetry section has made many fundamental discoveries in the field of carbohydrates. A commercial method was developed for the production of corn-sugar (dextrose) and this is now a most important industry. Similar work is now in progress on levulose (sugar obtained from a weed, the Jerusalem artichoke) and experiments will soon be possible on a commercial scale. Revolutionary developments are expected to follow as the sugar has many advantages over cane-sugar for certain uses.

In 1914 experiments were started on the making of optical glass, and in three years the bureau was able to turn out good grades of glass in all the usual varieties. This work has been continued and recently there was cast at the bureau the largest disc of optical glass ever made in this country, 70 in. in diameter and 11 in. thick. This will be used as the mirror of the reflecting telescope at Perkins observatory, Ohio Wesleyan university.

On the experimental paper-mill, a paper on which to print American currency has been developed which shows a strength of 40% greater than the paper formerly used. In co-operation with the Iowa State College experiments are in progress on the manufacture of wall board from corn stalks, and on recovering other valuable products from waste material of the farms.

At the last meeting of the International Conference on Weights and Measures at Paris, in 1927, the bureau was largely responsible for the adoption of a uniform international temperature scale, and for the tentative adoption of a value of the international metre in terms of the wave length of light.

The publications of the bureau can be purchased from the superintendent of documents, Government printing office, Washington, D.C. (*See* STANDARDIZATION.) (G. K. B.)

STANDARDS DEPARTMENT. A department of the English Board of Trade, having the custody of the imperial standards of weights and measures. As far back as can be traced, these were in charge of the chamberlains of the exchequer. This office was abolished in 1826, but the custody of the standards remained attached to an officer in the exchequer (*q.v.*) until that department was abolished in 1866. Meanwhile, in pursuance of recommendations of Standard Commissions of 1841 and 1854 and a House of Commons committee of 1862, the Standards of Weights, Measures and Coinage Act, 1866, was passed. This act created a special department of the Board of Trade, called the "Standard Weights and Measures Department." The Weights and Measures Act of 1878 made the office more strictly a department of the Board of Trade.

The functions of the standards department include the custody of the imperial standards, the periodical comparison of these with their parliamentary copies and the verification and re-verification of local standards and scalebeams for local authorities and of any standards submitted by other bodies in this country or by any colonies or foreign countries. The types of apparatus accepted for verification include standard weights, measures, weighing and measuring instruments, gas-measuring standards and apparatus for determining the flash-point of petroleum. Under the Weights and Measures Act 1904, the department is charged with the duties of examining and certifying candidates nominated by local authorities for appointment as inspectors of weights and measures or inspectors of gas meters; the making of regulations with regard to the verification and stamping of weights, measures and instruments for use in trade, the tests to be applied, the limits to be allowed and the conditions under which stamps are to be cancelled; also the examination and certification of novel patterns of weighing or measuring apparatus with reference to fraud.

There are also standards departments under the charge of experienced scientists in Berlin, Leningrad, Paris, Vienna, Rome, Madrid, Washington and elsewhere. The United States Bureau of Standards is in the Department of Commerce and Labor. (*See* STANDARDS, NATIONAL BUREAU OF.)

STANDERTON, a town in South Africa on the Vaal river, here spanned by two bridges, 114 m. by rail S.E. of Johannesburg; altitude 5,022 feet. It is the chief town of a district of the same name and the centre of an agricultural and of a coal-mining region.

STANDISH, MILES or MYLES (*c.* 1584–1656), American colonist, was born about 1584 in Lancashire, England. He emigrated to New England in the "Mayflower" in 1620 with the Pilgrims, and became the military leader of the Plymouth colony. He was sent to London in 1625 on an unsuccessful mission to secure the intervention of the Council for New England in the affairs of the colony; and in 1628 was one of the eight members of the colony who pledged themselves to pay £1,800 and thus buy out the merchant adventurers who had financed the colony. In 1631 with William Brewster and others he settled at Duxbury, where he died on Oct. 3, 1656, and where on "Captain's Hill" there stands a monument to him.

Longfellow's *Courtship of Miles Standish* apparently has no basis in fact, and Lowell's *Interview with Miles Standish* misrepresents him; he was not a typical Puritan.

See William Bradford's *History of Plimouth Plantation.* Tudor Jenks's *Captain Myles Standish* (1905) and Henry Johnson's *Exploits of Myles Standish* (1897) are popular sketches.

STAND PAT, a term used in American politics, signifying the act of opposing progressive or advanced policies. It originated in the latter part of President Roosevelt's administration when certain progressive or insurgent members of the Republican Party, mostly representatives and senators in Congress, from States west of the Mississippi, called the conservative members of the party "standpatters."

STAND-PIPE is a vertical pipe coupled to a ground hydrant, to lead off water suitably for filling buckets, street-watering hose, fire-hose, watering-carts, etc. The pipe is either permanent or detachable, and the top may be of fixed or swivel type, with one or more outlets. A tall bent pipe is sometimes attached for filling watering-carts or small locomotives. A stand-post is often combined with a drinking fountain or with a lamp column. In either case space is saved and in the latter event the lamp serves as a quick indication of the spot for fire-hose application. In cold climates special construction is necessary, the valve being placed well below the ground. (*See* HYDRANT.)

STANFIELD, WILLIAM CLARKSON (1794–1867), English marine painter, was born of Irish parentage at Sunderland in 1794. As a youth he went to sea, but he practised sketching to such good effect that, on being incapacitated by an accident, he was able to paint scenery at the "Old Royalty," a sailors' theatre in Wellclose Square, London, the Coburg theatre, Lambeth, and at Drury Lane. His first easel exhibit was "Wreckers off Fort Rouge" at the British Institution in 1827, and in 1832 he was made A.R.A. and in 1835 R.A. He died on May 18, 1867. His art was influenced by his early scene painting and tends to be spectacular and dry and hard in colour; on the other hand the treatment is broad and effective.

His principal works are: "Mount St. Michael", "The Opening of London Bridge" and "Portsmouth Harbour" (1832), "The Battle of Trafalgar" (1836) for the United Service Club, "Isola Bella" (1841), "The 'Victory' bearing the Body of Nelson towed into Gibraltar" (1853) and "The Abandoned" (1856). *Stanfield's Coast Scenery* contains 40 of his works engraved in line.

STANFORD, SIR CHARLES VILLIERS (1852–1924), Irish composer, was born in Dublin on Sept. 30, 1852. After studying in London under Ernst Pauer he won (1870) a scholarship at Queen's College, Cambridge, whence he migrated to Trinity College in 1873, and succeeded J. L. Hopkins as college organist, a post he held till 1892. His appointment as conductor of the Cambridge University Musical Society gave him great opportunities. In 1874 to 1877 he visited Germany each year, studying under Reinecke and Kiel. His first important composition was incidental music to Tennyson's *Queen Mary* (Lyceum, 1876). In 1881 his opera, *The Veiled Prophet,* was given at Hanover; followed by *Savonarola* (Hamburg and Covent Garden, 1884), and *The Canterbury Pilgrims* (Drury Lane, 1884). A long interval separates these from his later operas, *Shamus O'Brien,* the least pretending but most successful of all his dramatic works (Opéra Comique, 1896) and *Much Ado About Nothing* (Covent Garden, 1901).

Meanwhile he had been appointed professor of composition at the Royal College of Music in 1883; conductor of the Bach choir in 1885; professor of music in the university of Cambridge, succeeding Sir G. A. Macfarren, in 1887; conductor of the Leeds Philharmonic Society, in 1897, and of the Leeds Festival from 1901 onwards. He was knighted in 1902 and died in London on March 29, 1924. His instrumental works include six symphonies, many chamber compositions, among them two string quartets; besides many songs, part-songs, madrigals, etc., and incidental music to the *Eumenides* and *Oedipus Rex* (as performed at Cambridge), as well as to Tennyson's *Becket.* His last operatic work was *The Travelling Companion,* posthumously produced in 1926. His church music and editions of Irish and other songs are well known.

See his *Studies and Memories* (1908), and *Pages from an Unwritten Diary* (1914).

STANHOPE, CHARLES STANHOPE, 3RD EARL (1753–1816), English statesman and scientist, was born on Aug. 3, 1753, and educated at Eton and Geneva, where he studied mathematics. In politics he was democratic; he represented High Wycombe from 1780 until his accession to the peerage in 1786, giving his support (1783–84) to the administration of Pitt, whose sister, Lady Hester Pitt, he married in 1774; but when Pitt forsook his Liberal principles, Stanhope severed their political connection. He was the chairman of the "Revolution Society," which expressed its sympathy, in 1790, with the aims of the French Republicans, and in 1795 he introduced into the Lords a motion deprecating any interference with the internal affairs of France, on which point he was in a "minority of one." He thereupon retired from politics for five years. He spent much money on experiments in science and philosophy. His inventions include the printing press and the lens which bear his name, a monochord for tuning musical instruments, and two calculating machines. He projected a canal through Devonshire, and took the levels himself. His writings include *Principles of Electricity* (1779); a reply to Burke's *Reflections on the French Revolution* (1790); and an *Essay* on the rights of juries (1792). The lean and awkward figure of Lord Stanhope figured in a host of caricatures. His first wife died in 1780, and in 1781 he married Louisa, daughter and heiress of the Hon. Henry Grenville, who survived him, and died in 1829. Lady Hester Stanhope (*q.v.*) and Lady Lucy Rachael Stanhope, who eloped with the family apothecary and was never reconciled with her father, were daughters by his first wife. Lord Stanhope died at Chevening, Kent, on Dec. 15, 1816.

See G. P. Gooch, *Life of Charles, 3rd Earl Stanhope* (1914).

STANHOPE, LADY HESTER LUCY (1776–1839), the eldest child of the 3rd Earl Stanhope by his first wife, Lady Hester Pitt, was born on March 12, 1776, and lived at her father's seat of Chevening in Kent until early in 1800, when his excitable and wayward disposition drove her to her grandmother's house at Burton Pynsent. In 1803 she became the chief of the household of her uncle, William Pitt. Although her wit and beauty cheered his declining days, her satire created enemies. Lady Hester Stanhope possessed great business talents, and when Pitt was out of office she acted as his private secretary. On his death she was granted a pension of £1,200 a year, dating from Jan. 30, 1806. On Pitt's death she lived in Montagu Square, London, but in 1810, she left England for ever. After many wanderings she settled among the Druses on Mt. Lebanon, and from the lonely villa of Djoun, 8 m. from Sidon, she wielded an almost absolute authority over the surrounding districts, maintained by her commanding character and by the belief that she possessed the gift of divination. Ibrahim Pasha, when about to invade Syria in 1832, solicited her neutrality. She died on June 23, 1839. Her disappointments and her dictatorship intensified a temper naturally imperious. In appearance as in voice she resembled her grandfather, the first Lord Chatham.

Some years after her death there appeared three volumes of *Memoirs of the Lady Hester Stanhope as related by herself in Conversations with her Physician* (Dr. Meryon, 1845), and these were followed in the succeeding year by three volumes of *Travels of Lady Hester Stanhope, forming the Completion of her Memoirs narrated by her Physician.* They presented a lively picture of this strange woman's life and character, and contained many anecdotes of Pitt and his colleagues in political life for a quarter of a century before his death. *See* also Mrs. Charles Roundell, *Lady Hester Stanhope* (1910); the Duchess of Cleveland, *Life and Letters of Lady Hester Stanhope* (1914); and F. Hamel, *Lady Hester L. Stanhope* (1913).

STANHOPE, JAMES STANHOPE, 1ST EARL (*c.* 1673–1721), English statesman and soldier, the eldest son of Alexander Stanhope (d. 1707), a son of Philip Stanhope, 1st earl of Chesterfield, was educated at Eton and Trinity college, Oxford. He served in Italy and Flanders as a volunteer against France, and in 1695 obtained a commission in the British army. Entering the House of Commons in 1701 he still continued his career as a soldier. In 1706 he was appointed British minister in Spain, and in 1708 commander-in-chief there. He captured Port Mahon, assisted at the battles of Almenara and Saragossa in 1710, but was forced to capitulate to the French at Brihuega on Dec. 9, 1710, and was imprisoned in Spain for a year.

Returning to England in 1712 he became one of the leaders of the Whig opposition in the House of Commons, and, in 1714, he became secretary of State for the southern department, sharing with Walpole the leadership of the House. In 1716, as George I.'s foreign minister he only just failed to conclude a treaty with France. He was made first lord of the Treasury in 1717, but in 1718 returned to his former office of secretary of State. In 1717 he was created Viscount Stanhope of Mahon, and in 1718 Earl Stanhope. He helped to conclude the quadruple alliance between England, France, Austria and Holland (1718). He died in London on Feb. 5, 1721, just after the collapse of the South Sea scheme, for which he was partly responsible, though he did not profit.

STANHOPE, PHILIP HENRY STANHOPE, 5TH EARL (1805–1875), English historian, better known as Lord Mahon, son of the 4th earl, was born on Jan. 30, 1805, was educated at Christ Church college, Oxford, and entered parliament in 1830. His chief interest was in literature. He was a trustee of the British Museum, and in 1856 proposed the foundation of the National Portrait Gallery, whose subsequent creation was due to his executors. He also assisted in the establishment of the Historical Manuscripts Commission, and was president of the Society of Antiquaries from 1846 onwards. In 1855 he founded the Stanhope Essay prize at Oxford. His works include: *Life of Belisarius* (1829); *History of the War of Succession in Spain* (1832); *History of England from the Peace of Utrecht to the Peace of Versailles* (1836–53); *Life of William Pitt* (1861–62); and *History of England, comprising the reign of Queen Anne until the Peace of Utrecht* (1870, new ed. 1908), the last two of which remain standard works. Stanhope had unique access to ms. authorities, a clear style, and a general impartiality in criticism. He died on Dec. 24, 1875, and was succeeded by his son, Arthur Philip (1838–1905).

STANIMAKA, a town of south Bulgaria, at the foot of the Rhodope mountains. Pop. (1926), 17,333. It is a very old Greek colony; its inhabitants speak a dialect containing otherwise obsolete classical terms. On the hill above the town is "Tsar Asen's tower" (*see* Asen). This was a very strong fortress, and here Renier of Trit, the Latin Count of Philippopolis, was besieged for nine months, until relieved by Villehardouin (*q.v.*). A few miles up the valley of the Čepelare is the monastery of Bačkovo, the second in Bulgaria, with a famous library.

STANISLAUS I. [Leszczynski] (1677–1766), king of Poland, born at Lemberg in 1677, was the son of Rafael Leszczynski, palatine of Posen, and Anne Catherine Jablonowska. He married Catherine Opalinska by whom he had one daughter. In 1697, as cupbearer of Poland, he signed the confirmation of the articles of election of Augustus II. In 1703 he joined the Lithuanian Confederacy against Augustus, and in the following year Charles XII. selected him to supersede Augustus, and by bribery and intimidation secured his election (July 2, 1704). A few months later Stanislaus was forced by a sudden inroad of Augustus to seek refuge in the Swedish camp, but finally on Sept. 24, 1705, was crowned king with great splendour. Stanislaus at once concluded an alliance with Charles, and rendered him some small assistance against the tsar; but he depended entirely on the success of his ally's arms, and after Poltava (1709) the vast majority of the Poles hastened to repudiate him and make their peace with Augustus, and Leszczynski, henceforth a mere pensioner of Charles XII., retreated to Swedish Pomerania. On the restoration of Augustus, Stanislaus resigned the Polish Crown (though he retained the royal title) in exchange for the little principality of Zweibrücken, residing at Weissembourg in Lorraine.

In 1725 Louis XV. of France married Stanislaus' daughter Mary, and supported his claims to the Polish throne after the death of Augustus II. in 1733, which led to the war of the Polish Succession. On Sept. 9 1733 Stanislaus himself arrived at Warsaw, having travelled through central Europe disguised as a coachman, and on the 10th was once more elected king of Poland. Russia, however, protested, proclaimed the Saxon candidate king as Augustus III. (June 30, 1734), and in October besieged Stanislaus with his partisans in Danzig. The expected French help did not arrive until May 20, 1735, when a fleet disembarked a small force, which, however, could do little. On June 30 Danzig capitulated unconditionally after a stubborn resistance of 135 days. Stanislaus, disguised as a peasant, had contrived to escape two days before. He attempted to rally his partisans from Königsberg, and to secure fresh help from France and from Count Potocki in the Ukraine, but without avail.

In 1736 Stanislaus again abdicated the throne, but received by way of compensation the dukedom of Lorraine and Bar, which was to revert to France on his death. He settled at Lunéville, founded there the *Academia Stanislai*, and devoted himself for the rest of his life to science and philanthropy. He died in 1766 at the age of 89. Among his works may be mentioned: *Oeuvres du philosophe bienfaisant* (Paris, 1763; 1866).

See Robert Nisbet Bain, *Charles XII.* (1895); Louis Lacroix, *Les Opuscules inédites de S. L.* (Nancy, 1866); *Lettres inédites de S. L.*, ed. P. Boyé (1901); Marchioness Des Reaulx, *Le Roi Stanislas et Marie Leszczynski* (1895).

STANISLAUS II. AUGUSTUS [Poniatowski] (1732–1798), king of Poland, the son of Stanislaw Poniatowski, palatine of Cracow, the friend of Charles XII. of Sweden. Through the influence of his uncles the powerful Czartoryski, he was sent to St. Petersburg in the suite of the English ambassador Hanbury Williams. Subsequently, through the influence of the Russian chancellor, Bestuzhev-Ryumin, he was accredited to the Russian court as the ambassador of Saxony. Through Williams he was introduced to the grand duchess Catherine, who was irresistibly attracted to the brilliant young nobleman, for whom she abandoned her other lovers. Poniatowski was concerned in the conspiracy to set aside the succession of the grand duke Peter and his son Paul in favour of Catherine, a conspiracy frustrated by the unexpected recovery of the empress Elizabeth and the consequent arrest of the conspirators.

Stanislaus returned to Warsaw much discredited, but nevertheless was (Sept. 7, 1764) elected king of Poland through the overwhelming influence of Catherine, and crowned on November 25 to the impotent disgust of his uncles. He was hated by the nobility, yet he tried to do his best. He inaugurated some economical reforms. After the first partition he sought to restore the power of their country, while his eloquent oration before the Diet on taking the oath on May 3, 1791, moved the deputies to tears. But when the confederation of Targowica was formed against the constitution, he was one of the first to accede to it, thus completely paralysing the action of the army which, under his younger brother Prince Joseph and Thaddeus Kosciuszko, was performing prodigies. On the outbreak of the insurrection of 1794 he was obliged to sue for his very life to Kosciuszko, and saw his effigy expunged from the coinage a year before he was obliged to abdicate his throne. The last years of his life were employed in his sumptuous prison at St. Petersburg (where he died in 1798) in writing his memoirs. He contracted a secret marriage with the countess Grabowska. He was capable of the most romantic friendships, as witness his correspondence with Mme. Geoffrin.

See Lars von Engeström, *Minnen och Anteckningar*, vol. i. (Stockholm, 1876); *Correspondance inédite de Stanislas Poniatowski avec Madame Geoffrin* (Paris, 1875); Jan Kibinski, *Recollections of the Times of Stanislaw Augustus* (Pol. Cracow, 1899); *Mémoires secrets et inédits de Stanislas Auguste* (Leipzig, 1862); *Stanislaw and Prince Joseph Poniatowski in the Light of their Private Correspondence*, in French, edited in Polish by Bronislaw Dembinski (Lemberg, 1904). Stanislaus's diaries and letters, which were for many years in the Russian foreign office, have been published in the *Vestnik Evropy* for January 1908. *See* also R. N. Bain's *The Last King of Poland and his Contemporaries* (1909).

STANISLAVSKY, stage name of Constantine Sergeevich Alexeev (1863–), Russian theatrical producer, was born in Moscow. His father was a rich mill owner and his grandmother a French actress; he studied at the imperial school of dramatic art and in 1888 began work as an actor and producer in the Society of Art and Literature and after ten years of training founded in 1898 together with the playwright V. N. Danchenko the Moscow Art Theatre. His productions were extremely varied, ranging from the historical *Czar Fedor* to the extreme naturalism of Chekhov's plays. He was also an actor of great force and subtlety, taking the leading parts in Chekhov's and Gorky's plays. Stanislavsky revolutionized the art of producing and is the acknowledged father of the modern Russian theatre.

See Stanislavsky, *My Life in Art* (Eng. trans., 1924).

STANISLAWÓW, a province of Poland. Area 7,090 sq.m. Pop. (1921) 1,349,000, of whom 69·7% are Ruthenians, 22·2% Poles and 6·8% Jews. The Ruthenians speak a different dialect from that of the Ukrainians and the Polesian groups, those in the Carpathian area maintaining their Highland customs, especially the interesting tribes of Hucules, who seem to be of Rumanian admixture. They are members of the Greek Catholic or Uniat Church. The province consists of a fertile belt drained by the tributaries of the Dniester, which forms its north-east boundary, of the Carpathian slopes and the mountains themselves, which rise in height to the east and form the lofty Czarna Hora, with dense forests of beech, fir, etc. The province produces 2,200,000 cubic metres of timber annually, the highest proportion per inhabitant of all the Polish provinces. Stanislawów is famous for its horses and dairy cattle. The salt of Kolomyja has been worked since the earliest times, forming part of the salt belt which extends all along the mountains to Cracow. Potash is found at Kalusz and Turka. The Stanislawów district also has oilfields, producing (1924) 40,495 tons. Other districts, such as Kolomyja, produce oil and there is mineral gas at Kalusz.

The mountain scenery of the province is very beautiful, particularly in the valley of the Stryj. There are a number of health resorts, such as Kosów, in Pokucie. The chief towns are Stanislawów (pop. 1921, 28,200), Stryj (27,300), Kolomyja, Kalusz, Sniatyn and Turka. Halicz (Russian *Galich*), the ancient capital of the three provinces of Stanislawów, Tarnopol and Lemberg, is a small town near the Dniester. It was the capital of a line of

Russian princes, which became extinct in 1340 when Casimir the Great occupied the principality.

STANLEY (FAMILY), derived its name from Stanley in Leek (in the Staffordshire "moorlands"). Its first known ancestor is Adam de Stanley, brother of Liulf de Audley, who lived in the time of King Stephen. His descendant, William de Stanley, acquired the forestership of Wirral, with an heiress, in 1284, and was ancestor of two brothers, Sir William and Sir John Stanley. The former married the heiress of Hooton in Wirral and was ancestor of the Stanleys of Hooton, whose baronetcy, created in 1661, became extinct in 1893. The younger brother, lieutenant of Ireland under Richard II. and Henry IV., obtained from the latter the Isle of Man in fee. His grandson Thomas was father of the first earl of Derby and of Sir William Stanley of Holt, whose great wealth led to his execution for treason in 1495, and also of Sir John Stanley, ancestor of the Stanleys of Alderley, who obtained a baronetcy in 1660 and a barony in 1839. The earls of Derby are noticed under DERBY.

The barony of STANLEY OF ALDERLEY was created in 1839 for Sir John Thomas Stanley, Bart. (1766–1850), of Alderley Park. EDWARD JOHN STANLEY, 2ND BARON (1802–1869), entered the House of Commons in 1831 and became under-secretary to the home department in 1841, patronage secretary to the treasury from 1835 to 1841, paymaster-general in 1841, and under-secretary for foreign affairs from 1846 to 1852. In 1848, two years before he succeeded to the barony of Stanley, he was created Baron Eddisbury of Winnington. He was president of the board of trade from 1855 to 1858, and postmaster-general from 1860 to 1866. His wife, Henrietta Maria (1807–1895), a daughter of Henry Augustus Dillon-Lee, 13th Viscount Dillon, was a remarkable woman. Before her marriage in 1826 she had lived in Florence, and had attended the receptions of the countess of Albany, the widow of Charles Edward, the Young Pretender; and in London she had great influence in social and political circles. When he was patronage secretary her husband was described by Lord Palmerston as "joint-whip with Mrs. Stanley." Later in life Lady Stanley of Alderley helped to found the Women's Liberal Unionist Association, and she was a strenuous worker for the higher education of women, helping to establish Girton College, Cambridge, the Girls' Public Day School Company, and the Medical College for Women. She died in 1895.

STANLEY, ARTHUR PENRHYN (1815–1881), English divine, dean of Westminster, was born on Dec. 13, 1815, at Alderley, Cheshire, the son of Edward Stanley (1779–1849), afterwards bishop of Norwich. He was educated at Rugby under Arnold, and at Balliol college, Oxford. In 1839 he was elected fellow of University college, also taking orders. In 1840 he travelled in Greece and Italy, and for ten years he was tutor of his college. In 1845 he was select preacher, and published in 1847 *Sermons and Essays on the Apostolic Age*. He was a strong advocate of toleration and used his influence to protect from formal condemnation the "Tractarian" party. In 1847 he resisted the movement set on foot at Oxford against R. D. Hampden's appointment to the bishopric of Hereford. Finally, in 1850, in an article in the *Edinburgh Review*, in defense of the "Gorham judgment" he asserted two principles which he maintained to the end of his life—first, "that the so-called supremacy of the Crown in religious matters was in reality nothing else than the supremacy of law," and, secondly, "that the Church of England by the very condition of its being, was not High or Low, but Broad, and had always included and been meant to include, opposite and contradictory opinions."

He was greatly interested in university reform and acted as secretary to the royal commission reporting in 1852. Stanley was also appointed to a canonry at Canterbury. During his residence there he published his *Memoir* of his father (1851), and completed his *Commentary on the Epistles to the Corinthians* (1855). In the winter of 1852–53 he made a tour in Egypt and the Holy Land, the result of which was his well-known volume on *Sinai and Palestine* (1856). In 1857 he travelled in Russia, and collected much material for his *Lectures on the Eastern Church* (1861).

At the close of 1856 Stanley was appointed regius professor of ecclesiastical history at Oxford, a post which, with the attached canonry at Christ Church, he held till 1863. He published the first two volumes of his *History of the Jewish Church* in 1863 and 1865. In the storm which followed the publication of *Essays and Reviews* Stanley opposed the High Church Party. In 1836 he published a *Letter to the Bishop of London*, advocating a relaxation of the terms of clerical subscription to the Thirty-nine Articles and the Prayer Book. An act amending the Act of Uniformity, and carrying out in some degree Stanley's proposals, was passed in the year 1865. In 1862, Stanley accompanied the prince of Wales in Egypt and Palestine.

In 1863 he was appointed dean of Westminster. In December he married Lady Augusta Bruce, sister of Lord Elgin, then governor-general of India. He wrote a third volume of his *History of the Jewish Church*, a volume on the *Church of Scotland*, another of *Addresses and Sermons* preached in America, and another on *Christian Institutions* (1881). He was constantly fighting for the interests of the poor. He gave offence by defending Bishop Colenso, although he disapproved of Colenso's views, and, still more, by his invitation to the Holy Communion of all the revisers of the translation of the Bible, including a Unitarian among other Nonconformists. He desired that the Athanasian Creed be optional instead of imperative in the Church of England. In 1874 Stanley, who was much esteemed by Queen Victoria, conducted the Anglican ceremony at the marriage of the duke of Edinburgh and the grand duchess Marie. He died on July 18, 1881, and was buried in Henry VII.'s chapel.

Stanley's other works include: *Life of Dr. Arnold* (1844); *Essays on Church and State* (1870); *Memorials of Westminster Abbey* (1865). *See* G. G. Bradley *Recollections of A. P. Stanley* (1883); R. E. Prothero and G. G. Bradley, *Life and Correspondence of Dean Stanley* (2 vols., 1893).

STANLEY, SIR HENRY MORTON (1841–1904), British explorer of Africa, discoverer of the course of the Congo, was born at Denbigh, Wales, on June 10, 1841, of a family named Rowlands or Rollant. John Rowlands, by which name Stanley was baptized, was brought up first by his maternal grandfather, and after his death was boarded out by his mother's brothers at half a crown a week. In 1847 he was taken to the St. Asaph Union workhouse, where the schoolmaster, James Francis (who eventually died in a madhouse), was a tyrant of the Squeers type, and in May 1856, Rowlands, after giving Francis a thrashing, ran away from school. His paternal grandfather having refused to help him, he became a pupil teacher at Brynford, where his cousin was master. But within a year he was sent to Liverpool, where he lived in poverty with an uncle, and after working at various trades, he sailed as a cabin boy to New Orleans, where he landed in 1859. There he obtained a situation through the good offices of Henry Morton Stanley, who subsequently adopted the lad as his son, but died without making provision for him.

When the Civil War broke out in 1861 Stanley enlisted in the Confederate army; he was captured at the battle of Shiloh (April 1862), and after two months' imprisonment at Camp Douglas, Chicago, he obtained release by enrolling in the Federal artillery. In less than a month he was discharged as unfit. In November 1862 he returned to Liverpool "very poor, in bad health and in shabby clothes," and made his way to Denbigh, but was turned away from his mother's door. For a livelihood he took to the sea—was wrecked off Barcelona—and in August 1864 enlisted in the United States navy. After the war he crossed the plains to Salt Lake City, Denver, and other parts, and became a vivid descriptive writer.

Thus began a series of adventures in search of "copy," which led him through Asia Minor, Tiflis and Tibet. In 1860 Stanley revisited Denbigh and St. Asaph, returning thence to America, where he joined General Hancock's expedition against the Red Indians, acting as correspondent for the *Missouri Democrat* and other papers. His reports induced the *New York Herald* to send him to accompany the British expedition of 1867–68 against the emperor Theodore of Abyssinia. Succeeding in sending through the first news of the fall of Magdala, Stanley received a roving commission from the proprietor of the *Herald*, James Gordon Bennett. He went to Crete and Spain, but in 1869 was recalled to Paris by Mr. Gordon Bennett, jun.

Convinced that David Livingstone was alive Bennett commissioned Stanley to go in search of him. But he cumbered Stanley with a large number of commissions in Egypt, Syria and Persia before the quest for Livingstone could be begun. Eventually he sailed from Bombay for Africa, reaching Zanzibar on Jan 6, 1871.

The journey to the interior was begun on March 21; on Nov. 10, having overcome innumerable difficulties, Stanley arrived at Ujiji, where he found Livingstone. With Livingstone Stanley navigated the northern shores of Tanganyika, settled the question as to whether the Rusizi was an effluent or an affluent—a point then much debated in connection with the hydrography of the Nile basin, and regained Zanzibar on May 7, 1872. His story, made public in a picturesque narrative, *How I Found Livingstone* (1872), was received in London with some incredulity; but the journals of Livingstone, which he brought home, silenced the critics, and from Queen Victoria Stanley received a gold snuff-box set with brilliants and her thanks for his services.

A series of public lectures in England and America followed. In 1873, as war correspondent of the *Herald*, he accompanied Wolseley's expedition to Ashanti, which he described, together with his Abyssinian experiences, in a volume entitled *Coomassie and Magdala: Two British Campaigns* (London, 1874). On reaching the island of St. Vincent from Ashanti in 1874 he first heard that Livingstone was dead.

Second African Journey.—Stanley now desired to return to Africa to determine geographical problems left unsolved by the deaths of Livingstone and Speke, and the discovery by Sir Samuel Baker of Albert Nyanza, a lake then reputed to extend illimitably in a southerly direction. A fund was raised by Lord Burnham, Gordon Bennett and others for an Anglo-American expedition under Stanley's command. This expedition lasted from October 1874 to August 1877 and accomplished more than any other single exploring expedition in Africa. Politically the journey led to the foundation of the Congo State and to the partition of the hitherto unappropriated regions of Africa between the states of western Europe. Stanley started from the east coast and reached the ocean again at the mouth of the Congo, having demonstrated the identity of that river with Livingstone's Lualaba by navigating its course from Nyangwe—the point at which both Livingstone and Lovett Cameron had turned aside.

Of the three white men who accompanied him all died during the journey; Stanley himself was prematurely aged. The discovery of the course of the Congo, though the greatest, was but one of many geographical problems solved during this memorable expedition. The part played by the Kagera in the Nile system, the unity and approximate area of Victoria Nyanza, the true length and area of Tanganyika and the whereabouts of its outlet, and the discovery of a new lake, Dweru, which at the time Stanley believed to be a branch of Albert Nyanza, are some of the other discoveries made by Stanley at this time. The story of the expedition was given at length in *Through the Dark Continent* (London, 1878). Stanley's letters from Uganda and his call for missionaries to go to the court of Mtesa met with an immediate response and proved the first step in bringing the region of the Nile sources under the protection of Great Britain. Commercially the discovery of a navigable waterway penetrating the heart of Africa, was of paramount importance, a fact which was grasped by Leopold II., king of the Belgians, who sent commissioners to intercept Stanley at Marseilles, when he was on his way back to England, with proposals to return to the Congo, proposals which Stanley, much needing rest, put aside for the time. In November, 1878, Stanley went to Brussels and entered into the schemes of the Belgian king.

Congo Free State.—A *Comité d'études du Haut Congo* was formed and Stanley was entrusted with the leadership of the new expedition. Stanley reached the Congo in August 1879, and the work he accomplished there in the ensuing five years enabled the comité, which had meantime changed its name to that of *Association internationale du Congo*, to obtain the recognition of America and Europe to its transformation into an independent state ("The Congo Free State") under the sovereignty of King Leopold. Stanley described his labours in *The Congo and the Founding of its Free State* (London, 1885). For the political aspects of the question *see* Africa (§ 5) and Congo Free State. He was restricted by the enterprise of the French traveller de Brazza, who, reaching Stanley Pool by a more northern route, placed the neighbouring districts on the north bank of the Congo under French protection (1880). Stanley returned to Europe in the middle of 1884 and attended the Berlin Conference of 1884-1885, which dealt with African affairs, acting as technical adviser of the American plenipotentiaries.

Third African Journey.—Stanley now became interested in the schemes of Mr. (afterwards Sir) William Mackinnon for establishing a British protectorate in East Equatorial Africa, and it was believed that this object could be furthered at the same time that relief was afforded to Emin Pasha (*q.v.*), governor of the Equatorial Province of Egypt, who had been isolated by the Mahdist rising of 1881–1885. Stanley agreed to conduct an expedition, nominally in the service of the khedive of Egypt, for the relief of Emin. He decided to go by way of Zanzibar and the Congo State. He left Europe in January 1887 and at Zanzibar entered into an agreement with Tippoo Tib, the chief of the Congo Arabs, appointing him governor of Stanley Falls station on behalf of the Congo State, and making another arrangement with him to supply carriers for the expedition. On June 15, Yambuya, on the lower Aruwimi, was reached, and here Stanley left his rearguard under command of Major E. M. Barttelot and Mr. J. S. Jameson. On the 28th Stanley and the advance-guard started for Albert Nyanza, "and until Dec. 5, for 160 days, we marched through the forest, bush and jungle, without ever having seen a bit of greensward of the size of a cottage chamber floor. Nothing but miles and miles, endless miles of forest." Starvation, fever, the hostility of the tribes, were daily incidents of this terrible march, during which Stanley lost nearly 50% of his men. On Dec. 13, Albert Nyanza was reached, and after some delay communication was opened with Emin, who came down the lake from the Nile in a steamer. Disquieted by the non-arrival of his rearguard, Stanley retraced his steps, and on Aug. 17, 1888, a short distance above Yambuya, found that Tippoo Tib had broken faith, that Barttelot had been murdered, that Jameson (who soon afterwards died of fever) was absent at Stanley Falls, and that only one European, William Bonny, was left in the camp.

Collecting those who survived of the rearguard Stanley for the third time traversed the primeval forest, and in January 1889 all that was left of the expedition was assembled at Albert Nyanza. Of 646 men with whom he entered the Congo, but 246 remained. In April the return journey to Zanzibar by way of Uganda was begun, Emin reluctantly accompanying Stanley. On this homeward journey Stanley discovered Ruwenzori (the Mountains of the Moon), traced the course of the Semliki River, discovered Albert Edward Nyanza and the great south-western gulf of Victoria Nyanza. During his stay in the Congo forests he had also obtained much information concerning the pygmy tribes. As to the political results of the expedition, Stanley's proposals to Emin to hold the Equatorial Province for the Congo State or to move nearer Victoria Nyanza and enter the service of Mackinnon's British East Africa Company had not been accepted, but he concluded agreements with various chiefs in the lake regions in favour of Great Britain, agreements which were handed over to the East Africa Company. Zanzibar was reached on Dec. 6, 1889, and the expedition was at an end. *In Darkest Africa*, was published (in six languages) in 1890.

Returning to England, Stanley was received with much honour, and received many distinctions. There was, nevertheless, bitter controversy over the fate of the rearguard of the expedition. On July 12, 1890, he married Miss Dorothy Tennant, second daughter of Mr. Charles Tennant, sometime M.P. for St. Albans. Later in the year he visited the United States, and in 1891–1892 went to Australia and New Zealand on lecturing tours. On his return he was renaturalized as a British subject, and after an unsuccessful attempt in 1892, he was elected member of parliament in 1895. He did not seek re-election in 1900. In 1895 Stanley published *My Early Travels and Adventures in America and Asia*, in which he retold the story of his experiences with the Red Indians and of his eastern journey of 1869–1870. In 1897 Stanley paid his last visit to Africa. He went to the Cape as the guest of the British South Africa Company, spoke at the opening of the railway from the Cape to Bulawayo, visited the Victoria Falls of the Zambezi and had an interview with President Kruger, of whom he gives a characteristic pen-picture. One result of this journey was *Through South Africa* (1898), the last of his published works. In 1899 in recognition of his services in Africa he was made a K.C.B. The last few years of his life were spent mainly in retirement on a small estate he had purchased, Furze Hill, near Pirbright. He died at his London residence in Richmond Terrace, Whitehall, on May 10, 1904, and was buried at Pirbright. The monolith over his grave bears the inscription: "Henry Morton Stanley 1841–1904" with his African name "Bula Matari" and the one word "Africa."

In geographical discoveries Stanley accomplished more than any other explorer of Africa. Notwithstanding his frequent conflicts with Arabs and negroes, he possessed in extraordinary degree the power of managing native races; he was absolutely fearless and ever ready to sacrifice either himself or others to achieve his object. His books differ widely from the ordinary books of travel. Stanley had a gift of dramatic narrative, and his power of portraiture was remarkable. Curiously, the least successful of his works was the only one which he cast in the form of fiction, *My Kalulu, Prince, King and Slave. My Dark Companions and their Strange Stories* (1893) is a valuable contribution to folklore.

The Autobiography of Sir Henry Morton Stanley, ed. by his wife, Dorothy Stanley, appeared in 1909. *Henry M. Stanley, the Story of his Life . . .* (London, n.d. [1872]), by C. Rowlands, contains, notwithstanding many inaccuracies, valuable information concerning his family and early career. The following books may also be consulted: Mrs. J. S. Jameson, *Story of the Rear Column of the Emin Pasha Relief Expedition* (1890); W. G. Barttelot, *The Life of Edmund Musgrave Barttelot . . .* (1890); H. Brode, *Tippoo Tib, the Story of his Career in Central Africa* (1907). (F. R. C.)

STANLEY, THOMAS (1625–1678), English poet and philosopher, son of Sir Thomas Stanley of Cumberlow, in Herts, was born in 1625. His mother, Mary Hammond, was the cousin of Richard Lovelace, and Stanley was educated in company with the son of Edward Fairfax, the translator of Tasso. He studied both at Cambridge and Oxford, and travelled widely in Europe. Stanley was the friend and companion, and at need the helper, of many poets, and was himself both a writer and a translator of verse. His *Poems* appeared in 1647; his *Europa, Cupid Crucified, Venus Vigils*, in 1649; his *Aurora and the Prince*, from the Spanish of J. Perez de Montalvan, in 1647; *Oronta, the Cyprian Virgin*, from the Italian of G. Preti (1650); and *Anacreon; Bion; Moschus; Kisses by Secundus . . .* a volume of translations, in 1651. Stanley's most serious work in life, however, was his *History of Philosophy* (3 vols., 1655–61). A fourth volume (1662), bearing the title of *History of Chaldaick Philosophy*, was translated into Latin by J. Le Clerc (Amsterdam, 1690). The three earlier volumes were published in an enlarged Latin version by Godfrey Olearius (Leipzig, 1711). In 1664 Stanley published in folio a monumental edition of the text of Aeschylus. He died at his lodgings in Suffolk Street, Strand, London, on April 12, 1678.

The English metaphysical school closes with Stanley, who went on weaving his fantastic conceits in elaborately artificial measures far into the days of Dryden and Butler. His *History of Philosophy* was long the principal authority on the progress of thought in ancient Greece.

Stanley's original poems were imperfectly reprinted in Sir S. Egerton Brydges's edition of 150 copies in 1814. His "Anacreon" was issued, with the Greek text, by Mr. Bullen in 1892.

STANNARIES, tin mines (late Lat. *stannum*, Cornish, *stéan*, tin). Stannary courts exercised a jurisdiction peculiar to Cornwall and Devon. By ancient charters, the tinners of Cornwall were exempt from all other jurisdiction than that of the stannary courts, except in cases affecting land, life and limb. Tin-mining in Cornwall, from the very earliest times was always prosecuted in accordance with a particular code of customs; the earliest charter which embodies them is that of Edmund, earl of Cornwall, but it is impossible to say how far these customs go back.

Twenty-four stannators were returned for the whole of Cornwall. Their meeting was termed a parliament, and when they assembled they chose a speaker. In earlier times the combined tinners of Devon and Cornwall assembled on Hingston down, a tract of highland on the Cornish side of the Tamar. After the charter of Earl Edmund, the Cornish stannators met (apparently) at Truro; those of Devon at Crockern Tor on Dartmoor. An officer was appointed by the duke of Cornwall or the Crown, who was lord warden of the stannaries. The last Cornish stannary parliament was held at Truro in 1752. A committee was appointed to report on the subject, and an act of parliament was (1836) passed, suppressing the law courts of the stewards of the different stannaries and giving to the vice-warden their jurisdiction. By the Stannaries Act 1855 the respective parliaments or stannaries courts of Cornwall and Devon were consolidated. By the Stannaries Courts Abolition Act 1896 the jurisdiction was transferred to the county courts. The most important customs were: (*a*) "free tinners" had the right to work upon rendering the "toll-tin," usually one-fifteenth of the produce, to the owner or lord of the soil; (*b*) the right of "tin-bounding," that is, the right of bounding waste lands, subject to tin-toll.

See G. R. Lewis, *The Stannaries* (Boston and New York, 1908); W. S. Lewis, *West of England Tin Mining*, with bibliography (Exeter, 1923); A. K. Hamilton Jenkin, *The Cornish Miner* (1927).

STANNITE, a rare mineral consisting of tin, copper and iron sulphide (a sulpho-stannate, Cu_2FeSnS_4), containing, when pure, tin 27·5, copper 29·5%. It has a metallic lustre, and, when pure, is iron-black in colour; more often, however, it is bronze-yellow, owing to tarnish or to the presence of intimately admixed chalcopyrite: for this reason it is known to miners as "bell-metal-ore" or as "tin pyrites." The hardness is 3·5 and the specific gravity 4·45. It usually occurs as granular to compact masses, rarely as crystals. Minute crystals from Bolivia have been shown to be tetragonal and hemihedral, like chalcopyrite; and to be invariably twinned, giving rise to pseudocubic forms. The mineral has been found in a number of Cornish tin mines, and was formerly worked to a limited extent as an ore. At Zinnwald in Bohemia it occurs with blende and galena, and in Bolivia with silver ores. (L. J. S.)

STANTHORPE, a town in the S.E. of Queensland, Australia, 198 miles by rail south-west of Brisbane. It stands at an altitude of 2,650 ft. on a N.W. spur of the New England Plateau (*see* New South Wales) in the midst of delightful scenery and in a bracing climate (Av. ann. temps.: 80°–35° F, with winter frosts; av. ann. rainfall 30·5 in.). Stanthorpe, which is situated on the main interstate line (Brisbane-Sydney), is a noted summer and tourist resort (Pop., including district: *c.* 7,000).

STANTON, EDWIN McMASTERS (1814–1869), American statesman, was born at Steubenville, O., on Dec. 19, 1814. He attended Kenyon college at Gambier, O., and was admitted to the bar in 1836. In 1847 he removed to Pittsburgh, Pa. As counsel for the State, he invoked successfully the aid of the Federal Government in preventing the construction of a bridge over the Ohio river at Wheeling, Va., (now West Virginia)—on the ground that the structure would interfere with the navigation of that stream by citizens of Pennsylvania. He removed to Washington in 1856. In 1858 he was sent to California by the United States attorney general as special Federal agent for the settlement of land claims. Before the Civil War, Stanton was a Democrat, opposed to slavery, but a firm defender of the constitutional rights of the slaveholders, and was a bitter opponent of Lincoln, whose party he then hated and distrusted. In the reorganization of President Buchanan's cabinet in 1860 Stanton became attorney general, and he did what he could to strengthen the weak policy of the President. Although he had often violently denounced President Lincoln, the latter thought he saw in Stanton a good war minister, and in January, 1862, invited him into his cabinet. Stanton was often harsh, and his peremptory manner was the cause of friction with the generals, an instance being his controversy with Gen. Sherman over the terms of surrender granted to J. E. Johnston's army. But he removed a horde of fraudulent contractors, kept the armies in the field well equipped and infused energy into procrastinating generals. Not the least of his achievements was the peaceable disbandment of 800,000 soldiers at the end of the war.

Remaining in the cabinet of President Andrew Johnson, Stanton exerted all his energies toward thwarting the policies of that executive, especially those related to the reconstruction of the Southern States. He expressed disapproval of the Tenure of Office Act, making the consent of the Senate necessary for the removal of civil officers, and drafted the supplementary act on reconstruction, passed over the President's veto on July 19, 1867. Stanton was finally asked to resign, and on his refusal to do so the President suspended him (Aug. 12) from office and appointed Gen. Grant (who had disapproved of the secretary's removal) secretary *ad interim.* When the Senate, however, under the terms of the Tenure of Office Act, refused (Jan. 13, 1868) to concur in the suspension, Grant left the office and Stanton returned to his duties. On Feb. 21, 1868, Johnson appointed Gen. Lorenzo Thomas secretary of war *ad interim,* and ordered Stanton to vacate, but on the same day the Senate upheld Stanton, and by way of reply the secretary made oath to a complaint against Thomas for violating the Tenure of Office Act, and invoked military protection from Gen. Grant, while Congress came to Stanton's rescue by impeaching the President, the principal article of impeachment being that based on the removal of Stanton (*see* JOHNSON, ANDREW). When the impeachment proceedings failed (May 26) Stanton resigned and returned to the practice of law. Stanton had a violent temper and a sharp tongue, but he was courageous, energetic, thoroughly honest and a genuine patriot. He died in Washington on Dec. 24, 1869.

See George C. Gorham, *Life and Public Services of Edwin M. Stanton* (Boston, 1899) and Frank A. Flower, *Edwin McMasters Stanton: The Autocrat of Rebellion, Emancipation, and Reconstruction* (1905).

STANTON, ELIZABETH CADY (1815–1902), American leader in the woman's rights movement, was born in Johnstown, N.Y., on Nov. 12, 1815, the daughter of Judge Daniel Cady. In her father's law office she learned of the discriminating laws under which women lived, and many tragic cases observed there determined her in the ambition to equalize the rights of her sex. She did much by the circulation of petitions to secure the passage in New York in 1848 of a law giving a married woman property rights. In the same year, on June 19 and 20, in Seneca Falls, was held, chiefly under the leadership of Mrs. Stanton and Mrs. Lucretia Mott, the first woman's rights convention in the United States. For this convention Mrs. Stanton had drawn up her famous woman's bill of rights setting forth the inferior and unjust position of women in State, church, law and society, and resolutions demanding redress, which were adopted. All of these demands have since been extensively granted. One of them, introduced without Mrs. Mott's approval, was a resolution in favour of equal suffrage for women, which, when approved, became the first organized demand in the United States by women for the ballot. In 1850 she became associated with Susan B. Anthony and for 40 years the two worked together, each admirably supplementing the other, Mrs. Stanton writing, Miss Anthony managing affairs. In 1867–70 they co-operated in editing *The Revolution,* a women's rights newspaper. She was president of the National Woman Suffrage Association from 1865 to 1893. With Miss Anthony and Mathilda Gage she wrote *The History of Woman Suffrage* (4 vol., 1887–1902). She died in New York city on Oct. 2, 1902.

See T. Stanton and H. S. Blatch, ed., *Elizabeth Cady Stanton as Revealed in Her Letters, Diary and Reminiscences* (1922).

STANYHURST, RICHARD (1547–1618), English translator of Virgil, was born in Dublin in 1547. At University College, Oxford, he met Edmund Campion. After studying law, he went to Spain, ostensibly as a physician, but really to keep Philip II. in touch with the Catholic interest in England. In 1602 he took holy orders, and died at Brussels in 1618. He translated *The First Foure Bookes of Virgil his Aeneis* (Leiden, 1582), to prove Gabriel Harvey's theory that classical prosody could be applied to English poetry. The translation is a jargon arranged in so-called hexameters.

A reprint in 1583 by Henry Bynneman forms the basis of J. Maidment's edition (Edinburgh, 1836), and of Professor E. Arber's reprint (1880), which contains an excellent introduction. Stanyhurst's Latin works include *De rebus in Hibernia gestis* (Antwerp, 1584) and a life of St. Patrick (1587).

STAPLE, originally a prop or support; in current usage a U-shaped piece of metal, generally galvanized or wrought iron, in wire form with sharpened points, and used as a fastener by driving into wood; also the chief or ordinary bulk articles of trade. In England the term was applied to towns which were appointed by the king to be the merchants of the staple. These merchants had a monopoly in the staple commodities, viz., wool, wool fells, leather, tin and lead, and were the origin of all English trading companies. (*See* also NAIL MANUFACTURE.)

See C. Gross, *Gild Merchants;* W. Cunningham, *Growth of English Industry and Commerce.*

STAR, the general term for the luminous bodies seen in the sky, but more especially applied to the "fixed stars," which maintain practically the same relative positions in the sky and form constant patterns or constellations. The planets or "wandering stars" are accordingly excluded (*see* ASTRONOMY).

Unlike the planets which shine by reflected light from the sun, the stars are self-luminous. They are bodies of the same nature as the sun; and the only reason why the sun appears so much more brilliant is that it is comparatively close to us. The following figures speak for themselves: Distance of sun—92,900,000 miles; distance of nearest star—25,500,000,000,000 miles. Each star is a fiery globe enormously larger than the earth. Some stars may have planets but we cannot yet detect such planets if they exist. Moreover, theoretical researches warn us against speculation; the system of planets round the sun may be something of a freak.

Although we have been able to learn indirectly the actual dimensions of many of the stars, their size is not revealed by telescopic observation. In the largest telescope a star remains a point of light, and there is no possibility of observing surface markings such as we see on the sun. One unexpected feature, however, is seen directly a telescope is used; a considerable number of the stars which appear single to the naked eye, are seen in the telescope to consist of two stars. The occurrence of close pairs of stars is far too frequent to be due to chance; and, indeed, in some cases the two components have been observed to be revolving round one another. We have to recognize that although single stars like the sun are in the majority, evolution has very frequently taken another course and furnished pairs of luminous globes.

It can be recognized with the naked eye that the stars differ in colour. The colour is not very vivid; but, for example, if the reader is familiar with the constellation Orion, he will easily see that the brighter of the two shoulder stars (Betelgeuse) has a reddish tinge in contrast to all the other bright stars in the constellation, which are white. The quality of the light (crudely indicated by the colour, and in a more detailed way by examination with a spectroscope) is a clue to the surface temperature of the star. As we should expect, the "white-hot" stars are the hottest, and the "red-hot" stars the coolest. Another fact which can be verified with the naked eye, though it requires patient and systematic watching, is that some of the stars give an inconstant light which varies periodically in the course of a few days or months. There are several different kinds of variable stars described below; in one class the variation is a genuine physical change, the star swelling and contracting with regular pulsations.

The Stellar Universe.—Thus the statement that the stars are "suns," whilst giving a correct general idea of their nature, must be amplified to cover a wide variety of objects with many individual characters. They differ greatly in physical condition. Betelgeuse (above-mentioned) is an example of one extreme; it is a gigantic globe so large that the whole orbit of the earth could be put inside it, but so tenuous that its density is less than $\frac{1}{1000}$ that of air—many a so-called vacuum is not more exhausted than this. An example of the other extreme is the companion of Sirius (*see* SIRIUS), which is compressed to a density far exceeding anything known on earth, and is in size not so large as the planet Uranus. Besides the study of the stars as individual units we have to consider their organization as a system. The principal indication of this organization is found in their motions. Although we often call them *fixed stars,* they are moving rapidly with speeds of the order 10 to 100 m. a second. Notwithstanding their great distance, the resulting changes of position in the sky can be determined by refined measurement; it is the exception for a bright star to have a motion too small to be detected in, say, 20 years. Further evidence of organization is afforded by the distribution of the stars in the sky. They are crowded towards one special plane, viz., that marked out by the Milky Way, or Galaxy, a band of diffuse light stretching all round the sky which, under telescopic examination, is resolved into millions of faint stars. In general, in speaking of the stars we refer to this galactic system or universe; but it is believed that the spiral nebulae, of which there are a great number, are island universes coequal with our galactic system. In some of these nebulae individual stars can be detected by aid of the largest telescopes.

We find ourselves then in a galaxy which is just one amid perhaps a million spiral nebulae. The nearest of the other systems is so remote that light takes nearly a million years to traverse the void which separates us from it. The number of stars in our own galaxy is estimated at some 3,000 millions—a prodigious number, but we might, perhaps, recall that it amounts to less than two stars apiece for the human inhabitants of the earth. To one of the less distinguished stars of this host is attached the earth, which is our home. The evolutionary process which has swept across this system, condensing stars out of the primitive mist, has occupied a time which must probably be reckoned in millions of millions of years. From this orgy of inconceivable numbers we may, perhaps, glean an impression of man's place in the material universe. The space and the time which belong to him are as nothing in the far extent and the untold ages of inorganic nature. Is terrestrial man the one and final purpose of it all? Nothing in astronomy has appealed more to the imagination than the conception that each of the myriad points of light in the sky may be giving warmth and light to planets like our earth. It would seem a presumption to deny to them inhabitants of the same order of creation as ourselves. Nevertheless, we must not forget the prodigality of Nature. If indeed she has no grander aim than to bring forth her favoured child, Man, it would be just like her methods to scatter a million stars whereof but two or three might haply achieve her purpose. Strong reasons have been given by J. H. Jeans for regarding our solar system as a very unusual development. Although probably not unique, the formation of a system of planets is not the normal course of evolution of a star. It only happens when, at a critical stage of development, disruption is caused by the accidental approach of another star—a fortune which, perhaps, not one star in a hundred millions would be likely to undergo. This theory is subject to much uncertainty; but it is at least a useful corrective to the view, often too facilely accepted, which assumes an almost infinite plurality of living worlds.

History of the Study of Stars.—In the older books on astronomy most of the space is devoted to the bodies of the solar system (sun, moon, planets, comets); the little that was known of the stars could be compressed into two or three chapters at the end. It is natural that our first acquired knowledge should relate chiefly to the bodies that are nearest to us. Much labour was devoted to observing the stars, but that was largely because they had to serve as graduation marks in the sky against which the movements of the planets and comets could be recorded. Of late the *centrifugal* march of astronomical knowledge has been very remarkable, and the study of the stars is now the largest field of astronomical research. The following may be selected as the chief landmarks in this progress:

1. The first variable star (Mira Ceti) was discovered by Fabricius in 1596.

2. The first double star (Mizar) was discovered by Jean Baptiste Riccioli in 1650.

3. Edmund Halley first detected the proper motions of stars (Arcturus, Aldebaran, Sirius) in 1718.

4. Sir William Herschel may be regarded as the pioneer of studies of the sidereal system. He discovered the solar motion (motion of the sun through the system of the stars) in 1783. By his famous counts of stars (star-gauges) he established the flattened form of the stellar universe. In 1803 he was able to announce, from his measures of double stars made during the previous 25 years, the confirmation of the theory (urged by Christian Mayer in 1779) that the components revolve round one another.

5. In 1839 distances of the two stars 61 Cygni and α Centauri were found by measurement of parallax by F. W. Bessel and T. Henderson, respectively. This gave the first definite idea of the scale of the stellar system.

6. In 1862 William Huggins applied the spectroscope to the stars and identified many familiar terrestrial elements as present in their atmospheres. The classification of stars according to their spectra was instituted by Angelo Secchi shortly afterwards.

7. Photography of the stars was developed between 1882 and 1887, the international photographic chart of the heavens and catalogue (not yet completed) being planned in the latter year.

8. Measurement of the velocities of stars in the line of sight by means of the spectroscope was developed very slowly in the latter part of the 19th century. The early measurements were entirely untrustworthy, and it is difficult to say when this powerful aid to stellar research properly started. Good results were obtained by H. C. Vogel and J. Scheiner in 1888–91. A great development of this branch of work was brought about by W. W. Campbell from 1897 onwards. The first spectroscopic binary star (Mizar) was found by E. C. Pickering in 1889.

9. J. C. Kapteyn discovered, in 1904, that, at least in our local system, the stars are moving in two main streams. This gave great stimulation to statistical studies of the sidereal universe.

10. The distinction between giant and dwarf stars made manifest by the researches of E. Hertzsprung and H. N. Russell began to be generally accepted about 1913.

11. The first direct determination of the angular diameter of a star, *i.e.,* the apparent size of its disc, was made by F. G. Pease and J. A. Anderson in 1920, using an interferometer designed by A. A. Michelson.

12. The physical theory of ionization was applied by M. N. Saha to the interpretation of spectral features of the stars in 1920. This led to a branch of research which has had most extensive developments.

The Twinkling of Stars.—Before entering on a fuller account of this progress we must refer to a question which is often put. Why do the stars twinkle? If we trace the beam of light, roughly $\frac{1}{10}$ in. in diameter, which fills the eye-pupil back towards the star, it has passed through some miles of terrestrial atmosphere. Differences of density due to slight inequalities of temperature will cause continual changes of refraction at one point or another on the path, giving rise to a general unsteadiness. More important still is the "interference of light." The irregularity of density may be such that the light at opposite edges of the narrow beam has traversed different effective thicknesses of air, so that the corresponding waves are delayed by different amounts. If the delay amounts to half a wave-length the waves will arrive crest-on-trough, and, instead of summing up to give a bright star-image, they will cancel one another. Thus the image pops in and out as the changes of atmospheric density succeed one another. The condition for cancelling is different for light of different colours (corresponding to different wave-lengths), consequently the star sparkles with different colours. To understand why this does not happen to the light of the planets we must recall that the disc of the planet, unlike the star-disc, subtends a considerable angle at the eye. The diameter of Saturn, for example, is normally about 20 seconds of arc, which means that at the height of a mile the rays which reach the eye fill an area 6 in. in diameter. This gives plenty of scope for the variations of the individual beams ($\frac{1}{10}$ in. in diameter) to average out, and consequently they combine to give a fairly steady brightness. Interference or cancelling of waves occurs between waves reaching different parts of the pupil, but not between waves starting from different parts of the disc of the planet or star; thus twinkling depends on the ratio between the angular sizes of the celestial object and of the eye-pupil as viewed from an average height in the earth's atmosphere.

NUMBER AND MAGNITUDE OF THE STARS

On a clear dark night the stars seem to be innumerable in multitude, but in reality the number in the whole sky visible to the unaided eye is about 6,000. A small telescope greatly multiplies the number, and the largest instruments (aided by long photographic exposures) would reveal some hundreds of millions. The brightness is expressed by "magnitudes," the progressively fainter stars being of progressively greater magnitude. A star is defined to be one magnitude higher than another if its light is fainter in the ratio 2·512; this ratio is adopted so that a difference of five magnitudes may correspond to a light-ratio of 1:100. The faintest stars visible to the naked eye on clear nights are about the 6th magnitude. The brightest star, Sirius, has magnitude −1·6 *i.e.,* 7·6 magnitudes brighter, or just over 1,000 times more luminous, than the faintest naked-eye stars. Classified on the same scale, the sun's magnitude is −26·7. It is possible with the largest instruments to reach stars of about the 21st magnitude. It gives some idea of the light-grasp which has been attained if we notice that the interval from the sun to Sirius (25 magnitudes) is comparable with the interval from Sirius to the faintest stars observed (23 magnitudes).

If the stars were distributed uniformly through infinite space and their light suffered no absorption, each magnitude would comprise 3·98 times as many stars as the preceding magnitude (the number 3·98 is the $\frac{3}{2}$ power of the light-ratio 2·512). This theoretical star-ratio is not realized in the actual distribution. It may be taken as a rough rule that an increase of one magnitude multiplies the number of stars about threefold for the brighter stars, but the factor falls off rapidly for the faintest stars. This is an indication that the density of distribution of the stars in space falls off at great distances—that we are in the midst of a limited cluster or star-cloud. The following table gives the results of F. H. Seares and P. J. van Rhijn (1925) for the number of stars in the sky brighter than the indicated visual magnitude:

Magnitude	Number of stars	Magnitude	Number of stars	Magnitude	Number of stars
4·0 . .	530	9·0 .	117,000	14·0 ..	13,800,000
5·0 . .	1,620	10·0 .	324,000	15·0 .	32,000,000
6·0 . .	4,850	11·0 .	870,000	16·0 .	71,000,000
7·0 . .	14,300	12·0 .	2,270,000	17·0 .	150,000,000
8·0 . .	41,000	13·0 .	5,700,000	18·0 .	296,000,000
				19·0 .	560,000,000

Up to a certain point each magnitude contributes more star light than the preceding, the increased number of stars in the magnitude-interval more than counterbalancing their individual faintness. The maximum is reached between the 11th and 12th magnitudes, the 1½ million stars in this interval giving a combined light equivalent to 84 stars of magnitude 1·0. Beyond this the contribution falls off. All the stars together give as much light as 1,100 stars of magnitude 1·0—a result which has been checked closely by direct measurement of the general light of the sky.

The above figures relate to the whole sky. Interesting results are found when we compare the density of distribution of the stars in different parts of the sky, particularly when we compare regions in the plane of the Milky Way with those near its poles. The galactic concentration (ratio of the number of stars in equal areas in the galactic plane and at the galactic pole) increases from 3·4:1 for mag. 4 to 4·3:1 for mag. 10, and to 21:1 for mag. 18. These results refer to photographic magnitude, no sufficiently extensive counts for visual magnitude being available. The great excess of stars in the galactic regions is not wholly or even mainly due to the star-clouds of the Milky Way itself; the star-density increases steadily from the poles to the galactic plane, and the concentration is conspicuous before any part of the Milky Way is reached. This phenomenon was discovered by Sir William Herschel and the modern results are in good agreement with the star-counts made by him and by his son, Sir John Herschel. It seems certain that the stars surveyed by us (the "local system") form an aggregation strongly flattened in shape like a bun or lens. Probably this is one of many star-clouds lying in the galactic plane, the whole being coiled into a spiral nebula. From other indications it appears that we are very far from the centre of the spiral, which is found to lie in the direction of the constellation Sagittarius. The sun cannot be said to occupy a privileged position among the stars; it is nearly central in the star-cloud to which it belongs, but this star cloud is an outlier of the main galactic system—which in turn is only one among thousands of its kind.

Nomenclature of the Stars.—The brighter stars are designated by a Greek letter followed by the name of the constellation, according to a system introduced by J. Bayer in his star maps in 1603. The letters are assigned roughly in order of brightness, but for stars of nearly equal brightness the order is that of position in the constellation usually beginning at the head of the object figured. Alternatively, a system of numbers (followed by the constellation name) introduced by Flamsteed can be employed; this covers many stars which have no Bayer letter. Flamsteed's numbers were assigned in order of right ascension. For example, 27 Geminorum = ε Geminorum; 32 Leonis = α Leonis = Regulus. A number of ancient names of conspicuous stars survive; many of these are of Arabic origin. The following list gives those which are familiar to the modern astronomer, together with their Bayer equivalents and their visual magnitudes:

Name	Bayer equivalent	Visual magnitude
Achernar	α Eridani	0·60
Alcor	γ Ursae Majoris	4·0
Alcyone	η Tauri	2·96
Aldebaran	α Tauri	1·06
Algenib	α Pegasi	2·87
Algol	β Persei	Var.
Altair	α Aquilae	0·89
Antares	α Scorpii	1·22
Arcturus	α Boötis	0·24
Bellatrix	γ Orionis	1·70
Betelgeuse	α Orionis	Var.
Canopus	α Carinae	−0·86
Capella	α Aurigae	0·21
Castor	α Geminorum	1·58
Cor Caroli	α Can. Venaticorum	2·90
Deneb	α Cygni	1·33
Denebola	β Leonis	2·23
Fomalhaut	α Piscis Australis	1·29
Markab	α Pegasi	2·57
Mira	o Ceti	Var.
Mizar	ζ Ursae Majoris	2·40
Polaris	α Ursae Minoris	2·12
Pollux	β Geminorum	1·21
Procyon	α Canis Minoris	0·48
Regulus	α Leonis	1·34
Rigel	β Orionis	0·34
Sirius	α Canis Majoris	−1·58
Spica	α Virginis	1·21
Vega	α Lyrae	0·14

Only 20 stars are ranked as brighter than mag. 1·5. Of these 17 (including the variable Betelgeuse) are named in the above list. The other three are the southern stars, α Centauri (mag. 0·06), β Centauri (0·86), β Crucis (1·50).

Stars not bright enough to have a constellation letter or number are designated by their reference number in some catalogue. Thus we have names like Bradley 1,940, Groombridge 2,230, Boss 3,932, the last reference (Lewis Boss, *Preliminary General Catalogue*), being especially preferred. The most comprehensive source of reference is the *Bonn Durchmusterung* made by Argelander. This work, completed in 1862, lists the places of 324,000 stars between the north pole and 2° S. An extension to 23° S. by Schönfeld adds 133,000 stars. Star charts to be used with the catalogue are published, and there is no difficulty in identifying in the sky a star referred to, for example, as B.D.+13°, 2,966. The *Cordoba Durchmusterung* (C.D.M.) and *Cape Photographic Durchmusterung* (C.P.D.) fulfil a similar function for the rest of the southern sky. For stars fainter than the limits of these surveys an author must describe the identity as best he can.

Double stars are generally designated by the name of the discoverer, with the ordinal number of his discovery, or the number in Burnham's *General Catalogue* may be given. Variable stars are assigned (in order of discovery in the constellation) Roman capital letters from R to Z, or a pair of these letters, *e.g.*, X Cygni, RT Aurigae.

Colour of Stars.—In stellar observation the photographic plate is used quite as commonly as the eye. Alongside the visual scale of magnitudes measuring the brightness of the stars as judged by the eye, we have a photographic scale of magnitudes giving the brightness as judged by the effect on ordinary photographic plates. It is well known that blue light has proportionately greater actinic power than red light; consequently a comparison of the magnitudes of a star on the two scales gives a measure of its colour. The difference, photographic minus visual magnitude, is called the *colour-index.* (*See* PHOTOMETRY: *Celestial.*)

A classification which runs nearly parallel with classification by colour is afforded by examination of the spectrum of the light. In the Draper classification, now universally adopted, a continuous sequence of types is recognized denoted by the letters O, B, A, F, G, K, M. Intermediate types are indicated by decimal division, *e.g.*, A2 is a type two-tenths of the way between A0 and F0. A cursory examination of the spectrum is sufficient to determine the type, and 225,000 stars have been classified in this way by Miss A. J. Cannon (*Harvard Annals*, vols. 91–99). The sequence O to M corresponds to progression in colour from blue to red, and progression in temperature from the hottest to the coolest stars. The sun is of type G0. The percentages of stars catalogued in these classes are: B, 2; A, 29; F, 9; G, 21; K, 33; M, 6. Type O is rare, not more than 20 stars brighter than mag. 6·25 being known. The letters N, R, S denote other rare types whose relation to the recognized sequence is still uncertain. The properties of the stars (distribution, mass, luminosity, motion, variability, etc.) are all closely correlated to the spectral type; so that in nearly all investigations it is necessary to study the different types separately. The terms "early type" and "late type" are still commonly used in accordance with the order in this series, *i.e.*, for the bluer and redder stars respectively. The terms originally had reference to a theory of the progress of stellar evolution which is now entirely discarded.

Some progress has been made with the direct measurement of the heat received from the stars, and the corresponding bolometric magnitudes (related to heat intensity in the same way that visual magnitudes are related to light intensity) have been determined. The star-image is focussed on a small disc in which a thermoelectric junction is embedded, and many hundreds of stars are found to give sufficient heat to be measured in this way. The main trouble in these investigations is that the radiant heat over a certain band of wave-lengths is largely absorbed by the water-vapour in our atmosphere, and rather large corrections must be applied on this account. The bolometric magnitude may also be inferred from the visual magnitude by applying a correction depending on the spectral type of the star. This correction, called the *heat-index,* is analogous to the colour-index, and varies in correspondence with it. Naturally, the red stars are "brighter" bolometrically than visually, because their radiation is of low luminous efficiency. The greatest luminous efficiency is for stars of types F and G, perhaps because the human eye has been developed so as to make the most of sunlight. In still hotter stars there is a falling off of luminous efficiency, the radiation being too far in the violet and ultra-violet to suit the eye.

Absolute Magnitude.—We turn now to consider the real brightness of the stars. How would they compare with the sun in splendour if we could see them at the same distance? To infer the true brightness from the apparent brightness we must first know the distance (for the methods of measuring the distance *see* PARALLAX). An idea of the variety of brightness may be given by considering the seven most conspicuous stars. Sirius gives 28 times the sun's light, but it has a companion only $\frac{1}{360}$ as bright as the sun. Canopus is so remote that its distance cannot be found accurately, but it can scarcely be less than 10,000 times as luminous as the sun. α Centauri consists of two stars, one almost a replica of the sun and the other considerably fainter. Then follow Vega and Arcturus with luminosities 50 and 100 in terms of the sun. Capella consists of two stars, with luminosities 110 and 70, having a faint distant companion of luminosity about 0·01. Rigel is remote, but its distance is more certain than that of Canopus; its luminosity is greater than 10,000.

This shows that there are stars far surpassing the sun in brilliancy; but, naturally, if we pay attention only to the most conspicuous stars we shall form an exaggerated idea of the general order of brilliance. There would be the same difficulty if we extended our survey to all the naked-eye stars; these would include the most luminous stars contained in a very wide region and the feebler stars in a much smaller region. It is only by rather elaborate investigations that we can get together a fair sample of the stellar population, in which the luminous stars are not over-represented by forcing themselves on our attention. According to the latest discussions the following table gives the relative proportions of stars of different degrees of intrinsic brightness in any volume of space:

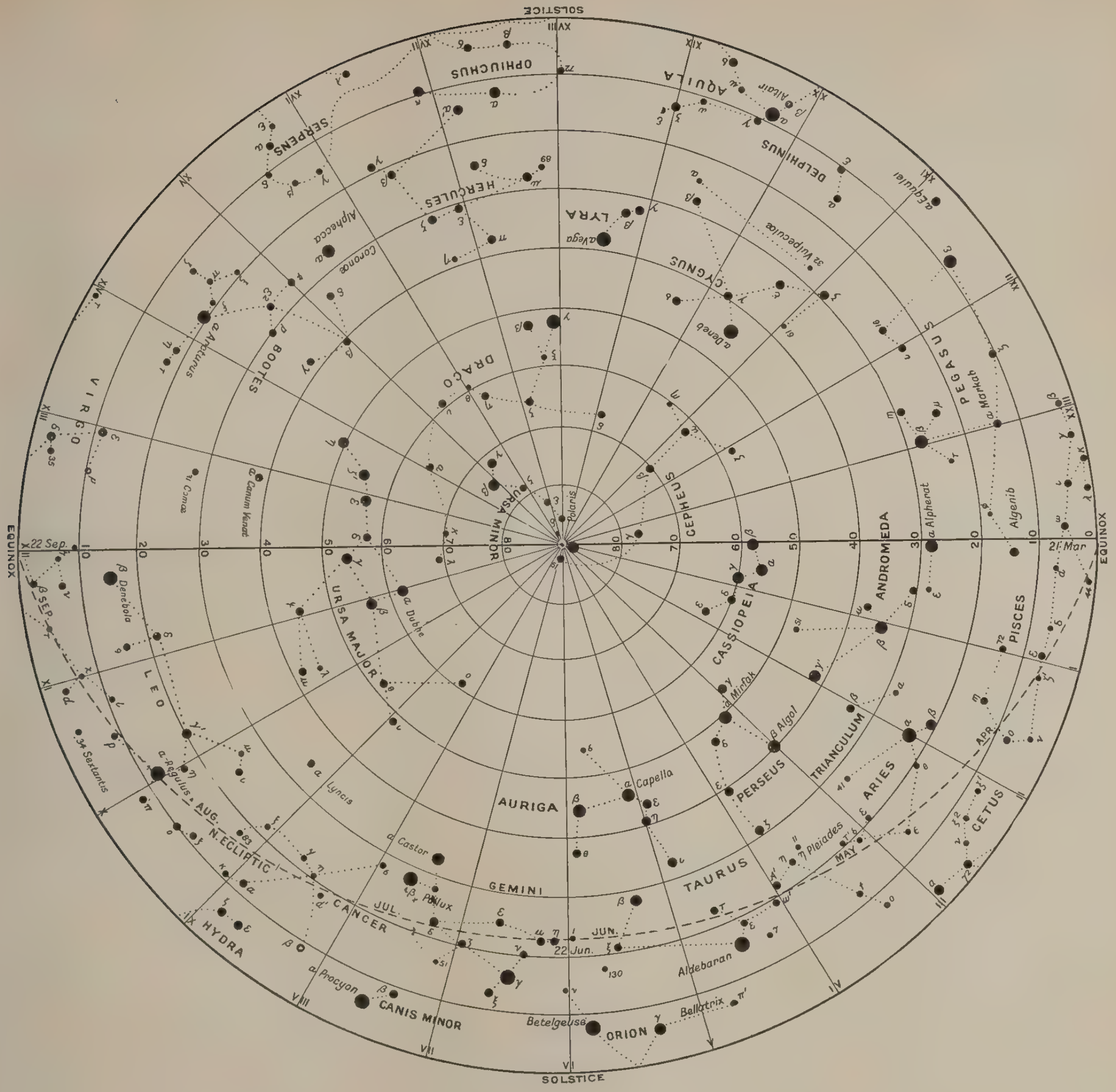
Light power	Number	Light power	Number
10,000 × sun . .	1	1 × sun . . .	200,000
1,000 ,, . .	90	0·1 ,, . . .	350,000
100 ,, . .	3,300	0·01 ,, . . .	500,000
10 ,, . .	42,000	0·001 ,, . . .	600,000

Stars fainter than the sun far outnumber those which are brighter.

At present the faintest known star is one to which attention was drawn by A. van Maanen. It was picked out from the multitudes of apparently similar stars by its rapid motion across the sky, which indicated that it was likely to be especially near to us. It has an absolute visual magnitude 16·5, corresponding to $\frac{1}{50000}$ of the light of the sun. Its catalogue designation is Wolf 359. Other very feeble stars are Proxima Centauri (mag. 15·4), van Maanen's star (14·3), Barnard's star (13·3), Groombridge 34 *comes* (13·0). All these are cool red stars and their photographic brightness is about two magnitudes fainter.

At the other end of the scale it is difficult to assign an upper limit to the brightness because the objects suspected of great brilliancy are generally too remote for parallax measurement. In the star clusters, however, we see a group of stars all at practically the same distance, and can therefore measure at once the relative brightness of different classes of objects. The star S. Doradus in the Greater Magellanic Cloud is believed to have an absolute magnitude −9(400,000 × sun); and other stars in the same cloud are not far short of this. The range in real brightness of the stars is at least 20 magnitudes—very much the same as the range in apparent brightness so far as it is possible to observe it.

Interferometer Measurements.—One of the striking achievements in recent years has been the measurement of the angular diameters of a few favourable stars by means of Michelson's interferometer (*q.v.*). As adapted to astronomical work this consisted of a 20 ft. beam carrying two inclined mirrors which could slide along it, and carried on the 100 in. telescope at Mt. Wilson observatory; the light from the movable mirrors fell on two fixed mirrors, and was directed by them on to the great telescope mirror. Virtually the observer was looking simultaneously through two apertures whose separation could be varied up to 20 ft., very much as in a gigantic range-finder. (*See* BINOCULAR INSTRUMENT: *Stereoscope.*) The effect of using two apertures is that the spurious (diffraction) disc of the stellar image is crossed by fine diffraction lines, and the lines become closer as the separation of the apertures is increased. If the object looked at is not a mere point of light, its finite size blurrs the diffraction pattern, and the object of using widely separated apertures is to obtain a diffraction pattern so fine that even the invisible disc of a star is sufficient to blurr it out and make it disappear. Seven stars have been found to have angular diameters exceeding 0·02″ which is about the limit attainable with this instrument; a 50 ft. interferometer was, in 1928, under construction at Mt. Wilson, with which it is hoped to secure more stars, but the great majority must remain beyond the scope of this method. In some ways this application of the interferometer is to be regarded rather


SOLSTICE
XVIII
OPHIUCHUS
SERPENS
AQUILA
Altair
DELPHINUS
Aequulei
HERCULES
LYRA
a Vega
CYGNUS
32 Vulpeculae
a Deneb
Coronae
a Alphecca
a Arcturus
BOOTES
VIRGO
DRACO
PEGASUS
a Markab
a Alpherat
Algenib
ANDROMEDA
PISCES
URSA MINOR
Polaris
CEPHEUS
CASSIOPEIA
URSA MAJOR
a Dubhe
a Canum Venat.
Comae
β Denebola
LEO
a Regulus
34 Sextantis
AUG.
N. ECLIPTIC
a Lyncis
AURIGA
a Capella
PERSEUS
a Mirfak
β Algol
TRIANGULUM
ARIES
CETUS
Pleiades
TAURUS
Aldebaran
GEMINI
a Castor
β Pollux
CANCER
HYDRA
a Procyon
CANIS MINOR
Betelgeuse
ORION
Bellatrix
EQUINOX
22 Sep.
SEP.
21 Mar
APR.
MAY
JUN.
22 Jun.
JUL.
0
10
20
30
40
50
60
70
80
VI
SOLSTICE

MAGNITUDE: 1● 2● 3● 4●

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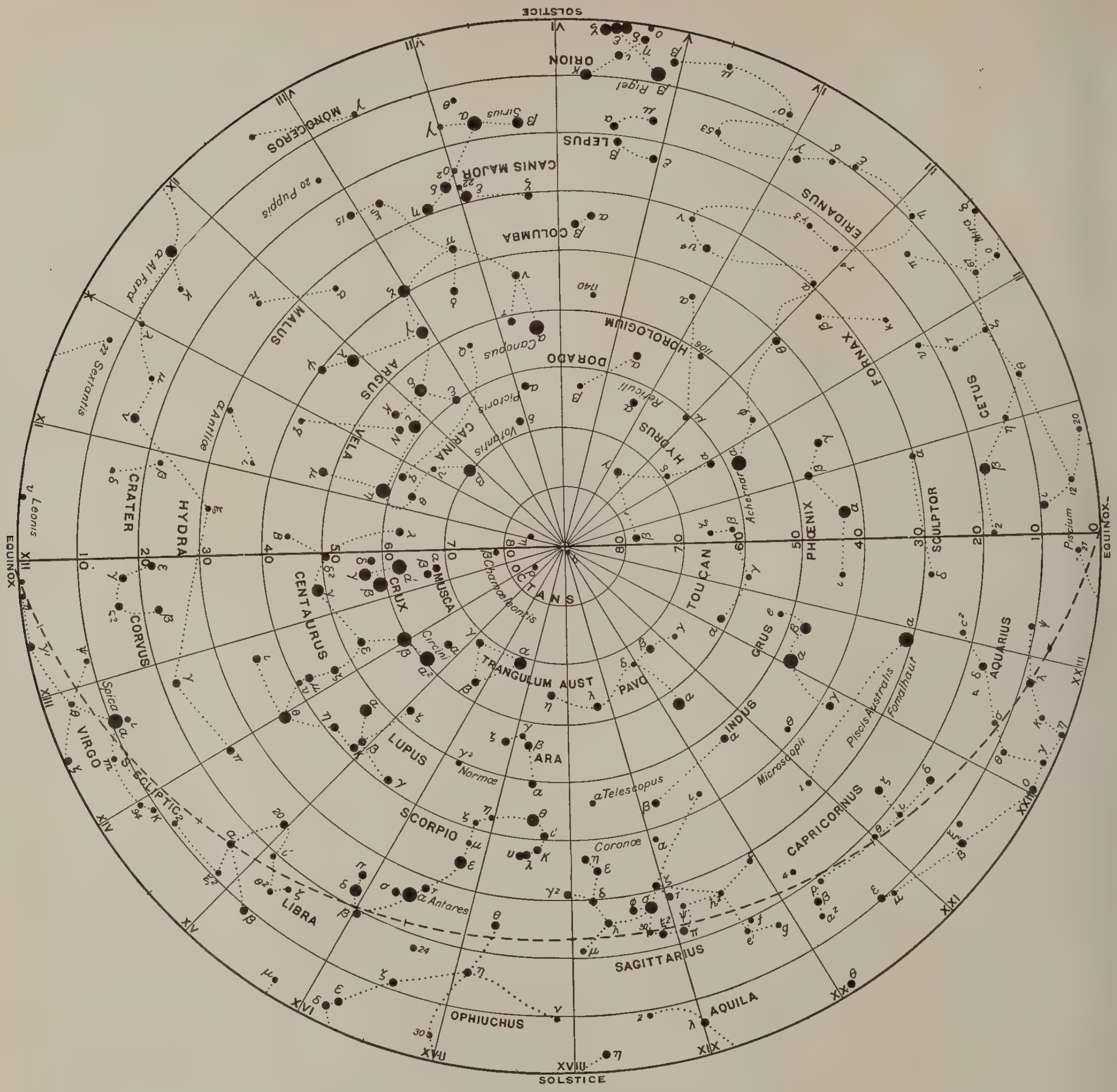
STAR CHART OF NORTH POLAR HEMISPHERE

Most stars visible to the naked eye and north of the celestial equator are shown in this chart. The North Star, Polaris, is shown slightly to the right of the north celestial pole. This star is not exactly true north. At the bottom of the chart is the first magnitude star Betelgeuse in the constellation of Orion. This was the first of the large stars to have its diameter measured. At the left of the north celestial pole is the "Great Bear" with its pointer stars in line with the North Star. In the upper part of the chart is the constellation Hercules toward which the entire solar system is moving at the rate of about 12 miles per second. Owing to the rotation of the earth on its axis, all stars shown in this chart appear to rotate around the north celestial pole in a counter clockwise direction


SOLSTICE
ORION
β Rigel
MONOCEROS
Sirius
CANIS MAJOR
LEPUS
20 Puppis
β COLUMBA
ERIDANUS
Mira
α Al fard
MALUS
Canopus
HOROLOGIUM
DORADO
FORNAX
22 Sextantis
ARGUS
Pictoris
Reticuli
CETUS
Sextantis
α Antliæ
CARINA
Volantis
HYDRUS
VELA
Achernar
CRATER
HYDRA
PHŒNIX
SCULPTOR
Piscium
Leonis
EQUINOX
CRUX
MUSCA
OCTANS
β Chamæleontis
TOUCAN
EQUINOX
CENTAURUS
CORVUS
Circini
TRIANGULUM AUST
PAVO
GRUS
AQUARIUS
Piscis Australis
Fomalhaut
Spica
VIRGO
INDUS
Microscopii
LUPUS
ARA
Normæ
α Telescopus
ECLIPTIC
SCORPIO
Coronæ
CAPRICORNUS
α Antares
LIBRA
SAGITTARIUS
OPHIUCHUS
AQUILA
SOLSTICE

MAGNITUDE: 1● 2● 3● 4●

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STAR CHART OF THE SOUTH POLAR HEMISPHERE

Showing all of the principal stars visible to the naked eye found south of the celestial equator. To the left of the south celestial pole in the chart is the Southern Cross (Crux). Below the south celestial pole and slightly to the left is Scorpio which contains the giant red star Antares, which has the greatest diameter of any star that has been measured up to the present time. It is visible from practically every point in the inhabited world. To the right of the south celestial pole is Fomalhaut, a first magnitude star in the constellation "The Southern Fish." Sirius, of the constellation "The Big Dog" and the brightest star in the sky, is near the top of the chart. All stars shown in chart appear to revolve around the south celestial pole in a counter clockwise direction due to the rotation of the earth on its axis as a *tour de force* than an important advance of knowledge, because we can always compute approximately the angular diameter from the apparent magnitude and spectral type (which determines the radiating power of the surface) by a simple theory that can scarcely be doubted. Up to the present the observed diameters have been found to be in close accord with the theory. Of special interest, however, are the observations of the variable star, Mira Ceti; here the interferometer measurements indicate variations in the diameter, and seem to confirm the theory, put forward on other grounds, that this type of variability is due to pulsation.

Another application of the interferometer is to measure the separation of double stars in which the components are so close that ordinary visual measurements are impossible. In particular Capella, which is known to be a double by spectroscopic observation, cannot be resolved by any telescope. Nevertheless, by interferometer measurement the orbit has been found just as though it were a visual double. We have the rare opportunity of combining visual and spectroscopic orbital data, and the result is that Capella is one of the best known stars as regards mass, absolute luminosity, etc.

DOUBLE STARS

About the year 1650 Jean Baptiste Riccioli made the first discovery of a double star, viz., Mizar or ζ Ursae Majoris, the middle star in the tail of the Great Bear. Looking at Mizar with the naked eye, we see a fainter star, Alcor, very close to it; it is a fair test of eyesight to separate them. Their separation is however, 11′, and although there is no doubt that Mizar and Alcor have a physical association, since they are found to be moving at just the same rate across the sky, the term double star is only applied in case of much closer proximity. Riccioli's discovery was that Mizar itself consists of two stars separated by 15″ or about $\frac{1}{40}$ of the distance between Mizar and Alcor. This would nowadays be regarded as a wide pair, and many of the most interesting double stars have a separation under 1″. The actual distance between the two components of Mizar is not less than 11 times the distance of Neptune from the sun. The two stars must be attracting one another, but the gravitational control across such a distance is so feeble that they will take more than 3,000 years to complete their orbital revolution. It is, therefore, not surprising that the measures made during the last 150 years fail to indicate definitely any orbital motion; and the only evidence of genuine connection (apart from the improbability of two independent bright stars lying so closely in the same line of sight) is afforded by their common motion across the sky, and common radial velocity.

Similar discoveries followed rapidly. θ Orionis (in the midst of the great nebula) was resolved by Huyghens in 1656; γ Arietis by Hooke in 1664. In the southern hemisphere the duplicity of α Crucis and α Centauri was discovered by Jesuit missionaries in 1685–89. The foundation of systematic measurement and study of double stars is due principally to Sir William Herschel and Wilhelm Struve. The latter, working at Dorpat between 1813 and 1835, formed a catalogue of 3,110 pairs as the result of surveying about 120,000 stars.

The number of recognized visual double stars is now about 15,000, but the number is necessarily somewhat arbitrary since, if too wide limits of separation are admitted, stars which are only in accidental proximity may be included. Among the naked-eye stars, one in nine is a telescopic double. It is certain that the true proportion of binary systems is much greater than this, many being too close to be resolved with the telescope. Thus, taking the nearest known stars (which give the best chance of observing duplicity), eight out of 20 are double.

Catalogues of double stars no doubt contain a number of spurious pairs, *i.e.*, stars which are not actually near one another in space and merely happen to lie in the same line of sight, but considerations of probability show that there will not be many of these. The physical connection is generally shown, as in the case of Mizar, by common proper motion. If spectroscopic determinations of radial velocity have been made these will provide an additional check. The connection implied is evidently the connection of a common origin. The two stars were born from the same nebula; they originally shared in common the velocity of the parent nebula, and they have gone on moving together because they have been subjected to the same influences ever since. In most of them the gravitational tie is too weak to resist any differential disturbance, *e.g.*, another star passing between the pair. The fact that so many of these wide doubles survive teaches us that chance approaches of stars to one another must be very rare.

Of greater interest are those double stars close enough together to show the effects of their mutual gravitation. There are about 120 double stars for which it has been possible to work out definite orbits. In about 700 more there is a rough indication of orbital motion, but the arc described since observation commenced is too short to determine the orbit satisfactorily. The shortest periods are 5·7 years (δ Equulei) and 6·9 years (13 Ceti); about 60 pairs have periods of under 100 years. It is natural to enquire whether the planes of the orbits tend to lie in any particular direction—parallel to the galactic plane, for example. A curious difficulty arises in this investigation. If the reader has watched the revolution of a cup-anemometer (or of a garden-sprinkler) he will probably recall that the direction of revolution appears obvious and unmistakable, but after blinking the eyes the revolution seems just as unmistakably in the opposite direction and in a different plane. For the same reason we always find two planes of rotation of the double star, either of which may be the true one. We can only adopt both planes, and investigate as best we can the resulting mass of data, half of which is correct and half spurious. So far as can be ascertained the planes of double star orbits are quite at random.

The two dog-stars, Sirius and Procyon, are double stars of exceptional historic interest. Being conspicuous stars they were well observed a hundred years ago and used as fundamental reference stars for determining time, etc. It was found that they were moving irregularly—not with uniform proper motion like other stars. It was evident that each was being disturbed by the gravitation of a massive body in its neighbourhood, although the companions were invisible. The theory was given by Bessel in 1844, and orbits were computed from the observations, the periods of revolution being 50 and 39 years respectively. The disturbing stars, whose existence was thus convincingly demonstrated, have since been seen. The companion of Sirius was observed by Alvan Clarke in 1862, and is a comparatively easy object for modern telescopes; the companion of Procyon, which is more difficult, was observed by Schaeberle in 1896. They are faint stars, respectively 10 and 13 magnitudes fainter than their primaries. Nevertheless, they must be massive bodies to exert so large a pull on their brilliant neighbours.

Masses of Stars.—The orbital motion of double stars conforms to the law of gravitation. It gives evidence that gravitation is universal in the stellar system. The study of binary systems performs a unique service in the general advance of our knowledge of the stars since it is through it that we arrive at knowledge of the masses of the stars. By the law of gravitation the extent to which a body disturbs the motion of other bodies is proportional to its mass. It is when we find bodies in close proximity that we obtain a chance to observe the disturbance, and so obtain a measure of the mass. It is good fortune for the astronomer that the course of evolution has been such as to provide pairs of stars close enough together; otherwise we should probably still be in total ignorance as to the masses of stars, except in so far as the sun's known mass might be assumed to be typical.

If M_1, M_2 are the masses of the two components, a the mean distance between them (strictly the semi-axis major of their relative orbit), and P the period of revolution, Kepler's laws give

$$k(M_1+M_2)=a^3/P^2$$

where k is a universal constant. Let us measure the mass in terms of the sun's mass as unit, the period in years, and a in astronomical units, *i.e.*, in terms of the earth's distance from the sun. Applying the equation to the earth's motion round the sun (the earth's mass M_2 being negligible) we see that for these units $k=1$. Now apply the equation to Sirius. The mean distance of the two components is 7·55 seconds of arc. To convert this into linear measure we must know the parallax of Sirius, 0·37 second. This means that one astronomical unit seen at the distance of Sirius would appear to extend 0·37 second; hence 7·55 seconds corresponds to 20·4 astronomical units, determining *a*. The period *P* is 49 years. Hence

$$a^3/P^2=(20{\cdot}4)^3/(49)^2=3{\cdot}5=M_1+M_2$$

We learn, therefore, that the combined mass of the two components is three and one-half times that of the sun. If it is preferred to express the mass in tons, this can be done since the sun's mass is 1,980,000,000,000,000,000,000,000,000 tons.

To find the masses of the two stars separately we must determine their absolute orbits about their common centre of gravity instead of the relative orbit considered above. This means measuring the motions of the components with respect to surrounding stars instead of with respect to one another. It is found that the bright star has the greater share of the mass, nearly in the ratio 3:1.

From the visual double stars, together with the spectroscopic binaries (described below), an idea of the masses of stars in general has been obtained. Comparatively few determinations reach high accuracy, because a rather accurate parallax is required which is not generally forthcoming. The first thing that strikes us is the wonderful uniformity of mass. By far the majority of the determinations give between one-third and three times the sun's mass, which seems a very small range when compared with the great differences of luminosity. Another result brought out is the close relation of mass to luminosity, the brighter stars being the more massive. It is probable that (excluding a peculiar class of stars known as *white dwarfs*) the luminosity depends almost entirely on the mass; it makes little difference whether the star is in a dense or in a diffuse state. The theory of this relation will be explained later. Having checked it by the masses determined for double stars, we can use it to find the masses of other stars whose absolute brightness is known.

We naturally select the most conspicuous stars for special investigation, and as a result we tend to pick out exceptionally high masses. Among the spectroscopic binaries some very high masses have been found, which, however, are believed to be exceptional. For one binary of Type O discovered by J. S. Plaskett the components have masses greater than 87 and 73 in terms of the sun. (Only a lower limit can be stated.) Another O type binary has masses 36 and 34. The eclipsing variable V Puppis has two components each of mass 19·2. There is at present no evidence of any stellar masses below one-sixth of the sun's mass.

From the close uniformity of stellar masses it follows that the stars of gigantic volume like Betelgeuse must be of extremely low density. Assuming that the mass of Betelgeuse is something less than 100 times the sun's mass, in order to fill a volume 50 million times greater than the sun, the density must be less than $\frac{1}{100}$ that of air.

Spectroscopic Binaries.—When a source of light is approaching us, the lines in its spectrum appear displaced towards the violet end; when receding, the displacement is towards the red end. By means of this "Doppler effect" (*see* LIGHT) the velocity of a star in the line of sight can be measured. In examining the stars with a spectroscope we sometimes turn the instrument on to what is telescopically a single point of light, but is actually a double star with components too close to be separated. Since the two components have different velocities towards or away from us their spectra will not be exactly superposed and every spectral line will appear double. The first example of this was found by E. C. Pickering in 1889. This was the star Mizar already mentioned as the first visual double star to be discovered. The two components seen in the telescope take at least 3,000 years to perform their revolution; but the doubling of the spectral lines of the brighter component shows that it is itself a double star with a revolution period of 104 days. If a star showing a doubled spectrum is watched for some time it is seen that the doubled lines close up and then cross one another. This is in accordance with the theory of orbital motion, for the two components must approach us and recede from us alternately in the course of a revolution.

It is only when the two components are of nearly equal brightness that this doubling of the spectral lines can be observed. A difference of about two magnitudes is sufficient to render the fainter spectrum invisible. In the majority of spectroscopic binaries only the brighter spectrum is observed, and the binary character is inferred from the periodic approach and recession of the source emitting it. The argument is that the changing displacement of the spectral lines shows that the source of light is describing an orbit; there must be some mass for it to revolve around; and therefore a fainter component must exist although invisible. Rather more than a thousand spectroscopic binaries have been discovered, and definite orbits have been computed for about 250 of these. The spectroscope can only measure velocity in the line of sight, and many binaries must escape detection through having their orbits nearly perpendicular to the line of sight.

Spectroscopic binaries afford valuable additional information as to the masses of stars, but of a statistical rather than of an individual kind. When one component only is observed, all that can be deduced is a rather complicated function of the masses and the unknown inclination of the orbit; but when both spectra are observed, a minimum mass of each component can be found. This minimum mass has to be multiplied by $\operatorname{cosec}^3 i$ (i=inclination of orbit plane to the sky plane) which is unknown unless the star can also be observed visually or is an eclipsing variable, but in researches on the average mass of any class of stars a suitable mean value of this factor may be used.

In rare cases the same system may be observed as a visual and a spectroscopic binary; but in general only the close pairs with periods less than a year are detected spectroscopically, and wide pairs with periods of many years or centuries are detected visually. Many intermediate pairs must escape both methods of discovery. The first star to be observed by both methods was α Centauri. The results have a special interest because they afford a determination of the star's distance entirely independent of the ordinary method of parallax measurement. The visual observations determine the angular size of the orbit; the spectroscopic observations determine the same quantity in kilometres; so that we have only to compute the distance at which the given length subtends the given angle. The result for α Centauri satisfactorily checked the ordinary trigonometric determination of its distance.

Multiple systems containing more than two components are not uncommon. We have already noticed the system of Mizar. The star Castor is an easy visual double, both components of which are spectroscopic binaries. These systems all appear to be built by successive subdivisions of one mass into two, and it is clear that after such a fission a long period of evolution and condensation must elapse before either of the resulting masses is ready to divide again. An important question is whether the widely-separated pairs were originally formed with their present separation or whether the distance has increased in the course of time. It is difficult to resist the impression that the components gradually recede from one another, especially as the statistics show markedly that the stars supposed to be oldest in evolution form the widest pairs. Two causes are acting which will tend to increase the initial separation to some extent, viz., the mutual tidal forces and the loss of mass of the stars by radiation; but neither can produce a large effect. The cumulative effect of perturbations by casual approaches of other stars would in the long run, drive the components further apart; this process, however, is too slow to produce much effect, even in the long periods of stellar evolution. The general problem of the formation of double stars is discussed in the article COSMOGONY.

VARIABLE STARS

There are three main classes of variable stars: (1) eclipsing variables, (2) Cepheid variables, (3) long period variables. In a sense the sun is a variable star, since the changes of its surface condition which follow the sunspot cycle of 11½ years must involve some small variation in the rate of emission of light and heat (*see* SUN); but this is not analogous to any of the recognized forms of stellar variability. Novae or "new stars" might also be counted technically as variables; it is, however, no longer believed that they have anything in common with the ordinary types of variables, and we shall not include them here. (*See* NOVA.)

Eclipsing Variables.—In this type of variation there is no physical change in the star. It emits light steadily all the time, but it is occulted at times by another body passing in front of it. The present explanation dates from 1782, when John Goodricke, having discovered the regular period of fluctuation ($2^d\ 20^h\ 49^m$) of the variable star Algol, suggested that the periodic dimming was caused by a dark body revolving round it and eclipsing it once a revolution. Knowing, as we now do, that there are multitudes of close binary systems, it is only to be expected that we should sometimes observe an eclipse of one component by the other. Each system will provide regularly recurring eclipses for observers situated sufficiently near the plane of the orbit; the eclipsing variables are therefore ordinary binaries whose orbits we happen to be viewing nearly edge on. For Algol and many other variables of this class it has been verified that the object is a binary system, and that the decline of light occurs when the principal star is in the part of its orbit most remote from us, which is the time when the second component would intervene.

It is not necessary to assume that the intervening object is a dark body. Even if the system consisted of two equal stars a total eclipse of one by the other would halve the light received. In most systems that have been studied, one component is considerably brighter than the other, but the light of the second component is quite recognizable. Half a period after the main eclipse, when the faint star occults the brighter, a secondary eclipse is observed owing to the bright star occulting the fainter. There is, of course, a considerable period when no eclipse is occurring and the system shines steadily with its maximum light. (By this feature eclipsing variables are easily distinguished from all other types.) The steadiness in these intervals is, however, only approximate, and is complicated by two phenomena of singular interest:

(1) *Reflection Effect.*—Systems in which the two stars are very close together have the best chance of showing eclipses, since the orbit does not then need to be so accurately orientated with respect to our terrestrial post of observation. The closeness of some of the best-known eclipsing variables is remarkable, the components being separated by no more than their own diameter. Each is therefore strongly illuminated by the other, and the hemisphere turned towards the companion becomes heated and shines more brightly than the other hemisphere. For the fainter star in particular, the disparity in brightness of the two hemispheres is considerable, and as it moves round its orbit it exhibits variations of brightness analogous to the phases of the moon. Owing to this reflection effect, the end of the principal eclipse is followed by a gradual brightening, which continues until the dip representing the secondary eclipse begins.

(2) *Ellipsoidal Effect.*—Owing to their close proximity the two stars are distorted, being elongated towards one another. Thus, in addition to the variation due to eclipses and reflection, there will be a variation depending on the aspect of these elongated objects. Their apparent sections will be smallest when we see them end-on near the time of the eclipses; half-way between eclipses we see the prolate spheroids broadside-on and correspondingly brighter.

We may hope ultimately to learn much as to the physical state of the stars from these two effects; but, unfortunately, they are only just within our range of detection, and it is difficult to obtain accurate measurements of their amount. Meanwhile, an examination of the light-curve during the eclipses teaches us much about the dimensions of the system. The method of analysing the light-curves was developed by H. N. Russell and H. Shapley; for an example of the results obtainable *see* ALGOL. As a rule the fainter component is found to have the larger diameter although it has the smaller mass; *i.e.*, the companion is one of the giant diffuse stars of fairly low density and surface temperature. The eclipses are usually partial, but are in a few stars total or annular. The number of eclipsing variables known at present is about 200.

Cepheid Variables.—Like the preceding class the Cepheid variables have short periods seldom exceeding 20 days, but the cause of the variation is entirely different. A very significant fact is that the colour of the light (or the spectrum) is different at maximum and minimum light, showing that the star undergoes an actual physical change. The surface temperature is much higher at maximum than at minimum, and, in fact, the changes of brightness may be ascribed to the changes of temperature. It is probable that the Cepheid variable is a pulsating star—a globe which swells and contracts with a regular period. Leaving aside the question as to how the star comes to be in this oscillating state, the pulsation theory agrees with the main phenomena. The alternate compression and rarefaction naturally produces the changes of temperature; moreover, the approach and recession, as the part of the surface presented towards us heaves up and down, is observed and measured spectroscopically. The most striking confirmation is the agreement of the theoretical period of such a pulsation with the observed period. The natural free period of a pulsation of a spherical mass of gas should vary approximately as the inverse square root of the density, and the observations show that the Cepheids closely follow this law; moreover, the absolute value of the period can be calculated (with a small margin of uncertainty due to our ignorance of the chemical constitution of the star's interior) and the observed period is found to agree. On the other hand, no satisfactory theoretical explanation has yet been given of the phase-relation between the velocity-curve and light-curve. The mathematical theory of a pulsating star seems to show that maximum brightness must occur at the moment of greatest compression, whereas in all the more typical Cepheids it is found to occur a quarter-period later.

The study of Cepheid variables is likely to lead to results of the greatest importance, since they give the opportunity of observing stellar matter in motion, thereby extending the information obtainable from the ordinary static stars. They are important also for another reason. Practically all our knowledge of the distances and dimensions of the more remote objects of the sidereal universes has grown up from a study of Cepheids. In 1912 it was noted by Miss Leavitt that, when the periods and apparent magnitudes of the variables in the Lesser Magellanic Cloud were plotted as abscissae and ordinates, the points lay on a smooth curve. Since the stars in the Cloud must all be at approximately the same distance from us, this indicates that the absolute brightness is a definite function of the period. H. Shapley subsequently found the same uniformity in a number of globular clusters. The same period-magnitude curve is repeated in each cluster, except that the curve is displaced as a whole towards fainter or brighter (apparent) magnitude, according as the cluster is remote or near. It follows that Cepheids of the same period have the same absolute luminosity, and presumably are alike in all respects. The absolute brightness being identical, the apparent brightness indicates the distance; *e.g.*, if the apparent magnitude of the Cepheids of 5-day period in a particular globular cluster is 13 we know at once that the cluster is 100 times as distant as a Cepheid of apparent magnitude 3; if the 5-day Cepheids observed in a spiral nebula have apparent magnitude 18, the nebula is ten times more remote than the cluster. Thus the general structure of the universe can be plotted out to scale. The scale is made absolute by a study of the brighter and nearer Cepheids which are not beyond the range of ordinary methods of distance determination. The only caution required in using these variables as standard lights for gauging distance is that we must have evidence that their light has not been dimmed by passing through absorbing matter. This point has been carefully studied, and it is believed that (except in particular localities) interstellar space is practically transparent; but the evidence is, perhaps, not beyond reproach.

No theoretical basis for the period-magnitude relation has yet been found. Since the period (as already explained) depends on the density and the absolute magnitude depends mainly on the mass, it would seem that for a star of given mass there is just one stage in the course of its contraction when it becomes unstable and is thrown into pulsation; at other times it burns steadily. The theoretical conditions for starting and maintaining a pulsation are bound up with the laws of liberation of sub-atomic energy in the interior of the star, as to which little is definitely known (*see* STELLAR EVOLUTION and COSMOGONY). It seems likely that ordinary stars may be near the border line between stability and pulsation, and that some small change in the physical constants of the material occurring when a particular temperature or density is reached puts the star over the borderline.

The typical Cepheid variable which has given its name to the class is δ Cephei. Its period is 5·366 days. It is seven magnitudes brighter than the sun, and is believed to have about nine times the sun's mass. It is a giant diffuse star having a radius of 20 million kilometres, which changes by ±1¼ million kilometres in the course of the pulsation. The light-range is 0·6 mag. visual and 1·0 mag. photographic, the difference being due to the fact that the light becomes much bluer at maximum brightness. The "cluster variables" are a sub-class of the Cepheids; they have very short periods usually about 12 hours. The shortest period known is 3·22 hours.

Long Period Variables.—There are very few variable stars with periods between 30 and 100 days, but beyond 100 days and especially near 300 days they become numerous again. The numbers within given limits of period are:

Days . .	100–200	200–300	300–400	400–500	7,500
Stars . .	64	194	182	54	12

The leading characteristics of these long-period variables are: (1) their light-range is very great averaging 5·5 magnitudes, and in a few stars exceeding 8 magnitudes; (2) the variations do not repeat themselves with the clock-like precision of the other classes of variables, and both the amplitude and period fluctuate irregularly; (3) they are red stars, chiefly of type M, but sometimes of the rarer spectral types N, R, S; during the great outburst of light at maximum, bright emission lines of hydrogen appear in the spectrum.

The enormous variation of light is rather misleading to us, because there is no such large variation in the output of heat. The surface-temperature is varying through a range which happens to be especially critical for the sensitiveness of the human eye. The following results relate to Mira Ceti which is the most famous star of this type (discovered by Fabricius about 1596). To the eye at minimum it appears as a faint star of magnitude 9, difficult to distinguish from the numerous other ninth magnitude stars in the field; but the more impartial bolometer, which measures the total radiant energy or heat received, singles it out as a very conspicuous object of bolometric magnitude 1·5. At maximum the surface temperature has risen a little, causing a moderate increase of radiation and bringing it up to bolometric magnitude 0·2; at the same time the character of the radiation becomes more suited to the sensitiveness of the eye, so that an enormous increase of visual brightness occurs. At maximum Mira is generally between mag. 3 and 4 (visual), and occasionally it reaches mag. 2.

Accordingly the variation of heat output is not much more than one magnitude, and is much the same as in the Cepheid variables. It is now generally believed that the long-period variables are pulsating stars not essentially different from the Cepheids. They are very diffuse stars of great bulk, and this extreme physical condition is probably responsible for the differences of behaviour between them and the typical Cepheids. Pease has succeeded in measuring the angular diameter of Mira with an interferometer, obtaining the result 0″·056. It is probable that the star has a radius of at least 1·5 astronomical units or 300 times the radius of the sun. A number of minor classes of variables are recognized, which differ in material respects from the three chief classes here described. The whole subject of variable stars is now one of the most active branches of stellar research.

STELLAR MOTIONS

We learn about the motion of a star in two ways. Firstly, the change of position in the sky can be observed directly by making from time to time accurate measurements of the position with respect to surrounding stars. The motion thus detected is called *proper motion.* It is measured in seconds of arc per year; if the distance of the star has also been measured, the result can be converted into miles per second. Secondly, by measurements of the positions of lines in the star's spectrum, the speed of approach or of recession can be found; this radial velocity is given immediately in miles per second, whether the distance of the star is known or not. The two methods supplement one another, the first giving the motion transverse to the line of sight, and the second the motion in the line of sight; combining them we obtain the direction and speed of the whole motion.

Proper Motions.—The stars differ greatly in proper motion. For a naked-eye star a motion of about 3″ per century may be taken as typical. The corresponding change of position would be measurable without difficulty in an interval of ten years. For some stars the displacement is less, either because their actual speeds are small, or because their motion is mainly in our line of sight, or because they are very distant. Other things being equal, the stars which are especially near to us will have large proper motions. Just as great apparent brightness may be due to nearness or to high intrinsic luminosity, so great proper motion may be due to nearness or to high actual speed; but, in general, great proper motion is a much more dependable indication of nearness than great apparent brightness, and it is used as a criterion to pick out stars likely to have measurable parallaxes from the great majority which are too far away to be measured. Proper motions have been measured in tens of thousands; and, moreover, there are methods of quickly detecting stars of large proper motion on a pair of plates of the same region taken at a suitable interval of time (*see* BLINK MICROSCOPE).

The star of greatest proper motion known up to the present is a ninth magnitude star discovered by Barnard, which travels 10¼″ per year (more than 300 times the typical speed mentioned above). Even at this speed it would take about 900 years to go from end to end of Orion's belt. The following table gives particulars of the stars of largest proper motion:

Star	Mag.	Ann. P.M.	Dist. (L.Y.)	Speed		Lum.
				Trans.	Rad.	
Barnard star . .	9·7	10″·25	6·0	90	−117	·0004
Kapteyn star .	9·2	8·76	10·3	131	+242	·002
Groombridge 1830	6·5	7·05	32·0	330	− 97	·23
Lacaille 9352 .	7·4	6·90	11·2	112	+ 12	·011
Cord. 32416 . .	8·3	6·11	14·8	132	+ 26	·009
61 Cygni . .	5·6	5·20	10·9	82	− 64	·058

The distance in light-years is given in the fourth column; the transverse and radial speeds are given in km. per sec. in the fifth and sixth columns; the last column gives the intrinsic luminosity, the sun's luminosity being the unit. It will be noticed that these are all inconspicuous stars, faint both apparently and actually. Well-known stars which come further down the list are α Centauri and Arcturus, with annual proper motions 3″·66 and 2″·29 respectively. The motions cannot have caused any noticeable change in the appearance of the sky within historic times; but the change in, say, 250,000 years would be considerable, and it is doubtful if any of the familiar constellations except Orion would be recognizable. When the parallax is known, proper motion is converted into linear measure by the formula:

$$\text{speed} = \frac{\text{annual P.M.}}{\text{parallax}} \times 4{\cdot}74 \text{ km. per second.}$$

The Solar Motion.—If we examine the proper motions in any small region of the sky, it is at once evident that they are not directed at random; an average motion in a certain direction is plainly shown. Comparing different regions of the sky and allowing for the different aspects of projection, it is found that the stars in the mean are moving in a direction towards the southern constellation Columba, not far from the south part of Canis Major. The same average motion is also shown by the spectroscopic radial velocities; *i.e.*, the stars in the Columba region have an average motion away from us, whilst those in the opposite part of the sky have an average motion towards us. The effect is so pronounced that a dozen stars taken at random will be sufficient to show the prevailing direction roughly (the first determination by Sir William Herschel was made from seven stars only); but in attempts to fix this important direction as accurately as possible many thousands of stars have been used.

In measuring proper motion, or radial velocity, our standard of reference is the sun; and the foregoing result shows that the stars in the mean are travelling past the sun in the direction towards Columba. This however is rather an egocentric way of expressing the facts. It is more natural to say that the sun is travelling relatively to the mean of the stars in the opposite direction—towards a point in Hercules or Lyra not far from the bright star Vega. This point is called the *solar apex,* and the relative velocity that is found is the *solar motion.* Attempts to determine an accurate position of the solar apex are not very closely accordant, and it does not seem possible to fix it to within 5°. In particular, radial velocity determinations seem to give systematically a lower declination than the proper motions, and bright stars give a lower declination than faint stars. We could scarcely expect the apex to be definite, because the "mean of the stars" is an indefinite conception. The stellar background appears to consist of interpenetrating clusters with different motions, and the relative solar motion will depend on what part of this background is sampled by our observational data. In round figures the general result is: Solar apex, R.A. 270°, dec. +30°; speed 20 km. per sec.

In measuring the parallaxes of stars we use the diameter of the earth's orbit as base line—a length of two astronomical units. The solar motion of 20 km. per sec. transports the observer through 4·2 astronomical units per year, so that observations taken now and 50 years ago give us a base line of 210 astronomical units. With the longer base line it should be possible to survey the stellar system to a distance far exceeding that attainable by parallax measurement. The method cannot be applied to individual stars because the parallactic displacement cannot be discriminated from the star's own motion; but when we are dealing with a class of stars (*e.g.*, stars of 9th magnitude, bright stars of type K, long-period variables, etc.) which are not likely to have any important common tendency of motion as compared with the general mean of the stars, the method will give the average parallax of the class. Fortunately, results obtained in this way can be checked by an independent determination based on similar principles. The *cross* proper motion, or component at right angles to the line towards the solar apex, is a component of the individual motion of the star; the radial velocity (after correcting for the known solar motion) is also a component of individual velocity. Hence, for a class of stars we can find the average value of a component of individual velocity both in arc and in linear measure; comparing the two results we deduce the mean distance. These methods have proved extremely useful in supplementing the meagre knowledge of the distances and absolute luminosities of the stars furnished by direct parallax determinations. For still greater distances the method described under *Cepheid Variables* and analogous methods are employed.

Moving Clusters.—A number of groups of stars have been recognized which share a common proper motion, and evidently form a connected system. We must assume that they have a common origin, *i.e.*, are evolved from the same nebulous condensation. Apparently, having started to move together, they continue to move together simply because encounters which might deflect them are extremely rare. One of the arguments against the existence of great numbers of dark stars in space, is that their passage between the stars of the moving cluster would break it up too rapidly. There is a typical moving cluster in Taurus, studied by L. Boss, which includes many of the stars in the Hyades. The true motions of these stars must be very nearly equal and parallel, otherwise the cluster would rapidly disperse, but as projected on the sky they appear to converge towards one point. As the cluster covers a reasonably large area the convergent point can be found with considerable accuracy. By geometrical construction it becomes possible (without parallax measurement) to determine the distance of each star of the group and to find the precise arrangement of the stars in three dimensions. Another cluster consists of five stars of the Plough together with Sirius and some other bright stars; the sun is in the midst of this moving cluster, so that its members appear in different parts of the sky. The stars of type B seem to have a special tendency to form associations of this kind; one of the best marked groups consists of about 16 stars in Perseus and neighbouring constellations. Perhaps the most important conclusion to be drawn from these clusters is that the stars are not born individually and independently, *e.g.*, by accidental collisions of extinct stars, but that the evolutionary process of star formation is capable of generating a number of stars simultaneously.

The Two Star Streams.—Eliminating the recognized moving clusters, we are left with the general body of the stars whose motions have no obvious association with one another. It is found on examination, however, that their motions are not at random. In 1904 J. C. Kapteyn showed that the proper motions show a decided preference for two favoured directions, apparently implying that the stars around us do not constitute a single system but a dual one. The observed motion of the stars in the mean towards the solar antapex is due to the intermingling of two systems moving in very different directions. These two streams are found to prevail in every part of the sky examined; they are shown both in the proper motions and in the radial velocities. It is not likely that the same stream motion extends throughout the galactic system, but up to the present no limit has been found. Originally discovered in the motions of the bright stars, the phenomenon is found to be essentially the same in stars as faint as mag. 11·5, and there is fragmentary evidence of its occurrence in much fainter stars. The following determinations of the apices and relative speeds of the two streams refer respectively to the bright stars of Boss's catalogue (Eddington) and the Cambridge photographic proper motions of faint stars (Smart). The speed is expressed in terms of a theoretical unit which is probably about 22 km. per second.

	Bright stars			Faint stars		
	R.A.	Dec.	Speed	R.A.	Dec.	Speed
Apex of stream I. . .	91°	−14°	1·52	88°	−12°	1·50
„ „ „ II. . .	288°	−64°	0·86	289°	−73°	0·97
Vertex	94°	+12°	1·87	92°	+20°	1·84
Solar apex . . .	267°	+36°	0·91	273°	+44°	0·88

The first two lines give the motions of the streams relative to the sun, but greater cosmical importance must be attached to the motion of one stream relative to the other, which is given in the third line of the table. The principal difference between bright stars and faint stars lies in their distribution between the two streams. For the bright stars the numbers belonging to stream I. and stream II. are as 3:2, for the faint stars the numbers in the two streams are practically equal. It is for this reason that the declination of the solar apex increases progressively with the faintness of the stars considered; stream II. is receiving more and more weight in the "mean of the stars."

Various attempts have been made to give a dynamical explanation of star-streaming. It was pointed out by H. H. Turner that the comets of the solar system have a preponderatingly radial direction of motion. It might well happen that the orbits of the stars about the centre of the stellar system show the same tendency; in that case, assuming that we are situated at some distance from the centre, the directions to and from the centre would be favoured directions of motion. The vertex or the antivertex would then indicate the direction in which the centre of gravity of the system lies. Others have favoured transverse instead of radial star-streaming, so that the centre of the system would lie 90° from the vertex; this has the advantage that it is possible for an oblate system of stars to continue in a steady state with transverse, but not with radial star-streaming, but on the other hand it is difficult to see how such a state of motion could originate. Observational evidence as to the direction of the centre of the galactic system does not accord well with either radial or transverse star-streaming. On the whole, Kapteyn's original idea seems the best; we have around us two groups of stars which have come together and are moving through one another.

Stars of type B are aloof from the two star-streams. Their motions (relative to the mean of the stars) are smaller than those of other types, and show little systematic tendency of any kind. A number of stars of other types are associated with them and form a third stream, known as stream O. In most parts of the sky it is difficult to disentangle stream O from stream I, but in regions where the circumstances of projection are favourable the third stream always appears clearly.

Rotation of the Galaxy.—If the galactic system is analogous to a spiral nebula it is presumably rotating in its own plane; in any case its flattened form would lead us to suspect rotation. Several attempts have been made to detect such a rotation from the proper motions of stars, but it is difficult to be sure that the results are not vitiated by the systematic errors of meridian catalogues. A determination by C. V. L. Charlier, in 1913, gave a general retrograde rotation of the stars in the galactic plane of 0·35″ per century; his more recent result is 0·24″. The rotation appears now to be confirmed by better evidence afforded by the radial velocities. If the rotation were like that of a rigid body the radial velocities, as viewed from any point, would be unaffected; but it is more reasonable to suppose that the angular velocity diminishes outwards from the centre of the system, as with the planets in the solar system. Then, if we take a group of stars surrounding the sun, those between us and the centre will be gaining on us and those outside us will be lagging behind. This shearing motion distorts a square into a parallelogram, that is to say one diagonal is lengthening and the other diagonal is shortening; so if we observe stars in two opposite regions of the sky, corresponding to the direction of one diagonal, these should be receding from us, and along the other diagonal, 90° away, the stars should be approaching us, on the average. J. H. Oort has found that this effect is quite prominently shown in the observed radial velocities, and that the direction of the galactic centre deduced from it accords well with the direction generally accepted (deduced from the distribution of globular clusters). Moreover, taking different classes of stars, the positions found for the centre are very accordant, and the effect increases, as it should do, proportionately to the mean distance of the class. Our survey covers only a relatively small region of the galactic system, but we can at least say that in this region the stars have systematic motions which shear the distribution in the same way as orbital motion about the centre of the galaxy would do. It is possible, however, that other physical explanations of this behaviour might be given.

Individual Motions.—After eliminating all systematic motion there remains the individual motion of the star itself. An interesting field of study arises from the correlation between individual speed and other characteristics, such as mass, spectral type, brightness. The earliest result of this kind was found by W. W. Campbell and J. C. Kapteyn in 1910; viz., a progressive change of mean speed with spectral type. Campbell's results for bright stars were: Type B, 6·5 km. per sec.; A, 11; F and G, 15; M, 17 km. per second. The figures refer to the radial component only, and must be doubled to give the mean speed in three dimensions. At the time it was thought that this sequence of types represented the order of evolution, so that the progression implied that the speed of the stars increases with their age; with the recognition of giant and dwarf stars this interpretation has become inadmissible. Actually type M consists of two distinct classes, viz., very diffuse stars supposed to be in the earliest stage of condensation from a nebula, and very dense stars supposed to be at the end of the evolutionary sequence; both classes have high speeds, the latter being particularly large. Generally speaking, faint stars have greater speeds than bright stars; owing to the mass-luminosity relation this means that stars of small mass have greater speeds than massive stars. It has been suggested that there is a law of equipartion of energy so that the average value of $\frac{1}{2}mv^2$ is the same for all classes of stars; this might have a dynamical explanation, since the speeds of the molecules of a gas distribute themselves according to the same law. Up to a certain point observations agree with the equipartion law, but there are noteworthy exceptions; the massive B stars have low average speed as the law requires, but the most massive stars of all, type O, have rather large speeds. The present position is that our knowledge of the factors determining the mean speed of different kinds of stars is made up of fragmentary correlations, and has not yet led to any generally comprehensive theory.

One complicating factor is the asymmetry of high velocity stars, which has been discovered by J. H. Oort and G. Strömberg. According to Oort, stars with speed greater than about 60 km. per sec. are moving almost exclusively towards one hemisphere of the sky. It seems reasonable to interpret this critical speed as the "velocity of escape" from our local star-cloud. Stars with velocity below the velocity of escape are permanent members of the star-cloud, and describe orbits within it under its gravitational attraction; on the average, therefore, they move as much in one direction as in the opposite. Stars with velocity above that of escape cannot be permanent members; they pass once through the system and do not return; accordingly they may well show an asymmetry of motion, dropping into our star-cloud from a cluster or clusters on one side of it, passing through it, and not returning. The value of the velocity of escape is more or less what we should expect from our general knowledge of the extent of the star-cloud and the number of stars per unit volume.

About 18 stars are known within a sphere of 4 parsecs radius surrounding the sun, *i.e.*, having parallaxes greater than 0·25″; there may be a few additional faint stars yet to be detected. Many of these near neighbours are red dwarfs with masses one-quarter or one-fifth that of the sun; on the other hand a considerable proportion are double stars (here counted as one). The total mass within the 4 parsecs sphere may be estimated at about 12 times the sun's mass. If this may be taken as the general average density of our star-cloud, it is possible to calculate the orbital period of the stars moving within it under its gravitational attraction; for the periods of orbits in a sphere of uniform density are isochronous, and depend only on the density and not on the size of the sphere. The period would be 200 million years. In addition to the mass of the lucid stars there may be other masses in the sphere, *e.g.*, dark stars or scattered nebulous matter of great tenuity. These added masses would shorten the period; but we cannot allow the period to be shortened very much, because then the stars in the largest orbits, hurrying to get from one side of the star-cloud to the other and back again in the prescribed period, would need to have greater velocities than we observe. Dark stars and nebulous material together cannot amount to many times the mass of the lucid stars. At the end of this article direct observational evidence will be given for the existence of a cloud of diffuse matter in interstellar space. This must be extremely rarefied; one atom per cubic centimetre is the most we can possibly allow consistently with the dynamics of stellar motions.

CONSTITUTION OF THE STARS

Density.—When the mass and radius of a star are known, the mean density of the material can be calculated immediately. Direct determinations of the *mass* are only available for double stars; but for other stars the mass may with some confidence be inferred from the absolute magnitude by means of the mass-luminosity relation described later in this section. In any case the range of stellar masses is so restricted that errors are not likely to affect the general order of magnitude of the densities deduced. The *radius* R may be calculated from the absolute luminosity and the observed surface-temperature. Other things being equal, the luminosity is proportional to the area of the surface, *i.e.*, to R^2, but allowance must be made for the different radiating power of surfaces at different temperatures; this allowance can be calculated from the laws of radiation (Planck's law). For a few stars the radii deduced in this way have been confirmed by direct measurement of the apparent angular diameter of the disc with Michelson's interferometer. In this way we find that some of the red giant stars, such as Betelgeuse, Antares, Mira, have densities less than $\frac{1}{100}$ that of air; Capella has a mean density nearly equal to air; the sun, we already know, has a density 1·4× water; the faint red dwarfs have density about 10× water. For the class of stars called *white dwarfs*, which includes the companion of Sirius (*see* SIRIUS), the method gave an enormous density 60,000 times that of water; this result was at first regarded as incredible, but it now appears probable that it is to be accepted literally.

For the more diffuse stars it is evidently legitimate to treat the stellar material as perfect gas. The study of stellar equilibrium thus reduces to the study of the equilibrium of a globe of perfect gas held together by its own gravitational attraction. It was thought that the simple theory must break down for stars of higher density (such as the sun) owing to the deviations from the laws of a perfect gas; but in 1924 it was found by Eddington that the dense stars agreed observationally with laws which had been deduced theoretically for gaseous stars. The fact is, that at the temperatures of the order of ten million degrees occurring in the stellar interior, the atoms are stripped of all their outer electrons and reduced to ions of very small dimensions; consequently the jamming of atoms against one another, which causes the breakdown of the gas laws, does not occur in the stars until far higher densities are reached. The high density found for the white dwarfs confirms this conclusion; close packing is possible because the atoms have lost their balloon-like envelopes. In all stars other than white dwarfs the material may be treated as perfect gas, except that in the stars of least mass (red dwarfs) there is a small correction arising from the electrostatic forces between the ions which makes the gas *superperfect, i.e.*, makes it deviate in the opposite direction to the deviations of *imperfect* terrestrial gases.

Internal Temperature and Pressure.—The distribution of temperature and density in a sphere of gas in equilibrium under its own gravitational attraction is a classical problem studied by Lane, Ritter, Emden and others. The mathematical analysis developed in these earlier researches is used in the modern theory, but three new features have been introduced. (1) It used to be supposed that the heat radiated from the star's surface into space was brought up from the interior by convection currents, but it has now become evident that it is transferred by radiation. Accordingly the stars are now assumed to be in *radiative* equilibrium instead of in *convective* equilibrium. The condition of radiative equilibrium is that each region must have settled down to a temperature at which it radiates an amount of heat equal to that which it absorbs from the radiation passing through it. One simplification resulting from this change is that we no longer need to know the ratio of specific heats of stellar material—a physical constant difficult to estimate. (2) Radiation-pressure is sufficiently great to play an important part in the equilibrium, especially of the massive stars, and it is now taken into account. (3) Formerly the average molecular weight of the stellar gas was taken to be the weight of the atoms likely to preponderate, *e.g.*, iron (at. wt. 56). It is now recognized that the atoms in the interior will be highly ionized; most of the electrons which circulate round the nucleus will have broken loose, and must be counted as independent "molecules." Taking this into account the molecular weight will be slightly over 2, a result nearly independent of the chemical constitution of the star provided only that there is not an excessive proportion of hydrogen. Owing to this decrease in the adopted molecular weight, the internal temperatures are considerably lower than those calculated on the older theories.

Since it is believed that a star's heat is maintained by liberation of sub-atomic energy, another unknown condition enters into the problem, viz., the distribution of sub-atomic sources in the interior. This, however, has no very important effect on the main results of the investigation, and, by considering the extreme cases of a source wholly concentrated at the centre and a source evenly distributed through the mass, we can set limits to the uncertainty.

For the sun the central temperature is found to be of the order 40,000,000° C. The mean temperature (averaged for equal mass) is 23,000,000°, and is less subject to uncertainty arising from ignorance of the distribution of the source of energy and other data. Moreover, all stars of the Main Series (*see* STELLAR EVOLUTION) have nearly the same internal temperature. The Main Series, which comprises the great majority of the stars, includes B type stars several hundred times more luminous than the sun, and red dwarfs, giving a hundredth or a thousandth of its light. It is remarkable that stars differing so widely in mass, in output of heat and light, and in surface temperature, should be so uniform in internal temperature. The giant stars have lower internal temperature, *e.g.*, Capella, which is of the same spectral type as the sun but has only $\frac{1}{600}$ of its density, has a central temperature 10,000,000°.

The temperature gradient from the centre to the surface causes a flow of heat outwards, which is hindered by the opacity of the stellar material; hence, knowing the temperature distribution in the interior, and having observed the total outflow of heat from the star (*i.e.*, its luminosity reduced to heat units) we can compute the opacity. This astronomical opacity may be compared with the theoretical opacity for material of the density and temperature concerned, as calculated from the modern theory of the atom. At present the results are not fully accordant, the astronomical opacity being about 12 times the calculated opacity, *i.e.*, the stars are about three magnitudes fainter than we should expect. The discrepancy is, however, the same for all stars, so that, if instead of attempting to predict theoretically the absolute brightness, we use the law of variation of opacity with density and temperature to predict differences of brightness, the agreement is very good.

The Mass-luminosity Relation.—Having calculated the temperature distribution in the star by the condition of radiative equilibrium, we find the following formula for the total outflow of heat L (in ergs per second):

$$L = 4\pi c G M (1-\beta)/k,$$

where c is the velocity of light, G the constant of gravitation, M the mass of the star (in grams); k the coefficient of opacity, and $1-\beta$ the ratio of radiation pressure to the whole pressure, obtained by solving the quartic equation,

$$1-\beta = 0{\cdot}0031\, M^2 \mu^4 \beta^4,$$

where M is now expressed in terms of the sun's mass, and μ is the average molecular weight in terms of the hydrogen atomic weight. Knowing L and M for any star we can calculate k; for example in Capella we find $k = 120$ C.G.S. units. This means that a screen containing $\frac{1}{120}$ gram. per sq.cm. (equivalent to about 6 cm. of air) would stop about two-thirds of the radiation passing through it. At first sight this is a surprisingly high opacity. The old problem as to how the heat is brought up from the interior of a star to replace that radiated from the surface, has completely changed; we see rather that the star has to be constructed of highly opaque material in order to hold back the internal heat and permit it to come to the surface no faster than it does. The high opacity is, however, not so surprising when we realize that at ten million degrees the radiation in the interior consists of X-rays chiefly of wave-length 2 to 6 Ångstroms, which are highly absorbed in a few millimetres of air. In fact the stellar opacity is less than the observed opacity in the laboratory—a fact explained by the high ionization of the stellar atoms, which throws a great part of their absorbing mechanism out of order.

According to modern theories of X-ray absorption, the coefficient of opacity should (approximately) be proportional to the density and inversely proportional to the $\frac{7}{2}$ power of the temperature ($k \propto \rho/T^{\frac{7}{2}}$). By the use of this law we can eliminate k from the equation given above and obtain the relation between L and M. The density of the star nearly disappears from this relation, so that the total radiation or absolute bolometric magnitude of a star is a function of the mass and molecular weight only, apart from a trivial correction dependent on the density, which can be calculated and applied when the spectral type is known. This predicted relation between L and M can be plotted as a graph; it is called the mass-luminosity relation. It appears to be well confirmed by all the observational data available; but it must be remembered that accurately determined masses are rare, so that the test is not so complete as we should desire. The mass-luminosity relation cannot conveniently be expressed by an algebraic formula, but as a rough guide it may be stated that the heat outflow from a star varies as the third or fourth power of the mass in the most important part of the range.

These results are mainly independent of the assumed chemical constitution of the stars, owing to the fact that the average molecular weight for all elements except the lightest turns out to be nearly 2 when account is taken of ionization; but for stars composed mainly of hydrogen the mass-luminosity relation would be greatly altered. It may be inferred, therefore, that the stars do not contain an excessive proportion of hydrogen.

It is interesting that we should be able to learn anything at all about the chemical composition of the inaccessible interior; but the fact has also a definite bearing on theories of the source of a star's heat. One theory suggests that the store of energy needed to maintain the star for thousands of millions of years is provided by the evolution of higher elements from hydrogen. (Hydrogen, which consists merely of protons and electrons is perhaps best regarded as *unformed matter.*) By cutting down the admissible proportion of hydrogen to, say, 10%, we reduce the supply from this source to one-tenth, and it becomes very doubtful whether it will suffice. Secondly, by admitting that 90% of the star must consist of "formed" matter, we must suppose that the main process of formation of matter occurs in a pre-stellar stage. Evolution of the elements is, therefore, in the main a low temperature process and, perhaps still more surprisingly, a low density process.

Radiation-pressure.—At any point in a star, gas-pressure and radiation-pressure together support the weight of the layers above. The proportion supported by radiation-pressure $(1-\beta)$ is found by a quartic equation already given. To a first approximation it is the same in all parts of the interior, and is independent of the star's density; the molecular weight being given, it depends only on the star's mass. It is remarkable that for stellar masses there is no great disparity between radiation-pressure and gas-pressure, whereas for masses of a different order $1-\beta$ would begin ·00.... or ·99.... It seems clear that the condition of rough equality of the two pressures has in some way determined the size of the aggregations of the primitive matter of the universe. The simplest view is to suppose that, when radiation pressure amounts to say one-tenth of the whole pressure, it renders the aggregation of further material more difficult or makes the mass more liable to break up. Hence larger masses are more and more rare. Gravitation by drawing together the primitive nebulous material will, in general, build up masses to a size at which radiation pressure first begins to offer serious opposition to further increase. It is now widely believed that the stars radiate away a large part of their mass during their life-time; hence it is fairest to consider only the youngest stars—those in the most diffuse state; 90% of these have masses (deduced by the mass-luminosity relation) between two and one-half times and five and one-half times that of the sun, corresponding to values of $1-\beta$ between ·17 and ·35. If the rise of radiation to importance plays a part in limiting the masses of the stars, this is just the range which we should expect to be most critical.

STELLAR SPECTRA

We deal rather briefly with this branch of the subject since some of the more interesting developments are treated under ASTROPHYSICS, STELLAR EVOLUTION, SUN. By the appearance of their spectra (*see* SPECTROSCOPY) stars are arranged in a sequence of types O, B, A, F, G, K, M. This turns out to be the order of decreasing surface temperature. The "effective" surface temperatures of stars are calculated by Planck's law of radiation (for theory, *see* RADIATION) from the relative intensity of the continuous spectrum for different wave-lengths; the higher the temperature the more the region of maximum intensity is displaced to the violet. For the sun this method of finding the equivalent black-body temperature is checked by calculating also the temperature corresponding to the absolute intensity of its radiation; so presumably it will apply to other stars, although we have not usually any direct check. Good indirect confirmation of these temperatures has been afforded by studying the spectral indications of ionization of the elements. (*See* below.) The following temperature scale is a combination from various sources; the results are in degrees absolute.

Type	Temperature	Type	Temperature
	°		°
Bo . . .	20,000	Go . . .	5,500
B5 . . .	15,000	G5 . . .	4,700
Ao . . .	11,000	Ko . . .	4,000
A5 . . .	8,500	K5 . . .	3,300
Fo . . .	7,500	Mo . . .	3,000
F5 . . .	6,500		

This refers to giant stars; dwarf stars of the same type are about 500° hotter. The radiating power of the surface in heat units is proportional to the fourth power of the temperature.

In all the later types the stars fall into two groups, the *giant* or diffuse stars, and the *dwarf* or dense stars. They are most widely distinct in type M, and converge to coalescence in types A and B. If, instead of arranging the stars in order of surface temperature, we put them in order of increasing density, we must start with the giants of type M, follow the giant branch through K, G, F until it coalesces with the dwarf branch in types A and B, and then continue along the dwarf branch in the reverse order A, F, G, K, M. It is natural to suppose that the order of increasing density is that of evolution, and accordingly we seek a theory of evolution which will be consistent with this order.

Following this supposed order of evolution, the temperature of the surface starts very low, increases to a maximum, and then decreases again, the giant stage being one of ascending temperature, and the dwarf stage of descending temperature. This fact, which was stressed in early theories, has probably no great significance, since the surface temperature does not correspond at all closely to the internal temperature. It is more important to note that the mass (corresponding closely with the luminosity) is nearly steady in the giant sequence, perhaps decreasing slightly, and then diminishes rapidly as we pass down the dwarf sequence. It seems impossible to retain our general ideas of stellar evolution without admitting that the mass of a star decreases substantially during its life-time. Radiation is the principal cause of loss of mass by a star, and hence we are inclined to believe that a large part of the mass of a star is convertible into radiation—in short, matter must disappear, its energy of constitution being released as aether waves. Admitting this source of energy, the age of the stars is of the order of a billion (10^{12}) years or more. In fact, we can calculate the time taken for a star to evolve from one type to another by reckoning how long it would take for its observed radiation to carry away the necessary amount of mass. In the latest dwarf stages, when the radiation is feeble, evolution will be very slow, and the sun may continue to shine with increasing feebleness for 300 billion years before it reaches the last stage of the sequence type M (dwarf).

After the first use of spectroscopy to identify chemical elements in the atmosphere of a star, the most important advance was the discrimination of "enhanced lines," *i.e.*, lines strengthened in the spark spectrum as compared with the arc. Much of the early progress in this direction was due to J. N. Lockyer and A. Fowler. In general, enhanced lines are those due to the atom with one electron missing (singly ionized atoms), the arc lines being due to neutral atoms. The spectra of all the important elements have now been unravelled, and we can say at once which lines belong to neutral atoms, which to singly ionized, which to doubly ionized atoms, etc. Thus it is found that in some stars the atoms of calcium in a position to form an absorption spectrum are neutral, in others they are singly ionized, in others doubly ionized. Clearly this is a clue to the physical conditions in the outer layers of a star. The modern thermodynamical theory of ionization was brought to bear on the astronomical observations by M. N. Saha in 1920, and has dominated all recent progress. The degree of ionization depends on both the temperature and pressure, the former representing the factor which causes the breaking away of electrons and the latter the factor which determines their opportunity of recombining. By connecting together the data for different elements and controlling the results by reference to other methods of determining stellar temperatures, much information has been obtained as to the temperature and pressure in the reversing layer. In particular it is found that the pressure is generally between 10^{-3} and 10^{-4} atmospheres—much lower than used to be supposed.

Spectroscopic Parallaxes.—Since the nature of the spectrum shown by a star is conditioned both by the temperature and pressure of the reversing layer, a complete classification of spectra should be two-dimensional. Ordinarily we recognize only a linear series—the Draper sequence of types considered above; but by attention to detail we can recognize also a classification transverse to this. Taking the Draper sequence to correspond roughly to temperature, the transverse classification will correspond to pressure. Since low pressure favours ionization, it will be marked in the spectrum by great strength of the enhanced lines relatively to the arc lines. The giant and dwarf stars of the same spectral type can easily be distinguished from one another by this method; the reversing-layer pressure is low in the giant stars owing to the small value of gravity at the surface.

It was early recognized by E. Hertzsprung that those spectra marked by Miss Maury as having the "*c*-characteristic" belong exclusively to the giant stars. This characteristic is an unusual fineness of the lines—a feature which also results from low pressure. More precise criteria were found by Adams and Kohlschütter in 1914; and the method has been developed by Adams into a means, not only of distinguishing giant and dwarf stars, but of determining quantitatively the absolute luminosities of stars. At present the procedure is empirical; the curve connecting absolute magnitude with differential intensity of certain selected pairs of spectral lines is deduced from and tested by stars of known trigonometrical parallax; it is then applied to find the absolute magnitudes and hence the distances of other stars. Parallaxes of some thousands of stars determined in this way have been announced, and are known as spectroscopic parallaxes. The underlying principle of the method may be summarized as follows: Stars may differ in mass, and stars of the same mass may differ in density; but, when the mass and density are given, no other important difference can occur, and the luminosity, surface temperature and pressure in the reversing layer should be uniquely determined; hence the spectrum should be determinate. Conversely, a sufficiently close examination of the spectrum (its position both in the Draper sequence and in the classification transverse to it) should fix the mass and density of the star, and hence its other physical properties, including luminosity. Ideally the deduction of luminosity might be made theoretically, but in any case the connection between luminosity and spectrum can be observed experimentally and formulated as an empirical law.

Calcium Cloud in Space.—In certain spectroscopic double stars the phenomenon of "fixed calcium lines" is observed. Whereas the other spectral lines shift to and fro as the star approaches and recedes in its orbit, the H and K lines of ionized calcium remain stationary. It is clear that somewhere between us and the star's photosphere there must be an absorbing cloud of calcium vapour which does not follow the star in its orbit. The phenomenon was first pointed out by Hartmann in 1904 for the star δ Orionis. Later Miss Heger discovered that the D lines of sodium also remain fixed in δ Orionis. The same behaviour has now been observed in a large number of stars, but no other "fixed" spectral lines have been found. The important question to decide is whether the cloud belongs to the double star or whether it is a continuous cloud filling interstellar space. J. S. Plaskett has shown that the latter alternative is correct; the motion of the calcium cloud is often different from that of the centre of mass of the star. After removing the solar motion the velocity of the cloud relative to the mean of the stars is found to be small. Just as there are lines in the solar spectrum which do not share in the sun's rotation and are accordingly to be attributed to absorption during the passage of the light through the earth's atmosphere, so we have fixed lines of calcium and sodium which do not share in the orbital or individual motion of the star and are to be attributed to absorption in an interstellar "atmosphere." The fixed lines only appear in the spectra of the hottest stars, but that is perhaps due to the fact that cooler stars have strong H and K lines of their own, masking the lines of the cloud, or because the cooler stars, being less luminous, are not observed at a sufficient distance to give the cloud absorption a chance. It has been suggested that the presence of the hot star is necessary in order to ionize the calcium vapour and render it capable of absorbing H and K light, so that although the absorption is performed by the interstellar cloud only the parts of the cloud stimulated by the star are effective. But this explanation would not hold good for the D lines of sodium which are absorbed by un-ionized unexcited atoms. There can be little doubt that the absorption occurs along the whole track of the light through space, and the intensity of the lines should be an indication of the length of track, that is of the distance of the star. This appears to be confirmed by the researches of O. Struve, who has found that the strength of the fixed lines increases steadily with the average distance of the objects observed.

In order to avoid a huge mass of the stellar system inconsistent with the observed velocities of the stars, it must be postulated that this interstellar cloud is of very low density. About one atom per cubic centimetre is the maximum that can be allowed. It is calculated that matter so diffuse as this would take up a high temperature not much lower than the photospheric temperatures of the stars; although a black body in interstellar space would sink to a temperature of 3° absolute. The density is too small to give any appreciable scattering or absorption of light in space other than the special line-absorption of calcium and sodium light.

See also NOVA; STAR CLUSTER; ALGOL; SIRIUS; STELLAR EVOLUTION; COSMOGONY; CONSTELLATION.

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STAR APPLE (*Chrysophyllum Cainito*), an evergreen tree of the family Sapataceae (*q.v.*), called also cainito, native to tropical America and cultivated for its edible fruit. The pleasantly flavoured fruit, 2 to 4 in. across, is apple-shaped. In a cross-section of the unripe fruit the seed-bearing cells form a star.

STARAYA RUSSA, a town of Russia in the province of Novgorod, in 58° N., 31° 22′ E., on the river Polista, by means of which and Lake Ilmen it is brought into steamer communication with Leningrad. Pop. (1926) 21,511. Brine springs on the east of the town were used as a source for the supply of salt as late as 1865; at present they are used only as mineral waters (temperature 51–54° F), having a great resemblance to those of Kreuznach in Germany. Some thousands of visitors were accustomed to resort to them every summer, and owing to this circumstance Staraya Russa was better built and better kept than any other town in the government of Novgorod. The inhabitants are supported chiefly by the summer visitors. There is a trade in rye, oats and flax. The name of Staraya Russa occurs in Russian annals as far back as 1167. It belonged to the republic of Novgorod, and suffered continually in the wars between Russia, Lithuania and Livonia. It was afterwards annexed to Moscow.

STARA ZAGORA, the capital of a department of southern Bulgaria lying on the southern slope of the Karaja Dagh, 70 m. N.W. of Adrianople, with which it is connected by railway. Population (1926), 28,929. The city is surrounded by vineyards, and has flour-mills, breweries, brandy distilleries, copper foundries and tanneries. The production of silk and attar of roses is carried on in the district, which contains numerous mineral springs, and there is a trade in corn and wine. It is the junction of the trans-Balkan and Burgas-Philippopolis railway lines. It was destroyed during the Russo-Turkish war (1877–78) and rebuilt on modern lines. During the rebuilding, important Thracian, Roman, Byzantine and Turkish antiquities were discovered.

Stara Zagora, founded probably by the Thracians, was known to the Romans as Augusta Traiana, but afterwards, to distinguish it from a Macedonian town of this name, it was named Beroe or Berrhoea. By the Turks the name was changed in the 17th century to Eski-Zagra or Eski-Zaara, whence its Bulgarian name.

STARCH. This is perhaps the most widely distributed substance in the vegetable kingdom and occurs, often in great abundance, in almost every plant. Pure starch has the appearance of a white, glistening, friable powder, and possesses a harsh feel when rubbed between the fingers; it is tasteless, has no smell, is not soluble in cold water and undergoes no change when exposed to the air. When examined under the microscope it is found to consist of granules of definite shape, size and appearance. These show very wide variations, some being minute while others attain a comparatively large size; they are, nevertheless, quite characteristic of the plant from whence they are obtained, and the identification of any particular starch by comparison with those of known origin is a more or less simple matter. Granules or cells which are usually oval in shape are found to be composed of a series of concentric layers arranged around a nucleus or hilum which appears as a dark spot, the outer layers being the oldest in point of growth.

Starch belongs to the group of carbohydrates in which are included the sugars, gums and cellulose, and is composed of the elements carbon, hydrogen and oxygen. Its constitution is very complex, but it is built up in the plant from two simple compounds, water and the carbon dioxide gas present in the atmosphere, through the agency of the green colouring matter, chlorophyll, under the activating influence of sunlight. The rôle of starch in plant economy is that of a reserve material, and as such it must be transferred from the leaves and other green parts of the plant, where it is formed, to more permanent quarters. To facilitate this migration it is broken down into sugars which dissolve in the cell juice, in this way passing through the cell walls of the plant finally to become reconverted into starch, either in the fruit or seeds, or in the bulbs and tubers as the case may be. It is thus rendered available as a source of sustenance for the young plant until it is sufficiently advanced to carry on the process of starch formation itself. The starch granule is composed of two distinct but similar compounds, amylose and amylopectin, the former being in considerable excess, and although it is quite insoluble in cold water, when mixed with hot water the cells rupture considerably below boiling point, and form a viscous, jelly-like liquid which is known as "starch paste," setting into a solid mass on cooling. When starch paste is heated with dilute acids the starch is first converted into the soluble form and, by a process known as hydrolysis, is subsequently changed into a series of sugars, the principal of which are dextrin, maltose and glucose. This process is employed in the manufacture of corn or glucose syrup, used very extensively in confectionery, and of glucose sugar used in brewing. Hydrolysis is also effected by certain natural ferments or "enzymes" such as those present in saliva, pancreatic juice, malted grain (diastase) and in fact all germinated seeds, and it is the latter agent which is employed in the fermentation industries—brewing, distilling, etc.—converting the starch in the materials used into material capable of fermentation by yeast. The development of starch in the growing plant already referred to, and the rebuilding of the soluble products into the cellulose which constitutes the tissues, is carried out by ferments or enzymes elaborated by the plant itself, while a similar process goes on in the human system when starchy foods are eaten and converted into soluble sugars capable of assimilation.

Dry starch heated to about 320° F is transformed into dextrin, a pale, yellowish powder soluble in water, known as British gum. A very sensitive reaction of starch is the production of an intense blue coloration with a solution of iodine, a characteristic much used in its identification.

The average starch content of the principal starch yielding plants, together with the temperatures at which the purified starch gelatinizes when heated with water, are, according to Lippmann, as in the following table:

	Average Starch content %	*Gelatinizing temp. ° F*
Potato	18–20	145
Wheat	54–58	152
Barley	40–46	145
Oats	35–38	. .
Rye	44–46	131
Maize	55–65	145
Rice	70–79	142
Millet	53–55	. .
Peas	39–40	. .
Lentils	39–40	. .
Arrowroot (*Maranta arundinacea*)	26–39	158
Tapioca (*Jatropha manihot*)	25–40	156
Yams (*Batata edulis*)	25–35	. .
Sago		158

The storehouse, or starch-containing part of the plant, consists of a network of cells, within the walls of which the starch granules are closely packed together. The process of manufacture involves the rupturing of the enveloping cell walls and separation of the starch from the associated material by levigation.

Manufacture.—The manufacture of starch from roots and tubers is usually carried on in the locality in which they are grown; that from potatoes on the continent of Europe, principally in Germany, France and Holland; arrowroot, cassava and tapioca are prepared from the roots and tubers of the maranta and manioc plants in the West Indies and South America; sago is manufactured from the pith of the sago palm and also from the yams or sweet potatoes in the East Indies and Borneo. Cereals can be more readily transported and stored, so locality is a matter of convenience; thus rice is used as a raw material in England, France, Germany and Italy and other parts of Europe, while maize is used very extensively in North America, and in England, France and Germany. Wheat is not now largely employed.

The purposes for which starch is manufactured can be classified under three heads:

(*a*) *Industrial.* These include sizing yarn and cloth in the textile industries; dressing cloth; thickening mordants and colours in calico printing; the preparation of British gums and dextrin, confectioners' glucose or corn syrups, and sugars for use in the fermentation industries.

(*b*) *Food.* Used alone in the form of cornflour, arrowroot, tapioca, sago, etc., or in conjunction with other substances in the preparation of custard and blanc mange powders, macaroni, semolinas, sauces, cocoa, confectionery, etc.

(*c*) *Laundry.* In pipe or crystal form and powders, both "thick" and "thin boiling" preparations.

The suitability of starches from various sources for these purposes depends on their cost, purity, the stiffness or viscosity of the paste they make with hot water and the size of the granules. Potato, maize, rice and wheat starches are those chiefly used for industrial purposes; rice, maize, arrowroot, cassava and sago for foodstuffs; and the small granuled starches, rice and maize, are used extensively in the laundry owing to the fact that the granules are required to enter the texture of the linen or cloth before becoming gelatinized by the hot iron.

The general principles for dealing with all types of roots and tubers are substantially the same, but of course vary in their elaboration and efficiency in different parts of the world, and they also only differ to some extent in detail when cereals are being treated. They are briefly as follows:—The tubers first go through washing machines where earth, stones, sand and grit are removed; they then pass to a rasping machine where all the cells are completely ruptured. The resulting pulp is washed in a fine stream of water on fine-mesh brass sieves, which separate the starch from vegetable fibre, etc.; the resulting milky starch liquor is run into vats to separate fine sand and grit by settlement, through fine silk sieves for further purification, and is finally allowed to run very slowly over long, shallow, wood troughs, runs or tables, where the pure starch settles out and the impurities pass off at the ends with the water. The pure white starch is washed from the runs by a jet of water and is pumped to either filter presses or hydro extractors, which remove all except about 40–45% of the water, leaving the starch in the form of a damp cake.

The cereals contain varying proportions of protein or gluten material associated with the starch, and special methods have to be employed in their preliminary treatment. The protein contained in rice is found to be rendered soluble by very weak caustic soda solution, and advantage is taken of this in the production of starch from the raw material.

Maize in addition to protein contains an oil-containing germ which it is necessary to remove. In this case the grain is first steeped for 2 to 4 days in warm water containing 1% of sulphur dioxide, ground in burr stone mills, and the resulting diffluent mass diluted with water is passed through a long V-shaped tank where the germ floats and is skimmed off.

Wheat contains gluten which forms an elastic paste with water and cannot be removed by levigation. The procedure carried out in this case is to reduce the grain to flour which is then made into a dough with water, divided into small pieces and placed in a semicircular silk or fine brass sieve where a travelling roller presses out the starch which is removed by a fine spray of water. The starch liquor goes through a very similar purification process to that employed for maize, often being treated with dilute caustic soda solution to swell the gluten and assist its removal between the sieving processes. It is necessary to carry out the final drying process at very low temperatures to prevent the gelatinization of the starch granules. Several methods, similar in principle for starches from all sources, are in use in the large factories, and consist of either bringing the starch lumps or blocks in contact with a continuous current of warm air, or evaporating off the excess of moisture in a vacuum chamber. For producing the starch in the form of powder or flour the moist lumps are either placed on an endless band running backwards and forwards in an enclosed chamber through which warm air is drawn, or they are placed on trays mounted on a trolley and passed through a tunnel in contact with warm air. In the tropics drying is usually carried out in the open air.

Prism or crystal starch is prepared from maize or rice starch for laundry purposes, and is produced by forming the damp starch into blocks by draining off the water from the starch liquor in boxes with perforated bottoms covered with filtering cloths; the blocks are cut into two or more sections which are partly dried in a warm chamber; the yellowish brown crust which forms on the outside is scraped off, and the blocks wrapped in paper, returned to the drying chamber and dried very slowly. Under this treatment the blocks break up into irregularly shaped prisms technically termed "crystals."

Pearl tapioca is made by heating the slightly moist starch from manioc in a steam heated copper pan with constant stirring, some of the cells becoming gelatinized and adhering together in small, irregular masses. Further drying follows and the crude lumps are passed through rollers and graded.

Granulated or pearl sago is prepared by drying the starch in such a way that it forms a plastic dough in which a portion of the granules have become gelatinized, forcing this through sieves, and drying the resulting granules in the air.

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STAR CHAMBER, the name of an apartment in the royal palace of Westminster, a meeting-place of the king's councillors, derived from stars fashioned on the roof, perhaps, of the hall. By derivation, later on, the name of councillors and judges sitting there as a court.

In 1398 repairs of the "Sterred chambre" are mentioned. In 1453 a meeting "in concilio nostro" (in our council) was held "in the Sterred Chambre." In 1542 a law provided punishment for those convicted "in the Starr Chamber at Westmynster before the Kinges most honorable Counsell."

In the middle ages judicial functions were exercised by the king of England and his council. The crown never parted with supreme jurisdiction. The council shared it, and also did judicial work not specially delegated to the particular courts which had evolved from the *curia regis*. The king's council, in Star Chamber and elsewhere, was reinforced by judges of the royal courts and by various others. From time to time parliament defined and approved this judicial work. In 1487 a statute (3 Henry VII., c. 1)—for a long time mistakenly supposed to have established the court of Star Chamber—named a commission of seven principal councillors and two of the judges, to try offenders too great to be dealt with by ordinary courts.

In the sixteenth century councillors, judges, persons specially summoned, additional "counsel," and great lords sometimes attending, acted either as a council or a court in Star Chamber, records being kept by clerks.

Councillors and judges sitting in Star Chamber were more and more thought of as the court of Star Chamber. They dispensed much justice and heard many cases often by desire of the parties concerned. Hearings were public; there was no jury; torture was sometimes used to get confession. Generally speaking, it was a court of criminal jurisdiction, particularly in respect of violation of royal proclamations; but "all offences may be here examined and punished if the king will." Sentence of death was never pronounced. The court punished with imprisonment and with fine, even with mutilation.

Under Elizabeth attendance at Star Chamber approximated to that at privy council, with reinforcement of judges, so that the two bodies were differentiated in function rather than in personnel. Under James I. and Charles I. Star Chamber continued as an active, important court, largely respected and liked. As Puritan and parliamentary opposition developed, however, it incurred odium from severe penalties, and the reputation then affixed by enemies has since persisted. In 1641 it was abolished by an act of the Long Parliament (16 Charles I., c. 10). At the same time the judicial power of councillors in privy council was abridged.

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STAR CLUSTER. In surveying the sky we find regions here and there where the stars are much more richly strewn than usual. Some of these are clusters, where hundreds or thousands of stars are seen concentrated together in a small field of view, providing show-objects—beauty spots of the celestial landscape. Not only are they impressive to observe, but they have led to remarkable advances in our knowledge. The measurement of the extent of the visible universe and an indication of its organization, together with intimations of its mass, population, and past duration, are among the contributions to astronomy and cosmogony that have been made chiefly through the study of star clusters. The researches have been descriptive, astrometric, photometric, spectroscopic, statistical, mathematical, and speculative—often complicated, and more often very tedious. In a three-page account of these ancient and instructive cluster systems, the reader can be and should be spared the details of method and the evidence of observatory labours. Perhaps the most important item will be the short bibliography, which will guide the reader who desires more information. The aim of the following treatment is a general survey of the subject and a statement of current results; we take up, successively, (1) introductory remarks on the frequency and variety of clusters,

(2) the naked-eye systems and their measurable motions, (3) classification and distribution, (4) the forms of globular clusters, (5) variable stars in clusters, (6) distances and dimensions, and (7) the rôle of clusters in the evolution of stars and galaxies.

1. **Introduction.**—The grouping and clustering of astronomical bodies are so common that we may infer from available observation that most of them are in close gravitational association. The earth-moon system, the sun and the planets, and the close double stars are examples of physically associated groups, probably all resulting from subdivision. Wide binary stars, typical star clusters, and star clouds are further examples of gravitational organization, but possibly they represent the accumulation of once isolated bodies and not the fission of originally larger masses. Organized systems smaller than any of these are the showers of meteors; and larger groups are the galaxies, and the clusters of "island universes."

It is not easy to draw a dividing line between multiple stars and star clusters. The brightest star, Sirius, is double; the nearest star, α Centauri, is triple; possibly Polaris is quadruple, and Castor is sextuple. The trapezium of the Orion Nebula, θ Orionis, is actually the many-starred nucleus of a widely spread system of stars. For the convenience of the present discussion we shall call the Ursa Major group of bright stars, the Great Bear, a cluster. All groups of equal or greater population will fall within the cluster category, up to the richest of globular clusters, where we shall limit the family, without including the spheroidal extra-galactic nebulae (which may be merely globular clusters of superior size), or the star clouds and the spiral nebulae.

It will be convenient to divide the star clusters into a globular class and a galactic class; the one is named from its form, the other from its apparent and real association with the Milky Way. The former can be limited fairly well to one hundred objects, only a dozen of which approach in structure, and in paucity of stars, the more open clusters of the galactic class; but the galactic clusters themselves are so varied in form, population, and angular and linear dimensions, that no distinct limits can be set, at least between them and the chance aggregations of stars in the Milky Way. A current compilation of well-defined galactic clusters, made at the Harvard Observatory, contains about 250 entries.

2. **Conspicuous Star Clusters.**—The stellar groupings that have led in ancient and modern times to the establishment of constellations frequently bring together stars that are not actually associated in space. A few, however, involve bright stars that are physically allied—notably Orion, Ursa Major, Scorpio, and Perseus. Thus, five of the seven conspicuous stars of Ursa Major are now known to be closely alike in distance, in amount of motion, and in spectral class; and though they are widely separated in the sky, Sirius and other bright stars are also members of the same Ursa Major family. These stars move in parallel paths through space, and probably they have constituted a cluster throughout their whole past history as stars, and will continue to be associated in the future for a period indefinitely long. Ultimately, through encounters with other stars, the members of such groups may be diverted from essentially parallel motion, for they move through the highly populated regions of the Milky Way.

A number of the naked-eye stars in the constellation Orion also form a large loosely organized cluster, composed almost wholly of the very hot stars of spectral class B. There are similar large loosely defined groups of B stars in Vela, Centaurus, Scorpio and Perseus. In fact, J. C. Kapteyn's researches and the subsequent investigations by C. V. L. Charlier and Harlow Shapley have shown that these various groups of B stars all together form a larger system of which the total diameter is probably in excess of a thousand parsecs (a parsec is 3×10^{13} kilometers, approximately). This system of loose clusters, named the "local system" by Shapley, is known to contain a great number of stars besides those in the localized B type clusters; according to recent researches by F. H. Seares, it also includes the vast majority of all stars surrounding the sun. The local system is, in fact, rather in the nature of a star cloud, like those in the Milky Way, or like the Magellanic Clouds, and as such it need receive no further consideration in this discussion of star clusters.

Systems more definitely circumscribed than the constellations just named are the Hyades, the Pleiades, Coma Berenices, Praesepe, and the Double Cluster in Perseus. All these clusters are visible with the unaided eye, and for all of them the proper motions (angular speeds) have been studied in much detail. An investigation of the proper motions of the individual stars of a cluster leads to the discovery, first made for the Hyades by Lewis Boss, that the paths converge towards a common point (or diverge from one). The convergence is obviously a matter of perspective. When the convergent point is accurately determined, and the motion of one or more of the stars of the cluster in the line of sight has been determined spectroscopically, then we can determine with high accuracy the linear distance to the cluster and the actual speed of the stars. If V is the radial velocity of the star in kilometers per second, μ its proper motion in seconds of arc per year, and θ the angular distance from the star to the convergent point, then the distance in parsecs, R, is given by

$$R = 0{\cdot}211\ V \tan\theta/\mu$$

and the velocity in space in kilometers per second is

$$v = V\sec\theta$$

When the velocities of several stars are measured spectroscopically, as is possible in the Hyades, mean values of V can be obtained, thus eliminating the effect of accidental errors and peculiar velocities, and the distances of the individual stars and of the cluster as a whole are determined with high precision.

If its distance is known, a cluster can be dissected in detail. The candle power of its various stars is readily deduced from measures of apparent brightness. In the case of the Taurus cluster, the dispersion in luminosity is found to range over at least six stellar magnitudes, that is, a range in brightness of more than 250 to 1. Most of the members of the cluster lie within a sphere of 10 parsecs radius, the centre of which is about 42 parsecs distant from the sun.

In a similar way, but with less accuracy, the convergent point and distance of the Pleiades can be determined. There is good evidence also (from a study by A. Kohlschütter) that the stars of Praesepe move toward the same convergent point as those of the Hyades, and this affords a means of determining the distance of Praesepe. The radial velocities of several of the brighter stars in the double cluster in Perseus (h and χ Persei) have been shown by Mount Wilson observers to be about 40 km/sec; the proper motion of the double system is so small, however, that the convergent point and distance are as yet uncertainly determined.

Frequently it has been suggested that certain stars move in paths parallel to the sun's motion in space, and that our system, therefore, is a member of an open star cluster. This matter has been especially investigated by W. J. Luyten, who finds no good evidence of solar companions, with the possible exception of the fifth magnitude star 46 Tauri. It may be suggested that the existence of planets around the sun argues against its membership in a star cluster, for the hypothetical ancient encounter with another star that gave rise to the planetary births would at the same time deflect the sun from its original path and detach it from the cluster to which it may once have belonged.

3. **Classification and Distribution of Clusters.**—Various classifications of clusters have been proposed, but because of the gradual transition from one form to another no classifying, beyond the major divisions of globular and galactic clusters, is much more than a working convenience. Recently, however, Shapley and Miss Sawyer have classified the globular clusters on the basis of central concentration, and R. Trumpler and Shapley have proposed simple classifications for the brighter galactic clusters on the basis of the spectral characteristics of their stars.

A typical globular cluster is an assemblage of scores of thousands of stars, perhaps hundreds of thousands. It is approximately circular in outline, strongly concentrated to the centre, and so remote in space that although actually of great dimensions it rarely exceeds the moon in angular size even when its most outlying members are included. Its stars are normal giants and super-giants, as far as our present researches show, for dwarf stars of the sun's light and diameter would be unattainable with our present telescopic power when at the distance of the nearest globular cluster.

There is a general similarity among globular clusters in size, form, content and integrated brightness; but marked deviations from the average have been noted in the matter of compactness. Also, some globular systems, such as No. 19 of Messier's list and ω Centauri, are conspicuously elongated; Messier 62 is easily seen to be non-symmetrical, and a few systems are obviously deficient in giant stars. The new classification distributes the one hundred globular clusters into twelve approximately equal classes, Class I representing the highest concentration of the stars toward the centre, and Class XII the least. A study of the relation of the concentration classes to distribution in the sky, total brightness, number of stars, and ellipticity of apparent form shows no significant interdependence of these quantities; but it is probable that the classes are an indication of developmental age, and they should thus prove useful in studies of the linear diameters, the frequency of variable stars, and the deeper problems of the origin and life-history of stellar systems.

The galactic clusters, which are typically irregular in form, loosely organized, and composed of a few scores or a few hundreds of highly luminous stars, can be most conveniently placed in two classes (according to Shapley)—the Hyades type and the Pleiades type—either of which may be associated with star clouds or diffuse nebulosity. In the Hyades type we find some yellowish or reddish giant stars (spectral classes G, K, M), together with stars of the hotter spectral classes (B, A, F); whereas in the Pleiades type of cluster the cooler giant stars are lacking and all the cluster stars fall along the main sequence of spectral types which extends from the giant B and A stars down through the intermediate Classes F and G to the dwarfish red stars of Classes K and M. Trumpler has proposed some subdivisions of these two main types of galactic cluster.

There is as striking a difference between globular and galactic clusters in distribution over the sky as in population and compactness. With scarcely an exception the galactic clusters are scattered along the central line of the Milky Way; very rarely is one found more than ten degrees from the galactic circle. The globular clusters, on the other hand, are frequently found in high galactic latitudes, that is, angularly far from the Milky Way. As we approach the low galactic latitudes, however, they become more numerous, up to the very edges of the stream of Milky Way star clouds. But their number suddenly falls off near the central line of the Milky Way, so that only two or three are found along a central belt seven or eight degrees in width. It is just within this region devoid of globular clusters that the galactic clusters and rich star clouds are most numerous.

The contrasted distribution may be explained largely by the fact that globular clusters are, on the average, much more distant than the open groups, and that globular clusters in low galactic latitudes therefore may be obscured by intervening clouds of cosmic matter which lie beyond the galactic clusters of our catalogues.

The galactic star clusters are distributed throughout all longitudes along the Milky Way, whereas the globular clusters are highly concentrated in the constellations of Ophiuchus, Scorpio and Sagittarius. The same region of the sky is also very rich in remote variable stars, in novae, planetary nebulae and star clouds; it is a region of depth and heavy stellar population.

4. **The Forms of Globular Clusters.**—A deviation of the photographic image of a star cluster from circularity was first pointed out with certainty for a few globular clusters by S. I. Bailey in his study of Harvard photographs. Subsequent detailed counting of stars in globular clusters at the Mount Wilson Observatory by F. G. Pease, Shapley and others, showed that the lack of exact radial symmetry in the globular clusters is typical. Thorough investigations of this matter, mainly at the Mount Wilson and Harvard Observatories, led to the conclusion that the average globular cluster is flattened, as though by rotation or by dynamical encounter with other stellar systems. This flattening reveals itself through the elliptical form of the projected image. In a recent study at Harvard the ellipticities of the photographic images of about one-third of all globular clusters are satisfactorily estimated; in the most extreme cases the minor axis of the projected ellipse is but six- or seven-tenths of the major axis; but it is not possible to evaluate separately both the true flattening of a cluster and the inclination of its equatorial plane to the line of sight. The most we can say is that some globular clusters have equatorial diameters at least forty per cent greater than their polar diameters. In no cases do they appear to attain the high degree of flattening observed in spiral nebulae (*q.v.*) or in the Milky Way system itself.

Much work has been devoted to studies of the laws of the distribution of stars in globular clusters. Various formulae relating the number of stars per unit volume, N, with distance from centre of projected image, r, or with ρ, the distance from the cluster center, have been derived or assumed, and applied to published counts of stars. For instance,

$$N(\rho) = \frac{1}{\pi}\int_{\rho}^{R} \sqrt{(r^2-\rho^2)}\,\frac{d}{dr}\left(\frac{1}{r}\,\frac{dn}{dr}\right)dr$$

(E. C. Pickering, H. von Zeipel) where R is the radius of the cluster and n is the number of stars in the corresponding unit area of the projected image. Analogies with the kinetic theory of gases have encouraged some of these researches. No completely satisfactory representation of the observations has been found, which is not surprising because the data, with which comparison is made, are inherently faulty. The so-called Eberhard effect, intrinsic in almost all photographic work in crowded regions, vitiates the results because the photographic development is more thorough, and brings out fainter stars, at the edges of clusters than in the centre. Further, the available counts deal only with the few hundreds or few thousands of the super-giant stars of the globular clusters; the tens or hundreds of thousands of fainter stars cannot be considered in the theoretical investigations. In counting cluster stars there are also practical difficulties with varying photographic contrast, and with the serious effect on stellar magnitude of the curvature of telescopic fields. And finally, nearly all discussions of the problem heretofore have ignored the lack of radial symmetry.

In general, the frequency of giant stars, except near the centre, is (roughly) inversely proportional to the fourth power of the distance from the centre for most of the typical globular clusters; the laws of distribution of fainter stars are even less definitely known. Beyond this we cannot go at present.

The distribution of stars in galactic clusters is too varied for any general statement beyond noting a frequent centralization; probably the distribution is here not very significant because these loose and irregular systems have been much distorted by the perturbations of the galactic stars among which they move.

5. **Variable Stars in Clusters.**—After a few sporadic discoveries of variable stars in the globular clusters had been made, S. I. Bailey turned his attention to the problem in the last years of the 19th century, making use of photographs taken with the 13-in. and 24-in. refractors of the Harvard Observatory. Bailey's work revealed literally hundreds of variable stars in the score of clusters he closely examined. In some globular systems one star out of six, among the giant stars, proves to be periodically variable (*see* p. 334); whereas in other clusters of practically the same appearance, brightness and concentration, no variable stars are found. Bailey's work on the variable stars shows them to be typically of the short period Cepheid class; a few Cepheids with periods greater than one day were found among the stars of the clusters, and a few irregular variables, but the overwhelming majority belong to that subtype of Cepheid which is now known as the cluster type variable. In ω Centauri Bailey finds three subclasses of cluster type stars, distinguished by the shapes of the light curves and the lengths of the periods. The most common, subclass *a*, has a period of about thirteen hours on the average, and this type appears most commonly in other globular clusters. The median magnitudes of all the variables

in a given cluster are essentially the same, whatever the subtypes or the range of variation. The difference in the observed median from cluster to cluster is probably due wholly to the different distances, the median absolute luminosity thus being the same everywhere, and apparently a constant of nature peculiar to the cluster type Cepheid.

In the galactic clusters there are as yet no known variable stars, the three or four possible cases on record being as readily attributed to the galactic foreground and background as to the cluster system itself.

Bailey's classical work on variable stars in clusters has recently been considerably extended through the discoveries and studies with large reflecting telescopes by Shapley and assistants at the Mount Wilson and Harvard Observatories, and by W. Baade and J. Larink at the Bergedorf Observatory, Hamburg.

Variable Stars

Name of cluster	Number of stars examined	Number of variables	Proportion variable
47 Tucanae . . .	2,000	6	0·003
Dunlop 62	675	14	·021
Messier 79	200	5	·025
ω Centauri . . .	3,000	128	·043
Messier 3	900	162	·180
Messier 5	900	85	·094
Messier 13	1,000	4	·004
Messier 62	960	26	·027
Messier 22	1,550	16	·010
Messier 15	900	51	·057

6. **The Distances of Globular Clusters.**—The relation between apparent brightness and period for Cepheids in the Small Magellanic Cloud, found by Miss Henrietta Leavitt, was generalized by Shapley with the aid of galactic Cepheids and the variables of the globular clusters. The "period-luminosity" curve, which relates the absolute magnitude (intrinsic luminosity) of the Cepheid variable to the logarithm of its period, was thus derived. The zero point of the curve was fixed with the aid of the nearer galactic Cepheid variables, for which the distances and absolute magnitudes were determined from studies of their motions.

The period-luminosity curve permits the determination of the intrinsic luminosity, and therefore of the distance, of any Cepheid variable when the period of its variation and its apparent brightness are measured. With its use, not only are the distances and distribution in space of the galactic Cepheids readily deduced, but also, of more importance, the distances of all the globular clusters, or other stellar systems, which contain Cepheid variables are simply derived. When the distances of clusters containing Cepheids have been obtained, the distances can be inferred also for the clusters devoid of variables, because of the apparently inherent similarity of all globular systems in linear size, total luminosity, and in the real brightness of their most luminous stars. The observed angular sizes and apparent magnitudes thus become indicators of distance. Applications of these principles by Shapley (1917) (later revised by Shapley and Miss Sawyer [1928]), have led to a determination of the distances and distribution in space of all known globular clusters. Uncertainties may arise through the absorption of light in space, the dissimilarity of globular clusters in the characteristics used in estimating distances, the errors in the apparent magnitudes of the variable stars and other stars in the faint clusters which are hard to measure, and, finally, through error in the determination of the zero point of the period-luminosity curve. The last contributes the most serious possibility of systematic error, but the current work at various observatories on the distances and luminosities of the brighter galactic Cepheids will soon remove the difficulty, and provide accurate calibration of the period-luminosity curve.

The studies of the colours of stars in distant clusters have shown conclusively that no absorption of light in space that is proportional to the wave length of the light is measurable, except in localized regions; and the inference is probably safe that except in special nebulous regions space is clear of matter that seriously obstructs or scatters light.

The studies of variable stars in distant clusters, using photographic plates sensitive to blue and yellow light, led to the measurement with surprising accuracy of the relative velocity of light of different wave lengths. It was found that light waves differing twenty-five per cent in length travel in space with identical velocity, the probable error of the determination not exceeding one part in ten thousand million. This accuracy is possible solely because of the enormous distances of globular clusters.

Though subject to the uncertainties mentioned above, the distances of the clusters, derived as indicated, are now generally accepted. The one hundred known systems range in distance from 15,000 to nearly 200,000 light years. Their concentration to the Milky Way indicates that they are a part of the general galactic system, and in fact their distribution has been generally taken to outline the form and extent of the Galaxy. The diameter of the system of globular clusters is of the order of two hundred thousand light years; the centre of the system lies in right ascension $17^h\ 30^m$, south declination 33°, near the junction of the constellations Ophiuchus, Scorpio, and Sagittarius. The distance from the earth to the centre of this system is of the order of fifty thousand light years.

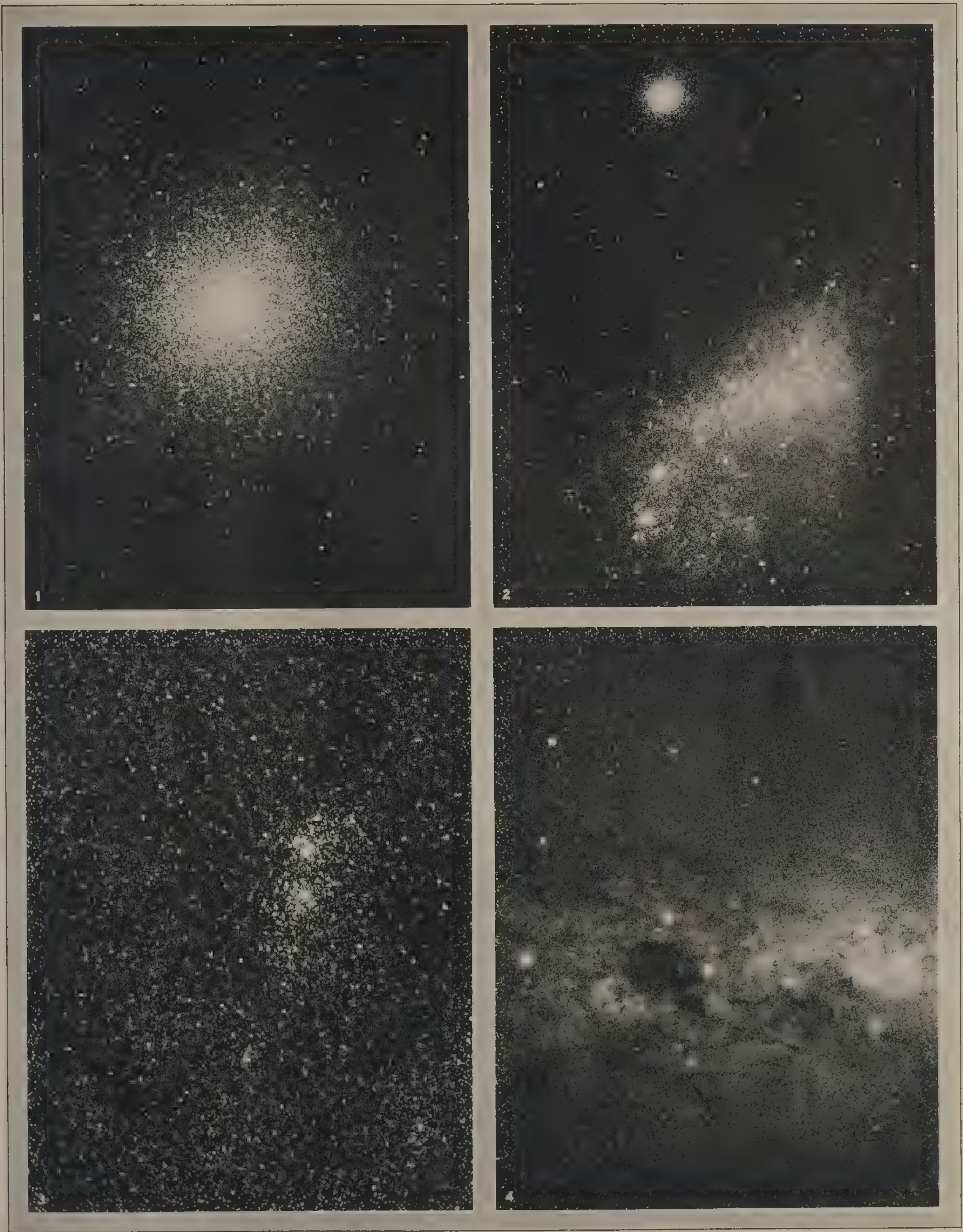
The linear diameter of the average globular cluster is between one and two hundred light years, not counting its most outlying members. The density of stars, therefore, near the centre is uncommonly high compared with the density in the solar neighbourhood, for a cluster's population probably exceeds 100,000.

For the galactic clusters, the distances are not as yet satisfactorily determined. The absence of Cepheid variables, and the irregularity and diversity of form and population, leave us with very indirect methods of estimating their distances or the luminosities of their stars. From preliminary results we know that most galactic clusters are but a few hundred or a few thousand light years distant. It is probable that the more distant galactic clusters are lost to observation through being indistinguishable in the rich Milky Way star clouds.

The velocities of a number of the globular clusters, measured for the most part at the Lowell Observatory by V. M. Slipher, lie mainly between one hundred and three hundred kilometers a second—much higher than the velocities of most classes of stars. The proper motions are as yet practically unattainable because of the great distances of the clusters. The radial velocities of galactic clusters, so far as determined, are of very moderate amount, and the motions appear to be parallel to the galactic plane.

7. **The Rôle of Clusters in Cosmogony.**—The centre of the system of globular clusters can be accepted in the first approximation as the centre of the Galaxy; and the extent of the system of clusters indicates at least a minimum for the size of the galactic system. It has been shown in recent years that the same centre is indicated, but with less certainty, by other highly luminous objects—the novae, the galactic Cepheids, the planetary nebulae, as well as by the distribution and density of galactic star clouds. Furthermore, there is evidence from the motions of stars in the solar neighbourhood that the whole galactic system rotates about this same centre in the southern Milky Way. Apparently, therefore, the globular clusters lead to a conception of an enormously large stellar system in which the solar system is eccentrically situated. The condensation of stars in the solar neighbourhood appears to indicate only that the sun is near the centre of a local cloud or system.

The total number of luminous stars in the Galaxy is probably not less than fifty thousand million. Of this number a relatively small proportion is involved in the now recognized globular and galactic clusters. But there is some evidence supporting the hypothesis that the star clouds throughout the Milky Way are largely composed of disintegrating clusters. The possibility that the galactic clusters represent the remnants of globular systems that have been dragged into the Milky Way star fields and dismembered, is advocated by Shapley, P. ten Bruggencate, and others. J. H. Jeans suggests that the globular clusters may represent groups that have escaped from the Milky Way, or at least are keeping clear of its disintegrating tendencies. The solution of the problem does not seem hopeless, given enough observations and



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EXAMPLES OF GLOBULAR AND GALACTIC STAR CLUSTERS

1. Globular star cluster, M 13, in Hercules. 2. Small Magellanic Cloud, below, and globular cluster 47 Tucanae, above. 3. Double star cluster in Perseus. 4. Section of the southern Milky Way showing the globular cluster (ω) Centauri in the upper left-hand corner. The dark nebula in the centre is the "Coal Sack." Directly north-west of the "Coal Sack" and consisting of four stars, is the constellation of the Southern Cross

thought; and at any rate the various clusters seem to be intimately connected with the star clouds of the Milky Way and with the genesis and future development of this largest of all known galaxies.

The most important problems immediately ahead of the investigator of star clusters appear to be (1) the question of the relative frequency of dwarf stars, to be answered by study of the faintest attainable stars in the nearest globular star clusters with the greatest reflecting telescopes; (2) the stability of globular clusters in traversing stellar and nebular fields (a problem already partially solved by Jeans); (3) the abnormal and connectant type of globular clusters; (4) the spectral composition of clusters, compared with that of galactic star fields and the Magellanic Clouds; (5) further study from many standpoints of the variable stars in clusters. These problems indicate the many points where star cluster investigations touch on questions of stellar evolution as well as on the measurement of the Galaxy.

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STAR-FISH. This name covers three classes of the echinoderms, namely sea-stars or Asteroidea, brittle-stars or Ophiuroidea, and feather-stars or unstalked Crinoidea. (*See* Echinoderma, figs. 1, 2 and 4.) The Asteroidea and Ophiuroidea are free-moving and live mouth downwards like sea-urchins; thus they differ from Crinoidea, which are normally attached by a stalk, and live mouth upwards. (*See* Echinoderma.)

The Sea-stars, to which the name "star-fish" is often restricted, include many different forms, but the common cross-fish or five-finger (*Asterias rubens*) of British seas, or *A. vulgaris* from America, may be taken as typical. The animal consists of a central body and five (occasionally 4, 6 or 7) arms, not clearly marked off from it. The upper surface is covered with a leathery skin, in which are little plates of carbonate of lime, many bearing prickles and small pincer-like pedicellariae. (*Cf.* Sea-Urchin.) For further details of structure, *see* Echinoderma. A sea-star can crawl over any surface by means of its sucking-feet, and can squeeze its supple body through incredibly narrow crevices. The rate of progress is about 6 in. a minute. The but-thorn (*Astropecten*) has no suckers, and creeps over hard sand on its pointed podia. Cushion-stars are stiff, swollen, five-sided forms. The smallest British sea-star (*Asterina gibbosa*) is of this shape; its near relation, the bird's-foot star (*Palmipes*) is flat and thin. Sun-stars (*Solaster*) are remarkable for the number of arms, which may exceed 30.

Sea-stars are the scavengers of the sea, but unfortunately do not confine their attentions to decaying matter; they eat oysters, clams, mussels, barnacles, sea-snails, worms, crustaceans and even smaller sea-stars. No less than 42,000 bushels of sea-stars were removed from the oyster-beds of Connecticut in a single year; they had worked damage to the amount of $631,500. The simplest way in which a sea-star eats is by using its podia to pass small bits of food into the stomach, and ejecting the refuse through the mouth. But when the food is large, the sea-star finds it more convenient to turn its stomach inside out, and wrap it round the prey, which is then digested quickly and the stomach withdrawn again. In attacking oysters and similar bivalves, the sea-star first has to open them; this it does by fixing the suckers of one or two arms to one valve, and those of the opposite arms to the other, while it may get a purchase by also holding on to neighbouring objects. It then begins to straighten out its rays. The oyster can withstand a strong pull, but not a long pull, and the sea-star does not hurry. At last the oyster gives way, and the sea-star has its reward; its companions often join in, and a whole rolling ball of them may be seen interlaced round half-digested molluscs. Sea-stars begin to eat voraciously when quite young; one less than ⅜ in. across ate over 50 young clams of half that length in six days. A sea-star may become sexually mature in less than a year, then producing many thousands of young. Increase is kept in check by many causes. The free-swimming larvae are swallowed in millions by fish. When they settle down on sea-weed their bright colours attract eels and many small fishes. Later in life they are attacked by parasites, while those that stray into shallow water are eaten by gulls, crows and even foxes. Freshets and cold currents are also destructive. Probably the best way in which man can keep down the numbers is by dredging the seaweed a month after midsummer when covered with young; a single cartload thrown on shore would capture many millions. At a later stage tangles of hemp or cotton waste may be dragged over oyster-beds, when the sea-stars will cling to them by their pedicellariae. They make excellent manure. Fishermen who catch them often tear them in half and throw them back into the sea. Some of these mutilated animals may, however, grow fresh arms, and thus one may find a sea-star with one large arm and four small ones, the whole shaped like a comet.

The Brittle-stars or Ophiuroidea ("snake-tails") differ from sea-stars in moving almost entirely by means of their arms. (*See* Echinoderma, fig. 2.) Thus the arms are sharply marked off from the disc-like body, to which digestive and generative organs are confined. Brittle-stars proper have long wriggling arms, fringed with prickles, with which they can progress more than two yards a minute. If seized, they break off their arms, which continue breaking into smaller pieces; but the body soon grows new ones. Sand-stars have shorter, stouter arms, with prickles closely pressed to the sides; they progress by a rowing movement. Sand-stars and brittle-stars abound in the shallow waters of all seas, especially in the tropics. By constantly sweeping their arms over the sea-floor they gather in minute animals as food. They eat the bait of fishermen, and their fish as well if they find any already dead; but they are themselves a food of many fishes, notably cod. Basket-fish or medusa-heads are ophiuroids whose arms branch several times, their ends curling and interlacing round some marine object. They live in deeper water and are often brought up clinging to fishermen's lines.

The Feather-stars (Unstalked Crinoidea) are distinguished as Comatulida ("hair-stars") from various other crinoids that have at earlier periods of the world's history lost their stem. A typical form is the rosy feather-star (*Antedon bifida*). (*See* Echinoderma, fig. 4.) The stalk is not really absent, but reduced to a knob, from which spring numerous hooked tendrils (cirri); by these the animal clings to some object on the sea-bottom. From the body stretch five arms, each bifid (in other species they may fork more than once) and fringed with small branches (pinnules) giving a feathery appearance. Along these arms and pinnules, grooves pass from the central upturned mouth (Echinoderma, fig. 7), and the minute hair-like cilia that line them constantly sweep towards the mouth a stream of water, from the microscopic organisms in which the crinoid extracts nourishment. *Antedon* crawls by pulling and pushing with its arms, and swims, or rather treads water, by raising and depressing alternate branches. The ancestors of the feather-stars in the Jurassic period still had a stem in the adult. Since that period feather-stars have increased in number and variety, so that to-day they occur in all salt seas at all depths, often in enormous quantities, and are classified in 98 genera. (F. A. B.)

Bibliography.—For special works with bibl., *see* Echinoderma.

STARGARD, a town in the Prussian province of Pomerania, situated on the left bank of the navigable Ihna, 20 m. E. of Stettin on the railway to Danzig and at the junction of lines to Posen, Schneidemühl and Cüstrin. Pop. (1925) 32,575. Stargard, mentioned as having been destroyed by the Poles in 1120, received civic rights in 1229, and became the capital of eastern Pomerania. As a Hanseatic town it enjoyed considerable commercial prosperity, but it had also to undergo siege and capture in the middle ages and during the Thirty Years' War.

STARK, JAMES (1794–1859), British painter, was born in Norwich on Nov. 19, 1794, and at the age of seventeen was articled to John Crome for three years. He died in London on March 24, 1859. Between 1831 and 1859 most of his pictures were shown at the Royal Academy. He undertook in 1827 the publication of a work on *The Scenery of the Rivers of Norfolk,* which was completed seven years later; the illustrations he prepared for it have much topographical and artistic interest. His painting "The Valley of the Yare," is in the National Gallery of British Art.

STARK, JOHANNES (1874–), German physicist, was born April 15, 1874 at Schichenhof in Bavaria and studied at the University of Munich. In 1900 he became an assistant at the University of Göttingen. He went as professor in 1907 to the Technische Hochschule at Aix-la-Chapelle, in 1917 to Greifswald and in 1920 to Würzburg; he retired in 1922. Stark devoted himself principally to the study of the modern theory of radiation and the atomic theory. He discovered the Doppler effect in parallel rays, for which the Vienna Academy awarded him the Baumgartner Prize. Later he discovered the Stark effect, named after him, and in 1919 was awarded the Nobel Prize for Physics. He wrote numerous essays on physical problems, including the *Prinzipien der Atomdynamik,* in 3 parts (1910–5); *Die elektrischen Quanten, Die elektrische Strahlung, Die Elektrizität in Gasen* (1902) and *Die Dissociierung und Umwandlung chemischer Atome* (1903). He was the founder of the *Jahrbuch der Radioaktivität und Elektronik* (1904), which he edited until 1919.

STARK, JOHN (1728–1822), American soldier, was born at Nutfield, now Londonderry, N. H., on Aug. 28, 1728. During the Seven Years' War he served under Robert Rogers, first as a lieutenant and later as a captain. At the beginning of the Revolutionary War he raised a regiment and as colonel did good service in the Battle of Bunker Hill, the Canadian expedition, and Washington's New Jersey campaign in the winter of 1776–77. In March 1777 he resigned his commission. Later in the year, he was placed in command, with the rank of brigadier general of militia, of a force of militiamen, with whom, on Aug. 16, near Bennington, Vt., he defeated two detachments of Burgoyne's army. For this victory, which did much to bring about the capitulation of Gen. Burgoyne, Stark received a commission as brigadier general in the Continental army (Oct. 4, 1777). He took part in the operations about Saratoga, and for a short time was commander of the northern department. In Sept. 1783 he was breveted major general. He died at Manchester, N. H., on May 8, 1822.

See *Memoir and Official Correspondence of General John Stark* (1860) by his grandson Caleb Stark.

STARK EFFECT: *see* QUANTUM THEORY; LIGHT.

STARLEY, JAMES (1830–1881), British inventor, the son of a farmer, was baptized at Albourne, Sussex, on June 13, 1830. In 1857 he started in Coventry the manufacture of the "European" and other sewing machines from his patents. In 1868 he began the manufacture after a Paris model and at first for French use, of bicycles, several of the earliest suggested improvements being Starley's. A number of firms were soon devoting themselves exclusively to the manufacture of bicycles, and for one of these Starley designed the Coventry tricycle. As it was harder to propel than the bicycle, he invented the balance gear, and applied it in the Salvo tricycle. Starley died on June 17, 1881. His nephew, J. K. Starley, patented the tangent wheel in 1874.

STARLING, ERNEST HENRY, F.R.S. (1866–1927), English physiologist, eldest son of H. H. Starling, Clerk of the Crown at Bombay, was born in London, 1866. Educated at King's College School; entered Guy's Hospital in 1882 and graduated M.D. in 1890. He never practised as a physician and in the same year he was appointed lecturer in physiology at Guy's. In 1900 he became Jodrell professor of physiology at University College, London, where he continued to work throughout his life, although, in 1922, he retired from the Jodrell Chair and was appointed Foulerton research professor of the Royal Society.

Starling was one of the foremost physiologists of his age. The subjects for investigation which particularly attracted him were those physiological processes which seemed capable of interpretation in terms of chemistry and physics. The conditions determining transudation from the vessels and lymph flow occupied his attention for some years and he showed that the hydrostatic and osmotic pressures within the vessels supplied the balance of force necessary to explain the hitherto perplexing experimental facts. His researches on the movements of the intestines, undertaken in conjunction with Bayliss (*q.v.*) demonstrated the neuro-muscular mechanisms involved and reduced the previous chaos to order. Their discovery of "secretin" not only laid bare the way in which the secretion of the pancreas was called forth and adjusted, but stimulated further research on the chemical integration of the body functions, since so profitable. By ingenious methods of experimentation he was successful in maintaining the mammalian kidney, isolated from all connection with the body, in a state of functional activity and thereby to bring to light new and fundamental facts concerning renal secretion. Starling's most important researches were, however, those dealing with the heart and circulation. Together with many other important discoveries on the physiology of the circulation, he demonstrated the mechanism by which the heart is able to automatically increase the energy of each contraction in proportion to the mechanical demand made upon it and, apart from the nervous system, to adapt its work in accordance with the needs of the body. No one physiologist has so greatly advanced knowledge of the heart's action since the discovery of the circulation by Harvey 300 years ago.

During the World War, he became director of research at the R.A.M.C. College and engaged in devising defensive methods against poison gas. Subsequently, 1917–19, Starling rendered valuable national service as chairman of the Royal Society Food Committee, scientific adviser to the Ministry of Food and British scientific delegate on the Inter-Allied Food Commission.

STARLING (*Sturnus vulgaris*), a bird common throughout northern Europe and Asia and also found in India. About the size of the thrush, the starling has a plumage of black, beautifully glossed with purple, green and steel-blue and having each feather tipped with buff. The starling is an omnivorous feeder, but, where numerous (as in Britain), it must undoubtedly be numbered among the injurious species. It gathers in enormous flocks in the autumn to roost in reed-beds, and such a flock on the wing is a memorable sight, their simultaneous turns in the air being very remarkable. Of late years, it has taken to roosting in increasing numbers on large buildings in London and other towns. The song of the male is cheerful and varied, if not very beautiful, and the bird's disposition is bustling and lively. It nests in holes in trees, which it frequently appropriates from a woodpecker, or in buildings. The eggs, four to seven in number, are a pale blue-green. As the young grow, they become extremely noisy. The starling was introduced into New York city in 1890. It spread rapidly in New York and adjoining States.

It has caused a decrease in many native hole-breeding birds by usurping the available nest sites. Allied species occur in the Mediterranean, Kashmir, Persia and Armenia.

The related genus *Pastor* includes the beautiful rose-coloured starling (*P. roseus*), a bird of irregular and erratic habits, arriving in incredible numbers in unexpected places to breed—usually in a district where locusts are becoming or have become excessively abundant. The plumage is rose-pink and black.

STARNBERG, a village and climatic health resort of Germany, in the republic of Bavaria, on the Starnberger See, 16 m. S. from Munich by rail. Pop. (1925) 4,838. It has an old castle (now government offices). The Starnberger See (or Würmsee) is a lake with a length of 12 m., a breadth of 3 m., and covering 23 sq.m. Its greatest depth is about 400 ft. On the Roseninsel, an island in the lake, remains of lake dwellings were found.

See Ule, *Der Würmsel in Oberbayern* (Leipzig, 1901).

STAR-NOSED MOLE (*Condylura cristata*), a North American species. In habits it resembles the European mole, but is distinguished by the presence of a ring of tentacles, probably tactile, round the nostrils. (*See* INSECTIVORA.)

STARODUB, a town of Russia in the Bryansk province in 52° 35′ N., 32° 45′ E. It is the terminus of a branch railway, and three telegraph lines radiate from it. Pop. (1926) 10,919. Russian princes contended with one another for it in the 11th and 12th centuries. It was destroyed by the Mongols in the 13th century. In the 15th and 16th centuries the Russians and Lithuanians struggled for it; it became a Polish stronghold in the 17th century, but was handed over to Russia in 1686.

STARVATION, the state of being deprived of the essentials of nutrition, particularly of food (*see* HUNGER AND THIRST).

In starvation those tissues which are of the greatest importance to the economy are nourished at the expense of less important tissues. Thus the brain and spinal cord lose only 3 per cent of their weight in a hunger period during which fat loses 96 per cent. From the behaviour of the respiratory quotient in starvation it is clear that the wastage of muscle and other proteins is due to endeavours to keep up the body temperature at its normal level. Experimental starvation, even though food be entirely withheld is not accompanied by any great alteration in body temperature until starvation has been going on for perhaps three weeks.

STAS, JEAN SERVAIS (1813–1891), Belgian chemist, was born at Louvain on Aug. 21, 1813. He first studied medicine, and then worked in the Paris laboratory of J. B. A. Dumas (*q.v.*) whom he assisted in the redetermination of the atomic weight of carbon and in other work. From 1840 to about 1865 he was professor of chemistry at the École Royale Militaire at Brussels. He died at Brussels on Dec. 13, 1891.

Stas's name is best known for his determination of the atomic weights (*q.v.*) of a number of the more important elements. His work in this field, for which the Royal Society awarded him a Davy medal in 1885, was marked by extreme care. In connection with a poisoning case in 1850, Stas worked out a method for the detection of the vegetable alkaloids, which, modified by Friedrich Julius Otto (1809–1870), professor of chemistry at Brunswick, has been widely used by toxicologists as the Stas-Otto process.

Stas' papers on atomic weights were collected in *Recherches sur les Rapports réciproques des Prids Atomiques* and in *Nouvelles Recherches sur les Lois des Proportions Chemiques.*

STASINUS, of Cyprus, according to some ancient authorities the author of the *Cypria* (in 11 books), one of the poems belonging to the epic cycle. Others ascribed it to Hegesias of Salamis or even to Homer himself. The *Cypria* contains an account of the events leading up to the Trojan war, such as the judgment of Paris and the rape of Helen. It is probable that the list of the Trojans and their allies (*Iliad*, ii. 816–876), which formed an appendix to the catalogue of the Greek ships, is abridged from that in the *Cypria*. Proclus, in his *Chrestomathia* gave an outline of the poem (preserved in Photius, *cod.* 239).

See F. G. Welcker, *Der epische Cyclus* (1862); D. B. Monro, Appendix to his edition of *Odyssey*, xiii.–xxiv. (1901); T. W. Allen, "The Epic Cycle," in *Classical Quarterly* (Jan. 1908, *sqq.*); and CYCLE.

STASSFURT, a town in the Prussian province of Saxony, and one of the chief seats of the German salt-producing industry; on the river Bode, 20 m. S.W. of Magdeburg by rail to Aschersleben. Pop. (1925) 16,136. The systematic exploitation of the salt-beds to which the town owes its prosperity, dates from 1856 only. Besides the rock-salt, the saline deposits yield deliquescent salts and other saline products, which have encouraged the foundation of numerous chemical factories. For about 50 years prior to the World War the bulk of the potash used throughout the world originated in the Stassfurt mines. The deposit underlies an area of about 100 sq.m. and is the largest body of soluble potash known. Production continues to be heavy, although Germany's monopoly is no longer complete.

STATE: *see* SOVEREIGNTY.

STATE, ACT OF, the plea of "act of state" in English law means primarily a defence raised by the Crown on behalf of a servant of the Crown, who is sued in the English courts for some wrongful act ratified by the Crown. In this sense the plea is not recognized by the English courts who, in rejecting it, have uniformly held that, as the King cannot do a wrong so also "it follows that the King cannot authorize a wrong." The only exception to this rule is in the case of a wrongful act done to an alien who, in such a case cannot sue (*Buron* v. *Denman* [1848] 2 Ex. 167) if the act was done outside British territory and was ratified by the Crown, but it has recently been held in *Johnstone* v. *Pedlar* 90 L.J.P.C. 181 that if the act complained of was done to him in British territory he has the same right to sue as a British subject and the defence of "act of State" is, in that case, equally inapplicable. But the term is also used in another and less questionable sense. It will be entertained by English Courts where the acts in respect of which an action is brought are "transactions of independent States between each other," such as those arising out of the execution, or non-execution, of a treaty, the succession of the Crown to a foreign territory by cession or conquest, and the like. For example, a concession granted by the chief of native territory is not enforceable whether by Petition of Right or otherwise in British Courts by the grantees against the Crown, on succeeding to the territory by annexation (*Cook* v. *Sprigg* [1897] A.C. 572). So too the contractual obligations incurred, whether towards a British subject or an alien, by a foreign state are not binding on the Crown, after its conquest and annexation by the Crown, unless the Crown expressly elects to adopt them (*West Rand Gold Mining Co.* v. *the King* [1905] 74 L.J.K.B. 753); for annexation is an "act of State" of an international character. In such cases the title of the subject has originated with a foreign Government, not with the Crown. If the contract or concession in question had originally been made by the Crown itself, it would be another matter. Even in the case of a British Protectorate the Crown may plead "act of State" as a defence to claims in respect of expropriation of native territory because the Crown in such a case is acting in territory which is not British (*see* the recent case of *Sobhuza II.* v. *Miller* [1926] A.C. 518). So too claims arising under a treaty are not enforceable against the Crown unless and until the Treaty, which is an international act, becomes part of English municipal law by being incorporated in a statute. The negotiation of the Treaty is an "act of State" into which, and its meaning, the Courts cannot enquire. In this sense the declaration of war and the making of peace by the Sovereign is also an act of State. As Lord Somer put it in *Johnstone* v. *Pedlar* (Op. cit. at p. 794) "Municipal Courts do not take it upon themselves to review the dealings of State with State and Sovereign with Sovereign." On the other hand the mere fact that some act, wrongful *per se* in English law, was done in execution, or alleged execution, of a treaty made by the Crown against the person or property of a British subject is a defence that would never be entertained by the courts in action against a servant of the Crown, for, while a treaty cannot confer new rights, enforceable at law, upon a British subject, neither can it deprive him of any of his existing rights under English law. This was specifically laid down in *Walker* v. *Baird* [1892] A C. 491 where in an action for trespass an officer of the Crown put in the plea of "Act of State" in that he was acting in the execution of a Convention with the French Government.

AUTHORITIES:—Sir W. Harrison Moore, *Act of State in English Law;* Bellot's edition of Pitt Cobbett's *Cases and Opinions in International Law.* (J. H. Mo.)

STATE, DEPARTMENT OF: *see* GOVERNMENT DEPARTMENTS.

STATEN ISLAND, an island constituting the borough of Richmond, New York city, and Richmond county, the southernmost of the counties of the State of New York. It is separated from Long island on the east by the Narrows which connects upper and lower New York bay, from New Jersey on the north by the narrow channel of Kill van Kull which connects New York bay with Newark bay; and from New Jersey on the west by the narrow channel of Arthur Kill. On its south-east coast are lower

New York, Raritan and Prince's bays, Great Kills, and the Atlantic ocean.

Triangular in shape, it is 13½m. long from north-east to south-west, has a maximum width of nearly 8m. at its north end, and has an area of 57sq. miles. The north-east quarter is broken by two ranges of hills having a precipitous east slope and rising to a maximum height of about 400ft., 1m. inland from the Narrows; but on the west and south the hills fall gently to the coastal plain, which, occupying the greater part of the island, is broken only by low morainal ridges and terminates in salt marshes along much of the west coast. There are many species of forest trees and more than 1,300 species of flowering plants and ferns.

The population in 1910 was 85,969; in 1920, 116,531. The north shore, including New Brighton, West New Brighton and Port Richmond, is largely given over to industrial development. In 1927 the local chamber of commerce listed 252 industrial establishments, employing 20,320 persons, with a capital investment of more than $93,000,000, and a product valued at $103,000,000. There are shipyards, bakeries, lumber mills, printing and publishing houses, and factories for the manufacturing of clothing, soap, linoleum, fertilizer, fireworks and other products. The chief residential communities lie along the easterly shore, from St. George south to Ft. Wadsworth. Tottenville, on the south-west tip of the island, is both a residential and industrial district. South and Midland beaches below the Narrows are popular seaside resorts.

The Staten Island Rapid Transit Railway furnishes electrified passenger service along the north and easterly shores. The north shore branch of this railroad, with a terminal at St. George, is the New York terminus of the Baltimore and Ohio Railroad for the handling of freight. The island is connected by ferry with the boroughs of Manhattan and of Brooklyn, and vehicular bridges, completed in 1928, connect the south shore with Perth Amboy (N.J.) and Howland Hook, Staten island, with Elizabeth (N.J.). A third bridge, connecting the north shore with Bayonne (N.J.), is scheduled for completion in 1932; until that date ferries will continue to operate between these two points. The island has 21 deep-water steamship piers, 1,200ft. in length, equipped with modern freight handling devices, and within the free lighterage district of New York city. In March 1929 steps were taken for the construction of a tunnel at the Narrows to connect the island with Brooklyn.

When discovered by Europeans, Staten island was occupied by the Aquehonga Indians, a branch of the Raritans. Several Indian burying-grounds and many Indian relics, including a stone head with human features, have been found here. In 1630 the Dutch West India Company granted the island to Michael Pauw as a part of his patroonship of Pavonia, but Pauw sold his title back to the company without establishing a settlement and in 1636 a portion of it was regranted to David Pietersen de Vries, the remainder being erected into a patroonship and granted to Cornelis Melyn. In 1641 de Vries established a settlement at Oude Dorp (Old Town), near South Beach, but after its destruction by the Indians in 1655 it was abandoned. In 1658 a company of Waldenses settled at Stony Brook, about 2m. W. of the ruins of Oude Dorp, and this was the principal village for many years.

In 1664 when the duke of York became proprietor of the newly erected province of New York he granted Berkeley and Carteret all that portion of his province which lay west of the Hudson river, thus making Staten island a part of New Jersey. In 1668, however, the duke decided that all islands within New York bay which could be circumnavigated in 24 hours should be adjudged to New York. Capt. Christopher Billopp making the trip within the time limit, he was granted 1,163ac. of the south end of the island which became the manor of Bentley. The manor-house, built about this time, is still standing in the village of Tottenville. In this house Lord Howe on Sept. 11, 1776, held a peace conference with Benjamin Franklin, John Adams and Edward Rutledge representing the Continental Congress. From July 3, 1777, until the close of the Revolutionary War, Staten island was held by the British. In the War of 1812 Ft. Richmond was built at the Narrows and Ft. Tompkins in the rear of it. The Federal Government bought the site in 1847 and after destroying the old forts began the erection of the present Ft. Wadsworth and Tompkins, which constitutes one of New York's strongest defences. In 1898 Staten island became the borough of Richmond in Greater New York.

See J. J. Clute, *Annals of Staten Island* (1877); R. M. Bayles, *History of Richmond County* (1887); and I. K. Morris, *Memorial History of Staten Island* (1898–1900).

STATE RIGHTS, a term used generally in political science to denote those Governmental rights which belong to the individual States of a Federal union, there being a certain sphere of authority in which these individual States may act without interference from the central Government. Thus in the United States there were certain rights reserved to themselves by the States when forming the union under the Constitution of 1787. These rights the central Government is by fundamental law bound to respect, and they can be reduced only by amendment to the Constitution. For 1,000 years the various German States were so jealous of any curtailment of their individual rights as to prevent the formation of an efficient Federal Government. In Federal unions, such as Mexico and Brazil, where a central authority existed first and created the States, the belief in State rights is much weaker than it is in unions composed of originally independent States. The rights of a State are said to be delegated when, as in Mexico, Brazil and Colombia, the Constitution is created by a central national authority which also makes the States; State rights are residuary when independent States unite to delegate by a constitution certain powers to a central Government, as in the case of the United States, Switzerland and, until 1905, Sweden-Norway. History shows that States forming unions of the second class are certain in aftertime to deny or assert that the sovereignty of the State is one of the rights reserved, according as the State belongs to a stronger or weaker section or faction; State sovereignty being the defence of the weaker State or faction, and being denied by the stronger group of States which controls the Government and which asserts that a new sovereign State was created by a union of the former independent ones. This dispute is usually ended by civil war and the destruction of State sovereignty. The evolution of State rights as shown in the history of the United States is typical. Thirteen independent States formed a Union in 1787 under a Constitution reserving certain rights to the States. The sphere of the State authority embraced most of the powers of government, except, for instance, those relating to foreign affairs, army and navy, interstate commerce, coinage and the tariff; the powers of the central Government were specified in the fundamental law. Most of the States claimed at one time or another that sovereignty was one of the reserved rights of the States and on this theory the Southern States acted in the secession in 1861. The war that resulted destroyed all claims of State sovereignty. The other rights of the States consisted of those not delegated to the central Government or forbidden to the States by the Constitution. In case of doubt the presumption was in favour of the State. Since the beginning, however, the central Government has gained strength at the expense of the States, seldom by direct usurpation (except during the Civil War and Reconstruction, 1861–76), but indirectly through use and custom, as the country and people developed and new conditions of government arose. The field of State rights has not increased, while centralization has slowly but surely taken place. The central authority in the United States, formerly affecting the average citizen but little, now touches him in many of the activities of life and sometimes intrudes even into the domain of local self-government. The history of the decay of State rights makes it seem doubtful if the Federal form of government is a permanent one, or is only a transient form between independent State Governments or loose confederacies and a centralized national Government.

See U.S. Library of Congress "List of References on centralization in the U.S. Government including State Rights," *Select List of References* No. 947 (1926); Woodrow Wilson, *The State* (1900 and later eds.); A. H. Stephens, *Constitutional View of the War Between the States* (Philadelphia, 1868–70); A. L. Lowell, *Governments and Parties in Continental Europe* (Boston, 1896); and H. P. Judson, *Our Federal Republic* (1925).

STATE'S EVIDENCE, the term used in the United States for evidence given by an accomplice upon promise of pardon.

STATES-GENERAL, the English translation of (1) the *états-généraux* of France and (2) the *staten-generaal* of the Dutch Netherlands. The name in both cases signifies the assembly of the estates of the realm, as distinct from provincial assemblies of estates; it is thus the equivalent of the English parliament, of the Cortes in Spain, or the diet of the Holy Roman Empire, which the states-general resembled in their original constitution.

In France the states-general were first summoned, in 1302, by Philip IV. for the purpose of giving him moral support in his quarrel with Pope Boniface VIII. They consisted of representatives of the three orders of clergy, nobles and commons (*tiers état,* third estate), an arrangement which survived to the end, though their composition, as well as their effective powers varied greatly at different times. For various reasons (notably the Hundred Years' War and the religious wars of the 16th century) they never secured the power over taxation and legislation early obtained by the English parliament, and after 1614 they were never summoned until 1789, when they transformed themselves into the National Constituent Assembly. This Assembly consisted of the representatives of the three orders sitting together, but the states-general had ceased to exist (*see* FRANCE: *History*).

In the Netherlands the convocation of the states-general, consisting of delegates from the provincial estates, dates from about the middle of the 15th century, under the rule of the dukes of Burgundy. The name was transferred, after the separation of the northern Netherlands from the Spanish dominions, to the representatives elected by the seven sovereign provincial estates for the general government of the United Provinces. The states-general, in which the voting was by provinces (each province having one vote) was established from 1593 at The Hague. The states-general came to an end after the revolution in 1795, with the convocation of the National Assembly (March 1, 1796). (*See* HOLLAND: *History.*)

STATES OF THE CHURCH or **PAPAL STATES,** that portion of central Italy which, previous to the unification of the kingdom, was under the direct government of the see of Rome. Their area in 1859 was 16,000·8 sq.m.; their population in 1853 numbered 3,124,758.

With the exception of Benevento, surrounded by the Neapolitan province of Principato Ulteriore, and the small State of Pontecorvo, enclosed within the Terra di Lavoro, the States of the Church formed a compact territory, bounded on the N.W. by the Lombardo-Venetian kingdom, on the N.E. by the Adriatic, on the S.E. by the kingdom of Naples, on the S.W. by the Mediterranean, and on the W. by the grand-duchy of Tuscany and the duchy of Modena. On the Adriatic the coast extended 140 m. from the mouth of the Tronto (Truentus) to the southern mouth of the Po, and on the Tyrrhenian Sea 130 m. from 41° 20′ to 42° 22′ N. latitude. The former papal territories are now comprised within the Italian provinces of Bologna, Ferrara, Forlì, Ravenna, Pesaro and Urbino, Ancona, Macerata, Ascoli-Piceno, Perugia, Rome and Benevento. The question of the origin of the territorial jurisdiction of the pope is treated under PAPACY. With the moral and ecclesiastical decay of the papacy in the 9th and 10th centuries much of its territorial authority slipped from its grasp; and by the middle of the 11th century its rule was not recognized beyond Rome and the immediate vicinity. By the Treaty of Sutri (Feb. 1111) Paschal II. was compelled by the Emperor Henry V. to surrender all the possessions and royalties of the church; but this treaty was soon afterwards repudiated, and by the will of Matilda, Countess of Tuscany, the papal see was enabled to lay claim to new territories of great value. By the capitulation of Neuss (1201) the Emperor Otto IV. recognized the papal authority over the whole tract from Radicofani in Tuscany to the pass of Ceperano on the Neapolitan frontier—the exarchate of Ravenna, the Pentapolis, the March of Ancona, the bishopric of Spoleto, Matilda's personal estates, and the countship of Brittenoro; but a good deal of the territory thus described remained for centuries an object of ambition only on the part of the popes. The actual annexation of Ravenna, Ancona, Bologna, Ferrara, etc., dates from the 16th century. The States of the Church were submerged for a time by the groundswell of the French Revolution, but they appeared again in 1814. In 1849 they received a constitution. On the formation of the kingdom of Italy in 1860 they were reduced to the Comarca of Rome, the legation of Velletri, and the three delegations of Viterbo, Cività Vecchia and Frosinone; in 1870 they disappeared from the political map of Europe. From that time, the popes retired within the Vatican as self-constituted prisoners. This situation was changed by the Lateran treaty between the Holy See and the kingdom of Italy (signed Feb. 11, 1929), which recognized Pope Pius XI. as sovereign of a clearly defined territory, indicated by an annexed map, entitled "the city of the Vatican." Therein the Holy See is recognized as having full and exclusive dominion and sovereign jurisdiction. (*See* VATICAN; PIUS XI.)

STATE SUCCESSION. The extent to which a succession State is bound by the obligations of its predecessor constitutes one of the most difficult problems in international law. The clearest statement is probably that contained in the report of the Transvaal Concessions Commission; *see* Parl. Pap. South Africa, 1901 [Cd. 623]. The principles which the commissioners regarded as applicable to the determination of questions relating to various concessions granted by the Transvaal Government in view of the conquest and annexation of the Transvaal by Great Britain are as follows:—(1) "It is clear that a State which has annexed another State is not legally bound by any contract made by a State which has ceased to exist, and that no court of law has jurisdiction to enforce such contracts if the annexing State refuses to recognize them, see *Cook* v. *Sprigg* (1899) A. C. 572. But the modern usage of nations has tended in the direction of the acknowledgment of such contracts. After annexation, it has been said the people change their allegiance, but their relations to each other and their rights of property remain undisturbed, *U.S.* v. *Pencheman,* 7 Pet. 51; and property includes rights which lie in contract, *Soulard* v. *U.S.*, 4 Pet. 54." Concessions of a mixed public and private character probably continue to exist after annexation until abrogated by the succession State. There would not appear to be any distinction between cession and annexation. Private rights should be respected, but this is based rather on ethics than law. (2) "Though we doubt whether the duties of an annexing State towards those claiming under concessions or contracts . . . have been defined with such precision in authoritative statement or acted upon with such uniformity in civilized practice, we are convinced that the best modern opinion favours the view that as a general rule the obligations of the annexed State towards private persons should be respected. Manifestly the general rule must be subject to qualification, as that an insolvent State could not by aggression which practically left to a solvent no other course than to annex it, convert its worthless into valuable obligations; again an annexing State would be justified in refusing to recognize obligations incurred by the annexed State for the immediate purposes of the war against itself; and that probably no State would acknowledge private rights the existence of which caused or contributed to cause the war which resulted in annexation." (3) The principle to be adopted was that proclaimed by the Prussians upon the annexation of Hanover "we will protect every one in the possession and enjoyment of his duly acquired rights." (4) "The acceptance of this principle clearly renders it necessary that the annexing Government should in each case examine whether the rights which it is asked to recognize have, in fact, been duly acquired. (5) Thus a concession may properly be cancelled when "(*a*) the grant of the concession was not within the legal powers of the late Government, or (*b*) was in breach of a treaty with the annexing State, or (*c*) when the person seeking to maintain the concession acquired it unlawfully or by fraud, or (*d*) has failed to fulfil its essential conditions without lawful excuse." (6) A concession may be cancelled when its maintenance would be injurious to the public interest.

See A. B. Keith, *Theory of State Succession* (1907); Max Huber, *Die Staatensuccession* (1898); Westlake, *Collected Papers;* Pitt Cobbett, *Leading Cases on Intern. Law* Vol. II., 4th ed. (1924).

STATESVILLE, a city of North Carolina, U.S.A., the county seat of Iredell county; 130 m. W. of Raleigh, on Federal highways 21 and 70, and served by the Southern railway. Pop. 7,895 in 1920 (18% negroes); estimated locally at 18,000 in 1928.

The city is in the upper Piedmont section of the State, at an altitude of 960 feet. Statesville was laid out in 1790 as the capital of Iredell county (organized 1788), near old Ft. Dobbs, which was twice defended against the Indians by Daniel Boone. Kit Carson, the Indian scout, was born near the city. During the Civil War Governor Zebulon Vance took refuge in Statesville when Sherman entered Raleigh (April 13, 1865).

STATIC, a term in radio denoting conduction or charging current in an antenna (*q.v.*) resulting from physical contact between the antenna and charged bodies or masses of gas. In America this term is synonymous with atmospherics.

STATICS, the branch of mechanics which discusses the conditions of rest or equilibrium of forces (from Gr. root στα, stand) (*see* MECHANICS).

STATIONARY MACHINERY: *see* FARM (STATIONARY) MACHINERY.

STATIONERY. The word now covers all writing materials and implements, together with the numerous appliances of the desk and of mercantile and commercial offices. The principal articles and operations of the stationery trade are dealt with under such headings as BOOKBINDING; OFFICE APPLIANCES; INK; LITHOGRAPHY; PAPER; PEN and PENCIL.

STATIONS OF THE CROSS, a series of 14 pictures or images representing the closing scenes in the Passion of Christ, viz., (1) the condemnation by Pilate, (2) the reception of the cross, (3) Christ's first fall, (4) the meeting with His mother, (5) Simon of Cyrene carrying the cross, (6) Veronica wiping the face of Jesus, (7) the second fall, (8) the exhortation to the women of Jerusalem, (9) the third fall, (10) the stripping of the clothes, (11) the crucifixion, (12) the death, (13) the descent from the cross, (14) the burial. Sometimes a 15th—the finding of the cross by Helena—is added; on the other hand in the diocese of Vienna, the stations were at the end of the 18th century reduced to eleven. The representations are usually ranged round the church; sometimes they are found in the open air, especially on the ascent to some elevated church or shrine. The normal form of the devotion, which began among the Franciscans, is to visit the stations of the cross wherever represented, and exercise a devout meditation on passing from station to station.

See article "Stations of the Cross" in the *Catholic Encyclopaedia.*

STATISTICS. The name *statistics* was first applied to collections of data relating to matters important to the State, such as the numbers of the population, the yield of taxation, the value of trade carried on within the territory of the State or between that territory and other parts of the world, the mortality from particular diseases and from all causes together, etc., and to the study and interpretation of such data. The data were not at first numerical and later not exclusively numerical, but the precision and convenience of data expressed in numbers, as compared with other forms of statement, have led to the more general cultivation of arithmetical data and to the common use of the term "statistics" as if it related exclusively to data expressed in numerical form. At the same time, the numerical data to which the name "statistics" is generally applied are not limited to such as have some connection with the organization or administration of the State, the methods appropriate to the study of statistics being, broadly speaking, the same whether the data under consideration relate to human communities or are concerned with any other branch of knowledge or investigation.

Statistical Tables.—The simplest way of arranging numerical records is to set them out in tabular form. We may, for example, ascertain the amount of sugar consumed in a given country in each year of a given period. A table may be drawn up in which each line contains the figures for the year the date of which is shown at the beginning of the line. If each line relates to the year next following that dealt with in the preceding line, the sequence of figures of consumption will enable us to determine whether, and at what rate, the yearly consumption of sugar increased in successive intervals of years. The increase of population from year to year observed in most countries is an obvious influence tending to increased use of any popular article of consumption, and it will be advantageous to add, to the figures showing the total consumption of sugar in the country, another series of figures showing the number of persons living in that country in each of the years covered by the table. To the columns containing (1) the dates of the years to which the information relates, and (2) the total amounts of sugar consumed in the respective years, there will thus be added (3) a column showing the numbers of persons concerned in the consumption of these quantities of sugar. The significance of this last column in relation to the preceding may be made clearer by the addition of a fourth column (4) deduced from the two preceding by dividing the quantity of sugar shown in any line of the table by the number of the population shown in the same line, thus obtaining the average amount of sugar consumed per head of the specified population. The form of the table is sufficiently indicated by means of the lines relating to the United Kingdom in ten years, 1903 and 1913, given below:

Consumption of Sugar in the United Kingdom

(1) Year	(2) Total consumption thousand cwt.	(3) Population thousands	(4) Consumption per head, lb.
1903 . . .	28·847	42·247	76·5
1913 . . .	36·734	45·713	90·0

If to this table further columns are added or a new table is drawn up, in which data relating to the consumption of tea in the same country and in the same years is set out, we obtain two sets of facts the comparison of which may prove of interest and importance. We can ascertain whether the variations in the consumption of sugar and of tea were related.

Graphs.—It is frequently of advantage to set out in diagrammatic form such tabulated results as those referred to, as at least the broader features of the comparison of two or more series of figures can often be seen more clearly in this form. Such simple graphical comparisons are familiar through their use in meteorological reports where readings are shown by the upward and downward movements of a line crossing from left to right a series of vertical lines marking the hours of the day or the days of the week. The particulars of the consumption, per head of the population of the United Kingdom, of sugar and of tea in each of the 50 years from 1864 to 1913, are thus shown in Fig. (1). A necessary precaution in planning such graphical comparisons is also illustrated in the same diagram. The figures which are plotted relating to sugar show the average consumption year by year in lb. per head. The consumption of tea in lb. per head yields the

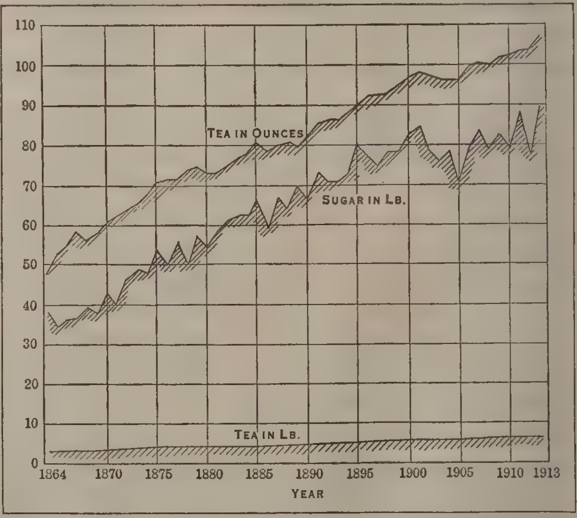

FIG. 1.—GRAPH SHOWING CONSUMPTION PER HEAD OF TEA AND SUGAR IN THE UNITED KINGDOM IN EACH YEAR, 1864–1913
Quantities in stock at the end of each year are not taken into account

line at the foot of the diagram, the variations of which are so slight as to suggest no similarity with those of the line showing sugar consumed. If, however, the consumption of tea per head is expressed in ounces, it becomes clear that, though in individual years the variations shown are by no means similar for sugar and for tea, over the whole period the increase was in approximately the same proportion for these two commodities[1]. The fluctuations were more considerable in the case of sugar, and the diagram suggests that, up to 1901, the quantities of sugar increased somewhat more rapidly than, and thereafter failed to maintain as great an increase as, those of tea.

Even though graphs fall short, in the matter of precision of statement, of the numerical tables, they have the great advantage of enabling a large mass of figures to be grasped as a whole much more readily than is possible when those figures are presented in one or more tables.

Averages and Dispersion.—A second illustration of statistical series is seen in the following summary of the heights of a number of men:—

Height in inches.	61	62	63	64	65	66	67
Number recorded	2	10	11	38	57	73	106
Height in inches.	68	69	70	71	72	73	74
Number recorded	126	109	87	75	23	9	4

The table may be interpreted as meaning that 126 were found between 5 ft. 7½ in. and 5 ft. 8½ in. and similarly for other heights. In tables such as this some method of dealing with cases falling exactly on the dividing line between two adjacent groups must be laid down, and a common method is to assign half the number found on the dividing line to each of the classes of which it forms the limit. This procedure may, of course, result in numbers in some of the groups which are not integers. The true average height of the 730 men covered by the table can be ascertained only by reference to a more detailed statement showing the height of each man exactly, instead of in a number of groups. It will be observed that 297 were not taller than 5 ft. 7½ in., while 307 were 5 ft. 8½ in. or more, the distribution being not quite symmetrical on both sides of the numerically largest group. The approximate average height was about $\frac{1}{20}$in. less than 5 ft. 8 in.

A table of this kind tells us, however, something more than the average height of the individuals represented. We note that 191 were not more than 5 ft. 6½ in. in height and 198 were not less than 5 ft. 9½ in. in height. By calculation from the figures shown, assuming that the individual heights were distributed with approximate regularity along the intervals from inch to inch, the points representing 5 ft. 6·3 in. and 5 ft. 9·7 in. would divide the series of heights so that one-quarter of the whole number fell below the former, and one-quarter of the whole number above the latter. A similar calculation gives, as the point dividing the series into two equally numerous groups, 5 ft. 8·04 in. This last point is called the *median* of the series, and the two others are the *lower* and *upper quartiles*, the three points serving to divide the whole number examined into four groups of equal numbers of cases. The distance between the upper and lower quartiles, in the case in question 3·4 in., gives the range within which the middle half of the instances recorded lay. This distance expresses much more definitely the degree of concentration of the individuals in the neighbourhood of the median height than, for example, the whole range (14 in.) within which all the measurements lie. If a more exact description of the nature of the distribution than is afforded by the specification of the median and quartiles, but of the same general character, is desired, the group may be divided into a number of parts, *e.g.*, into ten equally numerous parts, the points of division being then known as *deciles*.

In many varieties of statistical problems it is found that the observations are distributed in a manner similar to that shown in the above illustration, and the question arises whether the form of the distribution is of a recognizably definite character, the determination of which can be of use in the interpretation of the results obtained. It is found that, in numerous cases, the manner in which the individual observations are distributed is in close accordance with that of events dependent on pure chance. Such a case is presented by the following. A number of balls, indistinguishable in size, weight or form, are placed in a bag, half of the balls being white and half black. If one ball be drawn from the bag, its colour, whether white or black, may be noted. The ball being replaced and the bag shaken, another drawing will give a result wholly independent of the first. The repetition of such drawings will furnish a record of runs of white and of black balls, some short, some long. The numbers of cases (a) of a change of colour in consecutive drawings (b) of sequences of the same colour of two, three, four, etc., in number, being noted, the material for a table is furnished, and this table would have a general similarity with that of the men's heights used above for illustration. It is possible to determine theoretically the relative frequency with which the various sequences would recur in a series of trials indefinitely extended.

If, in a large number of drawings, sequences of x_r white (or of x_r black) balls are recorded on Y_r occasions, the total number n of drawings will be expressed by $n=x_1Y_1+x_2Y_2+x_3Y_3+\dots+x_rY_r+\dots$. The relative frequencies of the different series are y_1, y_2, etc., where $n \cdot y_1=Y_1$, $n \cdot y_2=Y_2$, etc., and, when n is indefinitely increased, the relation between the x's and the y's is expressed by the formula $y=a \cdot e^{-mx^2}$, which represents a curve of the shape shown below in fig. (2), known as the probability curve.

It is not proposed to enter into discussion of the character of the probability curve, or the interpretation of the variations. It will be sufficient here to point out that the equation given relates to a curve symmetrical in form to right and left of the position represented by $x=0$. The part to the right may be supposed to show the record of white sequences, and that to the left the exactly similar record of black sequences, *i.e.*, of sequences in which white balls failed to appear.

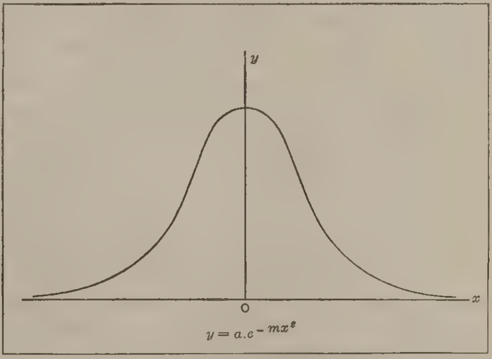

FIG. 2

In any actual series of observations (*e.g.*, of the colours of balls drawn from, and returned to, a bag) the observed numbers expressing the frequency of different events will be found to differ more or less from those expressed by the curve, of the form given by the above equation, which is appropriate to the circumstances of the experiment. Prolonged trials would give results approximating to those derived from theoretical calculations and expressed in the shape of the probability curve. Thus, in the case of the heights of 730 men, it is probable that records covering larger numbers of men, of the same race and social condition and within the same limits of age as those from which the 730 were selected, would give a distribution of heights more closely corresponding to that shown by a typical probability curve than the numbers cited. If, for example, for every one actually covered by our table, 10 or 20 or 50 or 100 had been measured, closer correspondence with a suitably selected theoretical series would have been probable.

In considering the meaning of changes in the observed frequency of events, it is generally of considerable importance to ascertain what is the extent of variation that is as likely to happen as not, since the significance of actual variations can only be judged in relation to those which may have no significance at all in reference to the problem under consideration.

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[1] *Cf.* Jubilee Vol. of the Royal Statistical Society, p. 257, where the late Professor Marshall used this illustration. The figures are based on imports less exports of sugar, excluding sugared goods.

Skew Distributions.—The normal probability curve, referred to above, is not the only form resulting from the theoretic consideration of chance events, and presenting close correspondence with statistical records of various kinds. The study of these forms, and of their theoretical bases, has been particularly active since the last decade of the 19th century. It will suffice here to mention that particular statistical problems are found to yield distributions of observations, not only symmetrical on either side of their mean, as with the normal probability curve, but also grouped more closely on one side of the mean than on the other. The illustration from men's heights showed some small tendency to a skew shape, though it appears possible that the apparent deformation would, on extending the field of observation, be found to disappear and be shown to result from the fact that, in so small a number of cases as 730, the even representation of men of all heights in the population from which these cases were drawn had not been exactly secured. The following records of weights of men of 25 and less than 30 years of age and within half an inch of 5 ft. 6 in. in height, shows a more marked skewness.

Weight in lb. .	105	120	135	150	165	180	195	210
Number of cases .	17	722	2,175	1,346	485	155	33	3

In this case the average (or arithmetic mean) of the weights of the 4,936 men is, on the assumption of continuous distribution, approximately 141·6 lb. The median is at about 1 lb. less, viz., 140·5 lb. In the previous illustration of heights, the median was greater than the mean, so that the skewness shown is of opposite direction in the two cases.

This illustration serves also to show a third characteristic of statistical distributions of this kind. Nearly four of every nine cases are included in that one of the eight groups of which 135 lb. is the central point, this group being notably more numerous than any other. The weight 135 lb. may be called, so far as the figures furnish a ready indication, the most generally occurring weight or the "modal" weight. The point in the distribution thus determined is called the "mode." A table like the above does not, however, give a very close measure of the central point of the group (covering a range of 15 lb.) which would prove largest if we compared various groups such as 127½ to 142½ lb. (the group shown) 127 to 142 lb., 128 to 143 lb., and so on. If the curve be found which represents the distribution in question, its highest point is the point the weight corresponding to which is the "mode" of the distribution, the most prevalent weight in the distribution under examination. Various problems in probability lead to curves of the distribution of chances which show the skewness that marks groups of statistical observations.

Groups That Are Not Homogeneous.—A case that may, however, be mentioned is that in which the measurements obtained relate, not to a homogeneous group, but to a mixture of two or more groups. The manner in which such a mixture might affect the characteristics of a distribution may be illustrated from the figures given below for the heights of a particular group of men. Suppose two such groups were found differing in the heights of the individuals composing them, but in such a way that the numbers in one of them whose heights were between any two specified limits were exactly twice those for limits an inch higher in the other group. We might have, for example:—

Height in inches. .	60–61	61–62	62–63	63–64	64–65	65–66	66–67	67–68	68–69	69–70	70–71	71–72	72–73	73–74	74–75
Numbers in Group I.	4	20	22	76	114	146	212	252	218	174	150	46	18	8	..
Numbers in Group II.	..	2	10	11	38	57	73	106	126	109	87	75	23	9	4
Numbers in the two groups .	4	22	32	87	152	203	285	358	344	283	237	121	41	17	4

The numbers in the last row represent a compound of two groups as numerous as the original group, the individuals of each of which were half an inch shorter than those of the original group, and another group, equal in number to the original group, the individuals of which were half an inch taller than those of the original group. If the distribution of the original group were such as could be precisely represented by an appropriate theoretical formula, the compound group would not be, in general, represented by the same formula. In some instances, it has been found possible to show that an observed group was so distributed as to be consistent with the assumption that it was made up of two groups of different characteristics, the members of which were included within one and the same series of observations. Such an analysis can clearly be of considerable importance with reference to the deductions to be drawn from the examination of the observed data.

Three Variable Elements.—In what precedes, the statistical material considered has consisted of series of pairs of quantities, the values of the two quantities in each pair being related; for example, where one of the quantities is the height of a man, the other the relative frequency with which men of that height were observed. We pass now to the consideration of series of three quantities, for example, where two of the quantities express the measures of different phenomena (which may be connected in some way, or may be independent) and the third expresses the relative frequency with which any combination of the other two occurs. Such a series is represented in the table given below, which shows the proportions in which, over a period of years, in a particular country, marriages in which both bride and bridegroom had been married previously were distributed according to the ages of the brides and of the bridegrooms. The particulars might advantageously be set out in fuller detail, but the condensed table will serve quite well to illustrate the nature of the problems connected with the analysis of data of this kind.

Ages of wives at date of marriage	Ages of husbands at date of marriage						Total wives
	Under 25	25–34	35–44	45–54	55–64	65 and over	
Under 25 . .	10	75	46	13	3	..	147
25–34 . .	20	175	167	65	17	3	447
35–44 . .	5	54	104	79	29	7	278
45–54 . .	..	5	18	36	33	9	101
55–64 . .	..	..	1	5	13	5	24
65 and over .	..	..	..	..	1	2	3
Total husbands	35	309	336	198	96	26	1,000

The table is to be read as follows: Of each thousand women married for the second (or later) time to men who had been married before, 447 were between 25 and 35 years old, and of these 20 married men under 25 years of age, 175 married men between 25 and 35, 167 married men between 35 and 45 and 17 men between 45 and 55. The other rows of figures will be read similarly, and the columns are to be read in corresponding manner, with the words "husband" and "wife" interchanged.

The columns, and also the rows, representing the age distributions of particular sections of the wives and of the husbands, are examples of skew distribution of numbers. It is clear, from the clustering of numbers in the neighbourhood of a band crossing the table from its upper left side towards its lower right side, that there is some association between the ages of the wives and the husbands, which are more often relatively high together, or relatively low together, than in other relations. The average age of the husbands is near 41 years and that of the wives somewhat in excess of 34 years.

Correlation.—If the average ages of the husbands shown in each row of the table be computed, and also those of the wives shown in each column, the two series of figures thus obtained show the variation of the average ages of corresponding groups of husbands and wives. They furnish the measures of what are known as the regression of the ages of husbands on those of wives, and the regression of the ages of wives on those of husbands. The two regressions would be complementary if the distribution represented complete linear correlation of husbands' ages and wives' ages. When this complete correlation is not shown, a measure of the degree in which the distribution diverges from that corresponding to complete correlation is afforded by the so-called coefficient of correlation. Between two series of quantities

$$x_1,\ x_2,\ x_3\ \ldots\ldots\ldots$$

and

$$y_1,\ y_2,\ y_3\ \ldots\ldots$$

if the sums of the squares of each series, $S(x^2)$ and $S(y^2)$ be calculated, and the sum of the pairs of products x_1y_1, x_2y_2, x_3y_3 . . . , *i.e.*, $S(x{\cdot}y)$ be also calculated, the fraction $S(x{\cdot}y)/\sqrt{[S(x^2){\cdot}S(y^2)]}$ gives the coefficient of correlation.

In the case represented by the final row and the final column of the last table, the calculation gives a fraction exceeding ·9. The highest possible value for the coefficient is 1. The coefficient is a measure of the divergence between the two lines of regression in cases like that illustrated, those two lines coalescing when the correlation is complete. If the series compared are such that decreases in the one correspond to increases in the other, the calculated coefficient is negative. The range of values for the coefficient lies between 0 and 1 for positive correlations and between 0 and −1 for negative correlations. Small values of the coefficient mean that the connection between the series is slight, and, in view of the extent to which, in actual observations, the records obtained are affected by disturbances having no relation to the matter under examination, no great significance can generally be attached to the occurrence of correlation coefficients of small magnitude.

The class of problem of which the figures given in the last table furnish an illustration is one of great importance in statistical work. Thus the variation of the height and weight of men with their age, the questions relating to the transmission of characteristics from parents to children, the association of different diseases or defects and the results of combinations of treatment of diseases or defects, the interpretation of the results of variation in different features of the weather, for example rainfall and temperature, on crop yields and many other problems give rise to such distributions, while the limitation of the illustration to the case of three kinds of variation should not be taken to imply that larger numbers of elements may not be considered.

The practical application of the procedure of calculating coefficients of correlation is not confined to cases such as that in connection with which the nature of correlation was illustrated. It may also be applied to determine, in cases such as that of the consumption of sugar and of tea, illustrated earlier, the closeness with which the variations in the two series of figures coincide. In some cases it is of importance to compare, not two series the trends of which are, on the whole, similar, but two series of which the trends are different, though the variations from the general trend may prove to be similar in the two cases. Whether for diagrammatic representation, or for preliminary arrangement of material for testing by the calculation of coefficients of correlation, it is desirable to isolate the important features as far as possible. The relation between economic prosperity and the marriage rate is a problem that has attracted much attention, and in using as a measure of economic prosperity the value of the exports year by year, or of imports and exports together, the connection which appears in some periods may be obscured in later periods by other conditions which cause one or other, or both, of the curves compared to diverge from the trend previously shown. To a considerable extent the effect of these disturbing elements in obscuring the significant relation may be evaded by using for comparison, not the absolute measures, *e.g.*, of the value of trade and of the marriage rate, but the proportion in which the figures for a given year are in excess or defect in comparison with those of the average of a series of several years of which the year under consideration is the middle year, or the final year.

It may be noted that when two series of quantities, showing the variations in time of phenomena under examination, are tested for closeness of fit by the calculation of correlation coefficients, it is possible to test whether one of the two series differs from the other mainly in respect of the time at which variations are greatest or smallest. In comparing two series such as

$$x_1\ x_2\ x_3\ x_4\ldots\ldots\ldots$$
$$y_1\ y_2\ y_3\ y_4\ldots\ldots\ldots$$

the sum of products used in calculating the correlation coefficient was conceived of as

$$x_1\ y_1 + x_2\ y_2 + x_3\ y_3 + \ldots\ldots\ldots$$

It may be found that such product-sums as

$$x_1\ y_2 + x_2\ y_3 + x_3\ y_4 + \ldots\ldots\ldots$$

or

$$x_2y_1+x_3y_2+x_4y_3+\ldots\ldots\ldots$$

show significantly larger resulting coefficients than the product-sum first named. If so, it may be taken as meaning that of the two phenomena the variations of which are compared, those variations are not contemporaneous, but the members of one series follow, or precede, those of the other by a roughly constant interval. The repetition of the calculations for several different intervals may furnish a measure of the lag of one of the two phenomena on the other.

It has been stated that the lowest value of the correlation coefficient is zero. It may be added that when, in practice, a calculation of such a coefficient gives a result practically equal to zero, it is not to be concluded that there is no correlation between the quantities. The form given for the correlation coefficient was based on the assumption that the lines of regression were sufficiently nearly straight lines to render it unnecessary to call attention to their divergence from that form. In some cases in which a high correlation with non-linear regression exists, the coefficient calculated by the formula given will be small. On the other hand, there are cases in which large correlation coefficients result from the formula of calculation, though the phenomena compared are, in fact, not related to each other. The principal cause of such apparently strange results is found in the fact that actual series of observations may be but small samples of the universe of phenomena of which they are taken as representative, and in small samples the securing of really representative results is not easily achieved. We turn, therefore, to the consideration of some questions relative to sampling.

Sampling.—Two principal reasons lead to the use of statistics of samples in place of complete statistics of an exhaustive character covering the whole of the so-called universe of instances. One is that only portions of that universe may be accessible as sources of data, the other that the labour and expense involved in handling very large masses of statistics render it expedient to seek representative selections of moderate extent as the basis of the data to be submitted to detailed examination. In the latter case, it is to be supposed that the selection of instances is at the discretion of the investigator, and the practical question involved is the devising of a means that will ensure that the instances selected should give, as far as is possible, a picture *in petto* of the whole field of enquiry.

The most common method is to choose the instances in a manner that shall ensure that there is no concentration on those possessing any particular characteristic in preference to those lacking that characteristic. All cases are to be given an equal chance of selection; the sample is to be a *random* selection. It is only necessary to illustrate the kind of procedure that will secure that result. Suppose we have to select 200 cases from a total of (say) 20,000. We may, if the 20,000 are arranged in any kind of sequence, take the first, pass over 99 and take the case then next following, again pass over 99 and take the case then next following, and so on. Another method would be to place in a bag cards bearing the series of numbers from 1 to 20,000 and to draw from the bag 200 cards in succession, shaking the bag between each pair of drawings. The numbers of the cards drawn would show what choice of cases from the complete series should be made, and any effect produced by the arrangement of the cases in a particular order, which might influence the result of the method of selection first named, would tend to be avoided by the second procedure.

Random sampling has, as its object, as already stated, the securing of a comparatively small group possessing the same general characteristics, *i.e.*, showing the same proportions in which each special feature is present or absent, as the complete series of cases. This may, in some conditions, be secured more effectively by deliberate selection of instances in which a number of characteristics are distributed in a manner similar to that in which the same characteristics are distributed in the mass from which the sample is taken. This involves, of course, that, in respect of the characteristics used as guides, available records exist covering the mass.

Another mode of testing a sample in respect of its representative character is to divide it into two or more parts at random, and compare the characteristics of the separate parts. Agreement between the parts is commonly taken as an indication that the sample is representative in character, though such agreement, or its absence, is not a final test. To illustrate, suppose the special case of random samples of men of specified age from a defined race and locality. Suppose a sample of 1,000 such men taken, and their characteristics examined: for example, their average height, median height, the dispersion of these heights and other features of the distribution of heights may be determined. The process may be repeated for a second, third, etc., sample of 1,000 until we have (say) 1,000 sets of results derived from 1,000 samples each consisting of 1,000 units. Taking one of the characteristics, say the average height, we may examine 1,000 results from the separate samples. It will almost certainly happen that these differ from one another but slightly as compared with the differences between the heights of the individuals in any one sample. But these averages would themselves generally possess a degree of variation, and their grouping according to their order of magnitude would furnish a frequency distribution having its own mean, median, dispersion, etc. This latter distribution would, in fact, indicate the degree of variability of the results obtained by sampling.

The study of the mathematical theory relating to the problems thus illustrated furnishes estimates of the answers to such questions as: what is the probability that the divergence of the mean value of a specified feature of the sample from the (unknown) mean value of the same feature of the universe from which the sample is drawn shall not be greater than a specified amount? The answers may be a guide to a decision on the questions of whether procedure by sample is satisfactory, and what size of sample may be desirable to justify the use of the sampling method.

When procedure by sample is adopted because only data derived from samples are procurable, the investigation of the entire mass of cases being excluded, the use of methods aimed at securing that the samples are *random* or are *representative* is, generally if not universally, not a matter for consideration. It is, therefore, of the greatest importance to examine the conditions affecting the selection of the sample. It may be found that some bias in the selection is unavoidable, while the extent to which that bias affects the results may not be capable of estimation. To apply to the results of biassed sampling the tests and limitations determinable by theory for the case of random sampling may lead to error.

The relative stability of the relations between different groups of statistics relating to human communities and their organization was a feature that attracted attention at a very early stage of statistical enquiry. Changes in habits of masses of men are generally of slow development. The consequence is that any well ascertained sequence of phenomena in economics may be expected to be repeated, that is, the repetition of certain conditions may be expected to be followed by consequences of a definite character. The underlying assumption is the permanence of the essential determining features of the organism with whose manifestations we are concerned. The introduction of new conditions, not all of which may be obvious or ascertainable, may destroy that stability of relations on the faith of which future changes might be expected when observed conditions show particular mutual relations. Not only new conditions, but also the deviations from uniformity recognizable in the comparison of different samples of one and the same universe of phenomena, must be kept in mind in forming any judgment of the probable future based on observations of the course of events in the recent past.

Sources of Statistical Data.—In the work of administration, the governments of most civilized countries are able to make exhaustive enumerations of various classes of events occurring within their territory. A few examples are:—the number of births in successive weeks, months or years, the deaths in the same periods, the causes of deaths and the sexes and ages of the persons dying, the amount of property or income serving as the basis of assessment to taxation of individual citizens, the value and quantity of each of various kinds of merchandise imported from or exported to other countries during any determined interval of time, the numbers of various kinds of animals existing in the country at selected dates, the length of the roads maintained at the public expense and of the railway tracks existing from time to time, the numbers of various kinds of vehicles for the use of which licences are required, the quantities of certain dutiable articles of food and drink on which duties are paid in successive months or years.

From time to time, generally at intervals of ten years, the total number of persons of each sex, the age of each being also recorded, is ascertained for each administrative subdivision of the country, and either simultaneously or on other, and possibly less frequent, occasions the number of persons engaged in each principal class of occupation is also generally ascertained.

Organizations of a private character, including corporate bodies, obtain, like the public administrative bodies, much information for their own guidance, some of which is made public. In some cases there results an exhaustive enumeration of events of certain kinds occurring within the country, in other cases a series of more or less representative illustrations of what has happened is furnished. Thus the total weight of goods carried by railway may be available, while the quantities of gas, water or electricity supplied may only be made public by some of the undertakings supplying them, and the extent to which the ascertained aggregates fall short of the actual aggregates supplied may be variable in a degree that cannot be determined and may be of importance.

In addition to the data arising out of the general administration of a country, and those published by business organizations, statistical data may be obtained as the outcome of special enquiries by either of these classes of bodies or by private bodies or persons. The latter class of data generally presents the characteristic just referred to as affecting some of the data obtained by business organizations, namely, that an exhaustive enumeration covering the whole country is not secured. What is obtained is a record relating to a part, more or less typical of the whole so far as the matter under examination is concerned. The principles to which attention was directed in the paragraphs relating to sampling apply to the statistics thus secured. (A. W. F.)

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STATIUS, PUBLIUS PAPINIUS (*c.* A.D. 45–96), Latin poet, was born at Naples. His father was also a poet, and Statius seems to have been trained as one from the start. Of events in the life of Statius we know little. From his boyhood he was victorious in poetic contests—many times at his native city Naples, thrice at Alba, where he received the golden crown from the hand of the emperor Domitian. But at the great Capitoline competition (probably on its third celebration in A.D. 94) Statius failed to win the coveted chaplet of oak leaves. Perhaps the emperor's favour had failed him; in any case, he withdrew to Naples (*Silv.* iii. 5).

The rôle of court poet seems to have suited Statius. His flattery is as far removed from the gentle propitiatory tone of Quintilian as it is from the coarse and crawling humiliation of Martial. It is in the large extravagant style of a nature in itself healthy and generous, which has accepted the theme and left scruples behind. In one of his prefatory epistles Statius declares that he never allowed any work of his to go forth without invoking the godhead of the divine emperor. Statius had taken the full measure of Domitian's gross taste, and, presenting him with the rodomontade which he loved, puts conscience and sincerity out of view, lest some uneasy twinge should mar his master's enjoyment.

As a poet, Statius unquestionably shines in many respects when compared with most other post-Augustans. He was born with exceptional talent, and his poetic expression is, with all its faults, richer on the whole and less forced, more buoyant and more felicitous, than is to be found generally in the Silver Age of Latin poetry. Statius is at his best in his occasional verses, the *Silvae,* which have a character of their own, and in their best parts a charm of their own. The subjects of the *Silvae* are very various. Five poems are devoted to flattery of the emperor and his favourites; but of these enough has already been said. Six are lamentations for deaths, or consolations to survivors. Another group of the *Silvae* give picturesque descriptions of the villas and gardens of the poet's friends. In the "Kalendae decembres" we have a striking description of the gifts and amusements provided by the emperor for the Roman population on the occasion of the Saturnalia. In his attempt at an epithalamium (*Silv.* i. 2) Statius is forced and unhappy. But his birthday ode in Lucan's honour (*Silv.* ii. 7) has, along with the accustomed exaggeration, many powerful lines, and shows high appreciation of preceding Latin poets. Some phrases, such as "the untaught muse of high-souled Ennius" and "the lofty passion of sage Lucretius," are familiar words with all scholars.

The epic poems of Statius are less interesting because cast in a commoner mould, but they deserve study in many respects. They are the product of long elaboration. The *Thebais,* which the poet says took 12 years to compose, is in 12 books, and has for its theme the old "tale of Thebes"—the deadly strife of the Theban brothers. There is also preserved a fragment of an *Achilleis,* consisting of one book and part of another. In the weary length of these epics there are many flowers of pathos and many little finished gem-pictures, but the trammels of tradition, the fashionable taste and the narrow bars of education check continually the poet's flight.

The *editio princeps* of the epics is dated 1470, of the *Silvae* 1472. Notable editions since have been those of Bernartius (Antwerp, 1595), Gronovius (1653) and Barth (1664). Recent texts are the Teubner (the *Achilleis* and *Thebais* by Kohlmann, the *Silvae* by Baehrens) and that contained in the new edition of the *Corpus poetarum latinorum;* and of the *Silvae* only, texts by Klotz (1899), and Vollmer (1898), the last with an explanatory commentary. Among editions of portions of Statius's works, that of the *Silvae* by Markland (1728) deserves special attention. A translation of the *Silvae* with introduction and notes was published by D. A. Slater in 1908 (Oxford Library of Translations). A critical edition of the *Thebais* and *Achilleis* was begun by O. Müller (*Thebaid* i.–vi., Leipzig, 1870) but not completed.

For the poet's life *see* Lehanneus, *De P. P. Statii Vita et Operibus* (La Rochelle, 1878); *Riv. Fil.* 35 (1907) 3. *See* also B. A. Wise, *Influence of Statius upon Chaucer* (Baltimore, 1911); W. A. Menite, *Notes on the Silvae* (Univ. of California, 1918). (J. S. R.; X.)

STATUTE, in English law, is a law made by the "sovereign power" in the State. (*See* ACT OF PARLIAMENT.) It forms a part of the *lex scripta,* which by English legal authorities is used solely for statutory law, a sense much narrower than it bore in Roman law. To make a statute the concurrence of the Crown and the three estates of the realm is necessary. Thus a so-called statute of 5 Ric. II. c. 5, directed against the Lollards, was afterwards repudiated by the Commons as passed without their assent. The validity of a statute was indeed at times claimed for ordinances such as that just mentioned, not framed in accordance with constitutional rule, and was actually given to royal proclamations by 31 Hen. VIII. c. 8 (1539). But this Act was repealed by 1 Edw. VI. c. 12, and since that time nothing but a statute has possessed the force of a statute, except perhaps certain subordinate legislation ("Statutory Rules and Orders"), the making of which has been delegated by parliament to departments and other authorities (*see* also PROVISIONAL ORDER), and except Church Assembly Measures passed under the Church of England Assembly (Powers) Act of 1919 and presented for the royal assent after a favourable resolution of both houses of parliament.

The list of English statutes as at present existing begins with the Statute of Merton, 1235. Many of the earlier statutes are known by the names of the places at which they were passed, *e.g.,* the Statutes of Merton, Marlbridge, Gloucester, Westminster, or by their initial words, e.g., *Quia Emptores, Circumspecte Agatis.* The earliest existing statute roll is 6 Edw. I. (the Statute of Gloucester). After 4 Hen. VII. the statute roll ceased to be made up, and enrolments in chancery (first made in 1485) take its place.

All statutes were originally public, irrespective of their subject-matter. The division into public and private dates from the reign of Richard III. At present statutes are of four kinds, public general Acts, public local and personal Acts, private Acts printed by the king's printers and private Acts not so printed. The division into public general and public local and personal rests upon a resolution of both houses of parliament in 1798. In 1815 a resolution was passed in accordance with which private Acts are printed, with the exception of name, estate, naturalization and divorce Acts. The last two are now practically superseded by changes in the law of divorce and nationality. Since 1815 it has been usual to refer to public general Acts by Arabic numerals, *e.g.,* 1 Edw. VII. c. 21, public local and personal Acts by small Roman numerals, *e.g.,* 1 Edw. VII. c. xxi. Each Act is strictly but a chapter of the legislation of the session, which is regarded as composing a single Act divided into chapters for convenience, the chapters themselves being also called Acts. The citation of previous Acts is provided for by the Interpretation Act 1889 (s. 35). Every Act now contains a short title by which it may be cited, *e.g.,* the Housing Act 1925. The Short Titles Act 1896 creates short titles for numerous single Acts and groups of Acts, and it is now usual to cite Acts and groups by their short and collective titles rather than by the year of the reign.

A public Act binds all subjects of the realm, and need not be pleaded (except where the law from motives of policy specially provides for pleading certain Acts, as in the defences of not guilty by statute, the Statute of Frauds and the Statute of Limitations). A private Act must generally be pleaded, and does not as a rule bind strangers to its provisions. Formerly an Act took effect from the first day of the session in which it was passed. The hardship caused by this technical rule was obviated by statute in 1793, since when an Act takes effect from the day on which it receives the royal assent, where no other date is named. This has been held to mean the beginning of the day, so as to govern all matters occurring on that day. An Act cannot in the strict theory of English law become obsolete by disuse. Nothing short of repeal can limit its operation. The law has, however, been interpreted in many cases with somewhat less rigour. In the case of a prosecution for blasphemy in 1883 (*R.* v. *Ramsay*) Lord Coleridge said, "though the principles of law remain unchanged, yet (and it is one of the advantages of the common law) their application is to be changed with the changing circumstances of the times." This would be applicable as much to the interpretation of statutes as to other parts of the common law.

Besides the fourfold division above mentioned, statutes are often classed according to their subject-matter, as perpetual and temporary, penal and beneficial, imperative and directory, enabling and disabling. Temporary Acts expire at a date fixed in the Act itself. Thus the Army Act is passed annually and continues for a year, and the London Traffic Act 1924 was to expire at the end of 1928. By such provision experimental legislation is rendered possible where the success of a new departure in legislation is doubtful. An annual Expiring Laws Continuance Act is passed for the purpose of continuing (generally for a year) various temporary Acts; the list is periodically revised and those of proved value are then made permanent. By legislation of 1808 a continuing Act is to take effect from the date of the expiration of a temporary Act, where a bill for continuing the temporary Act is in parliament, even though it be not actually passed before the date of the expiration. Penal Acts are those which impose a new disability; beneficial, those which confer a new favour. An imperative statute (often negative or prohibitory in its terms) makes a certain Act or omission absolutely necessary, and subjects a contravention of its provisions to a penalty. A directory statute (generally affirmative in its terms) recommends a certain Act or omission, but imposes no penalty on non-observance of its provisions. To determine whether an Act is imperative or directory the Act itself must be looked at, and many nice questions have arisen on the application of the rule of law to a particular case. Enabling statutes are those which enlarge the common law, while disabling statutes restrict it. This division is to some extent coincident with that into beneficial and penal. Declaratory statutes, or those simply affirming the common law, at one period not uncommon, are at the present time practically unknown; the Treason Act is an example.

Interpretation of Statutes.—The construction or interpretation of statutes depends partly on the common law, partly on statute. The main rules of the common law, as gathered from the best authorities, are these: (1) Statutes are to be construed, not according to their mere letter, but according to the intent and object with which they were made. (2) The relation of the statute to the common law is to be considered. In the words of the resolution of the court of exchequer in *Heydon's case*, 3 Coke's Rep. 7, the points for consideration are: "(*a*) What was the common law before the making of the Act? (*b*) What was the mischief and defect against which the common law did not provide? (*c*) What remedy the parliament hath resolved and appointed to cure the disease of the Commonwealth? (*d*) The true reason of the remedy." (3) Beneficial or remedial statutes are to be liberally, penal more strictly, construed. (4) Other statutes *in pari materia* are to be taken into consideration. (5) A statute which treats of persons of inferior rank cannot by general words be extended to those of superior rank. (6) A statute does not bind the Crown, unless it be named therein. (7) Where the provision of a statute is general, everything necessary to make such provision effectual is implied. (8) A later statute repeals an earlier, as far as the two are repugnant, but if they may stand together repeal will not be presumed. (9) There is a presumption against creation of new or ousting of existing jurisdictions, against impairing obligations, against retrospective effect, against violation of international law, against monopolies, and in general against what is inconvenient or unreasonable. (10) If a statute inflicts a penalty, the penalty implies a prohibition of the Act or omission to which the penalty is imposed. Whether the remedy given by statute is the only one depends on the words of the particular Act. In some cases an action or an indictment will lie; in others the statutory remedy, generally summary, takes the place of the common law remedy. In some instances the courts have construed the imposition of a penalty as operating not to invalidate a contract but to create a tax upon non-compliance with the terms of the statute. The Interpretation Act 1889 provides an authentic interpretation for numerous words and phrases of frequent occurrence in statutes.

The earlier Acts are generally simple in character and language, and comparatively few in number. At present the number passed every session is substantial; for the session of 1925 there were 91 general Acts (occupying over 1,800 pages in the official volumes) and 132 local and personal Acts. Without going as far as to concede with an eminent legal authority that of such legislation three-fourths is unnecessary and the other fourth mischievous, it may be admitted that the immense library of the statutes would be but a trackless desert without trustworthy guides. Revision of the statutes was evidently regarded by the legislature as desirable as early as 1563 (*see* the preamble to 5 Eliz. c. 4.). It was demanded by a petition of the Commons in 1610. Both Coke and Bacon were employed for some time on a commission for revision. In 1861 was passed the first of a long series of Statute Law Revision Acts. The most important action, however, was the nomination of a Statute Law Committee by Lord Chancellor Cairns in 1868, a body of experts in drafting and public administration, which continues to supervise the official publication of revised statutes and indexes to statutes and to statutory rules. *A Chronological Table and Index of the Statutes* which are still law is annually published under the Committee's direction; the Table shows how far any enactment has been repealed or amended. The first edition of *Revised Statutes,* begun in 1870, substituted 18 volumes for 118; a second edition, begun in 1886, contains the Acts from 1235 to 1900 in 20 volumes, extended further by the Statute Law Revision Act of 1927.

The chief editions of the British statutes are the *Statutes of the Realm* printed by the king's printers, Ruffhead's and the fine folio edition issued from 1810 to 1824 in pursuance of an address from the House of Commons to George III. The safest authority is the *Revised Statutes.* Chitty's selection of *Statutes of Practical Utility* is useful. Earlier works on statute law include the readings and commentaries on statutes by great lawyers, such as the second volume of Coke's *Institutes,* Bacon's *Reading on the Statute of Uses,* Barrington's *Observations on the more ancient Statutes from Magna Carta to the 21 Jac. I. c. 27* (5th ed., 1796), and the Introduction to Blackstone's *Commentaries.* Among the later works are the treatises of Dwarris (2nd ed., 1848) and Maxwell (6th ed., 1920) and Craies (founded on Hardcastle) (3rd ed., 1923). On the interpretation of statutes, *see* Sir C. P. Ilbert, *Legislative Methods and Forms* (1901) and *Mechanics of Law-Making* (1914); Sir H. Thring, *Practical Legislation* (1902). An official *Index to Statutory Definitions* (1923) is valuable for draftsmen. For bibliography of English Statutes *see* P. H. Winfield, *Chief Sources of English History* (1925). For Revised Statutes see *Law Quarterly Review* (1929, p. 168). Statutory rules and orders are officially published by H.M. Stationery Office both singly and in annual volumes.

Scotland.—The statutes of the Scottish parliament before the union differed from the English statutes in two important respects: they were passed by the estates of the kingdom sitting together and not in separate houses, and from 1367 to 1690 they were discussed only after preliminary consideration by the lords of the articles, a legislative committee. An Act of the Scottish parliament may in certain cases cease to be binding by desuetude.

Acts of the imperial parliament which have been passed since the union extend in general to Scotland, unless that country be excluded from their operation by express terms or necessary implication. Scottish Acts are cited thus, 1678, c. 10. An edition was issued by order of the Treasury, 1844–75. *Scots Statutes Revised (1707 to 1900)* in 10 volumes is a useful publication. Obsolete Acts from 1424 to 1707 were repealed by the Statute Law Revision (Scotland) Act 1906.

Ireland.—Originally the lord deputy appears to have held parliaments at his option, and their Acts were the only statutory law which applied to Ireland, except as far as judicial decisions had from motives of policy extended to that country the obligation of English statutes. In 1495 the Act of the Irish parliament known as Poynings' Law or the Statute of Drogheda enacted that all statutes lately made in England be deemed good and effectual in Ireland. This was construed to mean that all statutes made in England prior to the 18 Hen. VII. were valid in Ireland, but none of later date were to have any operation, unless Ireland were specially named therein or unless adopted by the Irish parliament, as was done, for instance, by Yelverton's Act, 21 and 22 Geo. III. c. 48 (I.). Another article of Poynings' Law secured an initiative of legislation to the English privy council, the Irish parliament having simply a power of acceptance or rejection of proposed legislation. The power of the parliament of Great Britain to make laws to bind the people of Ireland was declared by 6 Geo. I. c. 5. This Act and the article of Poynings' Law were repealed in 1782, and the short-lived independence of the parliament of Ireland was recognized by 23 Geo. III. c. 28. The application of Acts passed since the union is the same as in the case of Scotland. Irish Acts are cited thus, 26 Geo. III. c. 15 (I.) or (Ir.). The best edition is that issued in 20 volumes pursuant to an order of the earl of Halifax, lord-lieutenant in 1762. A volume of revised statutes was published in 1885. The earliest that is still law is one of 1459. Since the constitutional changes in the Government of Ireland, the Irish Free State passes Acts printed bilingually and cited by year and number. The Northern Ireland legislation in form and citation resembles that of Westminster.

British Colonies, Dominions and Dependencies.—Acts of the imperial parliament do not extend to the Isle of Man, the Channel islands or the colonies, unless they are specially named therein. By the Colonial Laws Validity Act 1865 ("the charter of colonial legislative independence") any colonial law repugnant to the provisions of any Act of parliament extending to the colony is void to the extent of such repugnancy, and no colonial law is to be void by repugnancy to the law of England unless it be repugnant to such an Act of parliament. The 1865 Act is discussed in the Summary of Proceedings of the Imperial Conference of 1926 in its application to the self-governing dominions, for which the imperial parliament does not legislate without their consent. For colonies without representative legislatures the Crown usually legislates, subject to the consent of parliament in particular cases. Examples of imperial legislation for the colonies in general are the Colonial Stock Act 1877, and the Colonial Courts of Admiralty Act 1890. Imperial Acts dealing with particular dominions include the New Zealand Constitution Act 1852, the British North America Act 1867, the Commonwealth of Australia Constitution Act 1900, and the South Africa Act 1909: these statutes, like the Irish Free State Constitution Act 1922, deal with the competence of the dominion legislature. A colony is defined for the purposes of imperial legislation by the Interpretation Act 1889, s. 18. In certain dominions like Canada, the constitutionality of an Act of the colonial legislature is, as in the United States, a matter for the determination of the local court or of the judicial committee of the privy council on appeal.

Other Countries.—In most European countries there is a code, the existence of which makes the system of legislation hardly comparable to that of Great Britain. The assent of two chambers and of the president or other head of the State, is generally necessary.

The term "statute" is used by international jurists and civilians mostly on the continent of Europe to denote the whole body of the municipal law of the State. In this sense statutes are either real, personal or mixed. A real statute is that part of the law which deals directly with property, whether movable or immovable. A personal statute has for its object a person, and deals with questions of status, such as marriage, legitimacy or infancy. A mixed statute affects both property and person, or, according to some authorities, it deals with Acts and obligations. Personal statutes are of universal validity; real statutes have no extraterritorial authority. The determination of the class under which a particular law ought to fall is one of great difficulty, and one in which there is often a conflict of legal opinion.

See J. Story, *Conflict of Laws* (Boston, 1834; 8th ed. by H. M. Bigelow, 1883) ss. 12–16; von Bar, *Private International Law* (2nd ed., Eng. trans. by Gillespie, 1892); A. Pillet, *Traité Practique de droit international privé* (1924). (J. Wil.; C. T. C.)

UNITED STATES

Statute in American law is generally confined to an act of the legislature, though the term is occasionally used to apply to municipal ordinances and the rules and regulations of administrative agencies passed in the exercise of delegated legislative functions. The concurrence of the executive is demanded for the efficacy of the legislative act. The executive is accorded a veto over legislative action which can, however, be overridden by concurrence of a sufficient majority in the houses of the legislature.

Any consideration of statute-making in the United States must bear in mind the Federal character of the nation. Not only does each of the 48 States possess statute-making powers for that State, but the national Government within the ambit of its delegated powers may pass statutes effective throughout the nation. The device of judicial review over legislation is the scheme by which conflict between the various statutes is resolved. As the supreme law of the land stand the Constitution, treaties and laws of the United States, and State statutes passed in contravention of them are unenforceable. Not only are State and the lower Federal courts obliged to refuse to enforce a State statute contravening Federal constitutional or statutory law, but by providing for an appeal to the U.S. Supreme Court, the validity of State statutes can be brought for judgment to that ultimate tribunal. The Supreme Court thus occupies the position of arbiter in the eternal conflict between States and nation. State statutes must also comply with the provisions of the State Constitution but the final arbiter of their compliance is the State supreme court and not the U.S. Supreme Court. (*See* Constitution and Constitutional Law.) State statutes in violation of the State or Federal Constitution are void, but State statutes contravening Federal statutes are suspended during the operation of the latter.

The fact that there are 49 different statute-making bodies in the United States makes for an immense mass of legislation. Despite the fact that most State legislatures have only biennial sessions, their legislative activity produces a vast number of statutes. The first thorough attempt to keep in touch with their activity by the mechanism of an index to State legislation was originated in 1928 by the Library of Congress. Periodic revisions of their statutes are made by each State but upon plans that lack any uniformity. No revision of the statutes of the Federal Government was made until 1874. A second revision was accomplished in 1925.

Statutes commonly take effect from the date that they receive the executive assent. In some States constitutional provisions prescribe that they shall not be effective until after the expiration of a certain time after their passage, unless the legislature shall designate that the matter is one of such public urgency as to require their immediate operation. The result of these restrictions has been simply to induce the legislature to append an urgency clause to each statute irrespective of its subject-matter and thus override the constitutional restriction. Two other common constitutional provisions relative to statute-making in the State legislatures deserve notice. To avert the process of "log-rolling" or the inclusion of particular legislation in a general statute, the Constitutions provide that no statute shall deal with more than one subject, to be plainly and specifically expressed in the title to the act.

The legislation of the United States and its constituent States is generally conceded to be in an unhappy state. Several significant reform movements are (1929) in progress. A movement for the creation of legislative reference bureaux, organizations with the double purpose of offering expert help in the draughting of statutes and of affording to legislators information upon the subject matter of specific statutory proposals, was begun in Wisconsin and has gained wide acceptance during the last 15 years. Expert legislative draughtsmen are now attached to the Senate and House of the U.S. Congress and to a number of State legislatures. A movement for introducing uniformity in the statutory laws of the several States was initiated by the organization of the Commissioners on Uniform State Laws in 1892. They consist of commissioners appointed by each State who meet annually to frame legislation on subjects upon which uniformity is believed essential and recommend its enactment by the various State legislatures. Their most successful achievements have been in the field of commercial law, though their endeavours have embraced subjects of wide variety. Similar efforts to promote uniformity have been made by groups representing private interests and public welfare organizations. Interpretation statutes upon the British model have also been enacted in some States and the work of expert draughtsmen has brought some order and method in the process of statute-making.

Another peculiar American problem relates to the extent to which courts take cognizance of statute law. All courts are bound to take judicial notice of the Federal laws and the statutes of the State in which suit is brought. But different doctrines are in force as to the extent to which they will take notice of the statute law of other States. Some State courts have boldly asserted their willingness to take notice of such laws; others refuse to recognize them unless they are specially pleaded or proved, in default thereof assuming that the law of the other State is identical either with their decisional or statutory law.

Statutes have different forms, being either acts of the legislature or joint or concurrent resolutions of both houses of the legislature. In each instance they must secure the approval of the executive. In many cases the same subject-matter is alternately dealt with by both forms of statutes. Treaties of the national Government have the force of statutes and stand on a parity with them. Like statutes they are the "supreme law of the land" and supersede conflicting State legislation. Just as a subsequent statute may repeal an earlier one, a later statute repeals an earlier treaty. States are forbidden to conclude treaties but may make compacts with one another with the assent of Congress. Such compacts also have the effect of statutes. They have been used as an instrument of statecraft to deal effectively with problems that demand a regional treatment greater than a single State can give and yet less than is desirable for nation-wide control.

Codification on an analogy to the European systems began as a movement in 1848, the date of the adoption of the Field Code in New York. That code was limited to an attempt to recognize and simplify procedural law. A similar programme for the codification of the substantive law was initiated by the same sponsor, David Dudley Field, but failed of adoption. Procedural and substantive codes on the model of the Field Code were, however, adopted in numerous States. The merits and demerits of a codification in statutory form of the procedural and substantive law became a heated matter of professional controversy during the latter part of the 19th century. The controversy has not yet abated. The hopes of the codifiers of remodelling the common law on lines akin to the civil law systems have not been realized. Judges imbued with the common law training and technique have continued to handle codifications as mere statutes and not as ultimate sources of the law in the manner of the civilians. The "code States" are thus common law jurisdictions to the same extent as the other States.

See Freund, *Standards of American Legislation* (1917); Reinsch, *American Legislatures and Legislative Methods* (1913); Willard, *Legislative Handbook* (1890); Jones, *Statute Law Making in the United States* (1912); Sutherland, *Statutes and Statutory Construction* (1904); Black, *Handbook on the Construction and Interpretation of the Laws* (1911); Clarke, *Science of Law and Lawmaking* (1898); Brown, *Underlying Principles of Modern Legislation* (6th ed. 1920). (J. M. La.)

STATUTORY RULES AND ORDERS. The British parliament being a sovereign body, its acts cannot be challenged as *ultra vires*. "Statutory rules and orders," not passed directly by parliament but made under delegated powers, have no such immunity. Occasionally a statute, when authorizing such delegations, directs that the resultant rules, regulations or orders shall "have effect as if enacted in this Act." These words, formerly used by draftsmen when annexing schedules to statutes, may place the rules and orders beyond challenge (*Patent Agents Institute* v. *Lockwood*, 1894, A.C. 347), but normally the law courts will vigilantly examine the departmental exercise of legislative power. Law-making by statutory rules and orders was immensely extended during the World War, under the Defence of the Realm Acts, and is authorized by the Emergency Powers Act of 1920, when the community requires special protection. The pressure upon parliamentary time is developing a system by which Acts contain bare principles of law, and the clothing of the skeleton is left to subordinate rule-making. The making of rules of procedure in various courts or Orders in Council (*see* PRIVY COUNCIL) to bring Acts into effect on appointed days are well-known instances of such delegated legislation. Special provisions exist for the publication of draft rules (*see* especially the limited effect of s. 1 of the Rules Publication Act, 1893), for consultation with interests concerned, for control by parliament, and for the promulgation of all subordinate legislation when finally made.

See C. T. Carr, *Delegated Legislation* (1921); J. H. Morgan, *Remedies against the Crown* (1926); Lord Justice Sankey, *Principles and Practice of the Law To-day* (1928). (C. T. C.)

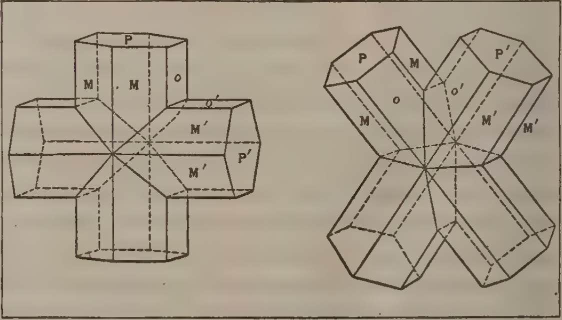
STAUNTON, HOWARD (1810–1874), English Shakespearian scholar and writer on chess, supposed to have been a natural son of Frederic Howard, fifth earl of Carlisle, was born in 1810. As a Shakespearian commentator he showed the qualities of acuteness and caution which made him excel in chess. He possessed, moreover, a thorough mastery of the literature of the period, shown in his papers in the *Athenaeum* on "Unsuspected Corruptions of Shakespeare's text," begun in October 1872. In 1864 he published a facsimile of the Shakespeare folio of 1623, and a facsimile edition of *Much Ado about Nothing*, photolithographed from the quarto of 1600. He died in London on June 22, 1874. Staunton's services to chess literature were very great, and the game in England owes much of its later popularity to him, while for thirty years he was the best player in England, perhaps in the world. For his important works on the subject *see* CHESS.

STAUNTON, a city of Macoupin county, Illinois, U.S.A., 42 m. N.E. of Saint Louis. It is on Federal highway 66, and is served by the Wabash and the Illinois Traction (electric) railways, and for freight also by the Chicago and North Western and the Litchfield and Madison. Pop. 6,027 in 1920, 28% foreign-born white. Staunton is in the heart of a great coal-field and has several mines within its limits. The city was founded in 1830 and chartered in 1891.

STAUNTON (stăn′tọn), a city of Virginia, U.S.A., 1,385 ft. above sea-level, in the heart of the beautiful and fertile Shenandoah valley, 135 m. N.W. of Richmond; the county seat of Augusta county, but administratively independent of it. It is on Federal highway 11 and is served by the Baltimore and Ohio and the Chesapeake and Ohio railways. Pop. 10,623 in 1920, 17% negroes; estimated locally at 12,500 in 1928. It is a city of beautiful residences and numerous schools and institutions. The manse of the First Presbyterian church was the birthplace and childhood home of Woodrow Wilson. About 20 m. S. of the city is the homestead of Cyrus McCormick, where he invented the reaper. Within 50 m. are five great caverns, Natural Bridge, and other points of interest. Just east of the city is a national cemetery, and west of it a Confederate cemetery. Staunton was the first city in America to adopt a city-manager form of government (1908).

The first settlement in the vicinity was made in 1731, 2 m. E. of the present city. A county court-house was built in 1745, and the name Staunton (the family name of the wife of Sir William Gooch) was adopted about 1748. In 1781, when Col. Tarleton drove the general assembly of Virginia across the Blue Ridge, they took refuge here, holding their sessions for a time in the old Trinity Episcopal church. During the Civil War Staunton was an important supply-base for the army of northern Virginia and for Jackson's Valley campaign, and it was twice occupied by Federal troops. It was chartered as a city in 1870.

STAUROLITE, a mineral consisting of basic aluminium and ferrous iron silicate with the formula $HFeAl_5Si_2O_{13}$. The material is, however, usually very impure, the crystals enclosing sometimes as much as 30 or 40% of quartz and other minerals as well as carbonaceous matter. Crystals are orthorhombic and have the form of six-sided prisms. Interpenetrating cruciform twinned crystals are very common and characteristic; they were early known as *pierres de croix* or *lapis crucifer*, and the name staurolite has the same meaning (Greek, *σταυρός*, a cross, and *λίθος*, a stone). In fig. 1 the twin-plane is (032) and the two prisms intercross at an angle of 91° 22′; in fig. 2 the twin-plane is (232) and the prisms intercross at nearly 60°. The mineral is translucent to opaque and dark reddish-brown in colour. Waterworn pebbles of material sufficiently transparent for cutting as gem-stones are occasionally found in the diamantiferous sands of Brazil. The hardness is 7·5, specific gravity 3·75. Staurolite is a characteristic mineral of crystalline schists, and it is also a product of contact-metamorphism. (L. J. S.)



FIGS. 1 & 2.—TWIN CRYSTALS OF STAUROLITE

STAVANGER, a seaport of Norway, capital of Stavanger *amt* (county), on the west coast on the Bukken fjord. Pop. (1921) 46,822. The town is one of the oldest in Norway, founded in the 8th or 9th century, but the greater part of the present town is modern and built of stone. It became the seat of a bishopric in the 13th century, and though the see was removed to Christian-sand in 1685, it was restored in 1925. The cathedral church of St. Swithun, founded by the English bishop Reinald at the end of the 11th century, and rebuilt after being burned in 1272, is, next to the cathedral of Trondhjem, the most interesting stone church in Norway. The old episcopal palace of Kongsgaard is now a Latin school. The fisheries are important—for herring, mackerel, sprats, cod, salmon, lobsters and anchovies. The extraordinary growth of Stavanger during the last half century is mainly due to the development of its fish-canning industry. Other industries are the making of iodine from seaweed, and shipbuilding.

STAVELEY, town, in the north-eastern parliamentary division of Derbyshire, England, 12 m. S.E. of Sheffield, on the L.M.S. and L.N.E. railways. Pop. (1921) 12,646. It lies in the valley of the Rother, in a populous industrial district.

STAVELOT, town on the Amblève, province of Liége, Belgium. Pop. (1925) 5,724. Here Charles Martel gained a signal victory over Neustria in 719. The prince-abbot of the monastery of Stavelot (established 7th century) exercised secular authority over many towns in the Amblève and Warche valleys, including Malmédy, and had a seat in the old German Diet.

STAVROPOL, a former government of Russia, now in the Caucasian Area, North (*q.v.*).

STAVROPOL, a town of Russia, in the North Caucasian Area, in 45° N., 41° 58′ E., situated on a plateau 2,030 ft. above sea-level, on the northern slope of the Caucasus. The railway from Rostov-on-Don passes through it. Pop. (1926) 57,488. The town has textile and oil-pressing factories and manufactures agricultural machinery. It is a centre for Armenian, Georgian and Persian trade.

STAWELL, a municipality of Borung county, Victoria, Australia, 179 m. by rail W.N.W. of Melbourne. Pop. (1921) 4,413. The quartz reefs of the Pleasant Creek goldfields near the town are worked at very deep levels and there are cyanide plants.

STEAD, WILLIAM THOMAS (1849–1912), English journalist, was born at Embleton, Northumberland, on July 5, 1849, the son of a Congregational minister. He was early apprenticed in a merchant's office at Newcastle-on-Tyne; he soon gravitated, however, into journalism, and in 1871 became editor of the Darlington *Northern Echo.* In 1880 he went to London to be assistant editor of the *Pall Mall Gazette* under John Morley, and when the latter retired he became editor (1883–1889). Up to 1885 he had distinguished himself for his vigorous handling of public affairs, and his brilliant modernity in the presentation of news. He introduced the "interview," made a feature of the *Pall Mall* "extras" (*see* also NEWSPAPERS: *London*), and his enterprise and originality exercised a potent influence on contemporary journalism and politics. In 1885 he entered upon a crusade against vice by publishing a series of articles on the "Maiden Tribute of Modern Babylon." Though his action undoubtedly furthered the passing of the Criminal Law Amendment Act, it made his position on the paper impossible; and he was imprisoned in Holloway gaol for three months on a charge arising out of his crusade. On leaving the *Pall Mall* he founded the monthly *Review of Reviews* (1890). He started cheap reprints (*Penny Poets* and *Prose Classics,* etc.), conducted a spiritualistic organ, called *Borderland* (1893–1897), in which he gave full play to his interest in psychical research; and became an enthusiastic supporter of the peace movement, and of many other movements, popular and unpopular. He wrote with facility and sensational fervour on all sorts of subjects, from *The Truth about Russia* (1888) to *If Christ came to Chicago* (1893), and from *Mrs. Booth* (1900) to *The Americanization of the World* (1902). In private life his keen sense of merit and kindly interest influenced many aspirants to journalism and literature. Stead went down in the "Titanic" on April 15, 1912.

See *Life of W. T. Stead* (1913), by his daughter; and F. Whyte, *Life of W. T. Stead* (1925).

STEAM, the vapour of water. In the pure state it is a dry invisible gas. Often, however, as in a jet escaping from the spout of a kettle or the funnel of a locomotive, it is mixed with minute particles of water which are produced by condensation of portions of the gas. In such a mixture the suspended particles of water constitute a visible cloud. Any mixture of steam with water, whether in such a cloud or in the working chamber of an engine or turbine, is often spoken of as wet steam.

Its properties are most conveniently described by imagining an experiment in which steam is formed by applying heat to a small quantity of water contained at the bottom of a large upright cylindrical vessel. Suppose that the vessel is fitted with a piston which rests on the water to begin with and can rise when the fluid below it is made to change from water into steam by applying heat. Imagine further that the piston is frictionless and carries a definite weight so that, as the piston rises, the fluid continues to be subjected to a constant pressure, say, p lb. per square inch.

Saturated Steam.—When heat is applied, no steam is formed until the temperature of the water is raised to a value T which depends on p. Steam then forms, raising the piston, and this goes on without further rise of temperature until all the water is converted into steam, when it occupies a certain volume V. During this stage the steam is said to be *saturated.* T is the temperature of saturation corresponding to the pressure p, and is the lowest temperature at which steam can exist in stable equilibrium at that pressure.

Superheated Steam.—Suppose now, after all the water has turned into steam, that we go on applying heat. The temperature will rise and the volume will increase beyond V if we keep p constant, or the pressure will increase beyond p if we then fix the piston so as to keep V constant. In either case the steam is said to be *superheated.*

Steam is superheated when its temperature is raised in any manner to a value which exceeds the temperature of saturation corresponding to the actual pressure. Thus for example steam may change from the saturated to the superheated condition by being compressed (without loss of heat), or by passing (without loss of heat) through a throttle valve into a region of lower pressure. When steam is so "throttled" its temperature falls to some extent, but remains higher than the temperature of saturation corresponding to the reduced pressure.

Properties of Steam: Callendar's Tables.—The physical properties of steam have been the subject of systematic experimental enquiry by Regnault and many later observers. Our modern knowledge of them is largely due to H. L. Callendar who, with the help of formulas the basis of which is partly theoretical and partly empirical, has rationalized the experimental data and has compiled comprehensive tables for the use of engineers. Callendar's tables, published in 1915 and in an enlarged form in 1924, set forth all the important properties throughout a suitable range of pressures and temperatures. From the principles of thermodynamics (*q.v.*) it is known that certain relations hold between various properties, in steam or any other vapour; the values stated by Callendar, besides being founded on the best available data, are consistent with these relations. They apply to the superheated as well as to the saturated state; saturation is to be regarded as only a limiting case.

So long as steam is saturated the relation of temperature to pressure is definite. But steam may be superheated to any temperature above the saturation temperature at which it is formed in the boiling of water, and the temperature then becomes an independent variable. This affects certain other properties with which the steam engineer is concerned, namely:—

The volume V,
The internal energy E,
The total heat I,
The entropy ϕ,

all of which are to be reckoned per lb. of the substance. Each of these quantities has a definite value for steam or for water in any assigned state of pressure and temperature. Steam tables usually follow a convention, according to which quantities such as the energy or the entropy are treated as zero for water at 0° C; the tabulated numerical value accordingly expresses the amount by which the quantity in question has changed when the substance passes from that zero condition to the actual state.

Internal Energy.—When steam is formed (starting, say, from the state of water at 0° C) heat is taken in, and some external work is done by the expansion of the substance. The difference, which depends simply on the final state and not on the manner of formation, is called the *internal energy E*.

Total Heat.—The total heat I is conveniently defined by the equation

$$I = E + APV,$$

where P and V are respectively the pressure and volume of the substance, and A is a factor which converts units of work into units of heat. Hence when the substance is heated under constant pressure the change of I is measured by the quantity of heat that is taken in, for it is then equal to the gain of internal energy plus the work done. In a process of throttling it is easy to show that I does not change, provided there is no loss of heat to other bodies.

Entropy.—To define entropy, it may be said that when the substance takes in heat in a reversible manner (namely a manner which excludes the existence of any turbulent movement) its entropy changes by the amount $\frac{Q}{T}$ where Q is the heat taken in and T is the temperature (on the absolute scale) at which it is taken in. If T is itself changing while the heat is being taken in, we must write this change of entropy as $\int\frac{dQ}{T}\cdot$ Thus when steam is formed in a quietly steaming boiler, at a constant temperature T, from water at the same temperature, the entropy ϕ changes by the quantity $\frac{L}{T}$, where L is the "latent heat." Like the other quantities, the entropy of water at 0° C is reckoned as zero for convenience in tabulation. Both the entropy of steam and the total heat are quantities of great importance in the theory of the steam-engine (*q.v.*).

Critical Temperature.—Imagine a quantity of superheated steam at any usual temperature to be compressed while the temperature is kept constant. When the pressure reaches a certain value condensation begins, and we are then dealing with a substance which is partly water and partly saturated steam. The pressure in question is that which corresponds to saturation at the assumed constant temperature. This pressure will not rise further until all is condensed: after that the pressure on the water may of course be increased to any extent. The process is discontinuous, with three distinct stages. Suppose this experiment to be repeated at various temperatures: it will be found that when the temperature is sufficiently high there is no stage during which both water and steam are present together. When this temperature is reached or exceeded, the substance passes, as its pressure is increased, from the condition of steam to that of water—from vapour to liquid—in a continuous manner without ever being a mixture of the two. The lowest temperature at which this can happen is called the *critical Temperature,* and the limit of pressure above which the substance cannot exist as a non-homogeneous mixture of liquid and vapour is called the *critical Pressure.* These conditions of pressure and temperature constitute the "critical point." The critical temperature of steam is about 374° C and the critical pressure about 3,158 lb. per square inch.

The properties of steam in the neighbourhood of the critical point are less exactly known than at lower and more usual pressures. The "characteristic equation" on which Callendar founds many of his tabulated values applies with sufficient exactness within the lower range of pressures commonly met with in engineering practice. It takes the form

$$V = \frac{RT}{P} - c + b,$$

where V is the volume (per lb.), T is the absolute temperature, P is the pressure, R is a constant relating to the ideal volume of a "perfect" gas, b is a constant which expresses the additional volume of the molecules, and c is a term, depending on the temperature, which expresses the loss of volume through "coaggregation" or temporary association of molecules. The equation is applicable to the superheated as well as the saturated state.

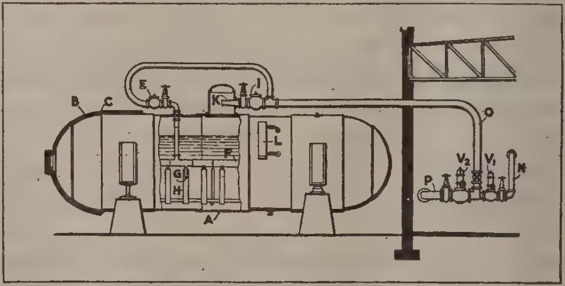
Super-saturation.—When steam is cooled to a temperature at which condensation should occur, it is found, when no nuclei are present about which water droplets may form, that the temperature may fall some way below the temperature of saturation before condensation begins. A temporary and unstable state may accordingly be produced, called *super-saturation.* The vapour in this condition may be described as supercooled: its state is analogous to that of a liquid cooled below its melting point without crystallization.

Water-vapour in Air.—Water vapour is one of the constituents of the atmosphere, the proportion depending not only on the temperature but on other causes which affect local dryness. At any given temperature air is said to be saturated with water vapour when the proportion present is such as to exert a partial pressure equal to the pressure of saturation corresponding to the given temperature. Any excess tends to be thrown out as mist or rain: any less quantity than that required for saturation is held as an invisible constituent, namely, in the state of superheated steam. The quantity of water-vapour present in air may be expressed as a fraction of the quantity which would cause saturation: this fraction is called the "relative humidity" of the air. The "dew-point" is the temperature to which air must be cooled to allow a deposit of water to take place.

Air is often dried for industrial uses by cooling it to a very low temperature. This causes it to deposit nearly all its contained moisture, which is then drained away, leaving only the trifling quantity that suffices to produce saturation at the low temperature. When the air returns to normal temperature without taking up more water its relative humidity is very small.

See Regnault, in *Mém. Inst. France* (1847, Vol. XXI.); H. L. Callendar, *Properties of Steam* (1920), and *The Callendar Steam Tables* (1915); J. A. Ewing, *Thermodynamics for Engineers* (1920).

(J. A. E.)



BY COURTESY OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS

FIG. 1.—MECHANICAL DRAWING OF A COMPLETE ACCUMULATOR INSTALLATION

STEAM ACCUMULATORS are devices for equalizing steam flow and steam demand. They are inserted between the source of steam supply and the point where it is used for the purpose of absorbing steam at times of low demand and releasing it when needed; several types have been developed. One of the earliest was the Rateau accumulator or regenerator. Its primary purpose was to utilize the intermittent exhaust from prime movers—such as steel rolling-mill engines—for driving low-pressure turbines carrying a fairly constant load; installed in the steam line between these two units, it served to equalize supply and demand, the turbine governor being designed to admit live steam when necessary. Another type is the Smoot accumulator, designed primarily for use in gas manufacturing plants. It collects, or accumulates, in a steel tank the exhaust from pumps and auxiliaries and from the hot-water drips; by decreasing the pressure in this tank steam is made available for the intermittent operation of the water-gas apparatus, and deficiency in supply is taken care of by a live steam "make-up" valve. The latest development is known as the Ruths steam accumulator, and while it operates on the same general principle as the others, it has been applied over a wider field of usefulness. Specially designed governor valves make its operation entirely automatic up to 200 lb. per sq.in. and through greater pressure ranges (fig. 1). The tank A is filled with water to 90% of its capacity, and the regulating valves V-1 and V-2 automatically control the charging and discharging of the accumulator. The accumulator must be placed between the high and the low pressure steam line, and its pressure varies between these limits; accumulated steam is made available by the regulating valves in such a way as to maintain uniform steam pressures in the low pressure steam lines. Any steam generated by the boilers and not used by the high pressure consumers overflows through valve *V-1* into the accumulator. *V-2* maintains a uniform pressure in the line *P* carrying the low pressure steam, so that if the valve *V-1* is passing more steam than is required in the low pressure line, the excess is stored in the accumulator. Charging nozzles *G* are equipped with circulating pipes *H* which permit a uniform and noiseless heating of the water. Should a sudden demand for high pressure steam arise the boiler pressure would drop slightly, *V-1* would close and a certain amount of steam would become available at or near this higher pressure. This diversion to the high pressure line of steam intended for the lower pressures would cause a deficit in the low pressure line. *V-2* would then open and the heat energy previously stored in the accumulator would instantly flash into steam to meet this deficit. Should the sudden increase in demand be caused by low pressure consumption and the flow through *V-1* not sufficient, the accumulator would supply it. (R. A. L.)

STEAM-CHEST is a box cast on or attached to the side of a steam cylinder, and containing the slide-valve which slides over the steam and exhaust ports, and uncovers these in turn. A stuffing-box maintains the valve-rod steam-tight. Some engines have two valves, one sliding upon the top of the other, for the purpose of giving expansive working of the steam. Cylindrical or piston valves are used extensively in marine and locomotive cylinders, as they give a balanced effect all around. In locomotive practice these valves have to be placed above the cylinders in many cases for reasons of design.

STEAM COAL: *see* COAL AND COAL MINING.

STEAM ENGINE. A steam engine is a heat engine in which the working substance is steam. By a heat engine is meant a machine for doing mechanical work through the agency of heat: it does this by taking in heat at comparatively high temperature, converting part of the heat into another form of energy, and rejecting the remainder of the heat at a lower temperature. The working substance is the vehicle by which heat is taken in and rejected. In a steam engine, the substance takes in heat mainly in a separate vessel—the boiler—in the process of being vaporized; it does work by expanding under pressure and thereby converts part of the heat that is taken in; finally the remainder of the heat is rejected, either by allowing the steam to escape into the atmosphere, as in locomotives, or by condensing it at a comparatively low temperature and pressure, as in marine and many other engines. This gives a broad distinction between non-condensing and condensing steam engines. The latter have the great advantage that they allow the effective expansion of the steam to be carried much farther; the substance rejects heat at a lower limit of temperature, and this enables the engine to convert into work a larger fraction of the heat which it has received. That fraction expresses what is called the *efficiency* of the engine as a contrivance for converting heat into work. The addition of a condenser, while it increases the efficiency, of course complicates the mechanism: it requires a supply of cooling water or some equivalent means of keeping down the temperature by absorbing the heat which the steam gives up in the act of being condensed, and also a pump or other means of removing the condensed substance together with any air that may be present. But the advantage which it brings about in respect of efficiency is so great that all engines of large power, where economy of fuel is an important factor, and where the use of a condenser is practicable, are of the condensing kind.

Given the upper limit of temperature, at which heat is taken in, the efficiency which the engine may attain is determined by the lowness of the temperature at which heat is rejected. Similarly, when the lower limit of temperature, at which heat is rejected, is assigned, the efficiency which the engine may attain is increased by raising the temperature at which the working substance takes in heat. To secure high efficiency there must be a wide range through which the temperature of the working substance falls, as a consequence of expansion within the engine, from the level of temperature at which heat is received to the level at which heat is rejected. Thus in the steam engine the most efficient performance, that is to say the greatest output of work in relation to the heat supplied, is secured by keeping the condenser as cold as the available cooling water will allow, and at the same time using a high boiler pressure, so that the working substance is very hot while it receives heat in the act of changing from water into steam. For this reason, modern practice tends towards higher and higher boiler pressures, as the mechanical difficulties of boiler construction and high pressure working are overcome.

After conversion into steam the working substance may take in a supplementary supply of heat on its way from the boiler to the engine, by passing through a *superheater*, in which its temperature is raised above that of the boiler. A common form of superheater is a group of parallel pipes with their surfaces exposed to hot gases of the boiler furnace.

Steam engines are classified into two general types according to the manner in which the steam does work during its expansion. In the first, or piston-and-cylinder type, the steam, in a confined space, namely the part of the cylinder behind the piston, enlarges the volume of that space by pushing the piston forward. It does work by exerting a static pressure on the moving piston: the movement of the steam itself is of no significance. In the second class, to which belong all kinds of steam turbines, the action is less direct. The pressure of the steam is first employed to set the steam itself into motion, forming a jet or group of jets, the momentum of which causes work to be done on a moving part of the machine, either by the impulsive action of the jet or jets on revolving vanes, or by the reaction on revolving guide-blades during the formation of the jets, or, as in Parsons' turbine, by a combination of impulse and reaction. In any turbine the action of the steam is kinetic, in contrast with its static action in an engine of the piston type. In both types there is progressive expansion of the steam from the high pressure and relatively small volume at which it is admitted, to the low pressure and relatively very great volume at which it is discharged. The principle already stated, that a large range of temperature and pressure, between admission and exhaust, is essential to efficiency applies equally to both types. In practice, the turbine has a notable advantage over the piston-and-cylinder engine in this respect, that it allows the last stages of the expansion, when the volume of the steam has become very great, to be effectively utilised, to a degree which is impracticable in the other type, because of the enormous size which the cylinder would have to assume and the waste of work that would be caused by piston friction, if the steam were expanded down to a very low pressure by the piston method. The turbine method escapes these difficulties; mainly for that reason it has become the most efficient way of converting heat into work, on a large scale, through the agency of steam. It has further advantages in compactness, in simplicity of working, and in the facility with which it can be adapted to take steam of exceptionally high initial pressure and high superheat.

HISTORICAL

In any historical sketch of the steam-engine, stress must be laid on the work of James Watt. But a process of evolution had been going on before his time which prepared a crude and primitive device for the immense improvements it received at his hands. The labours of Watt stand in natural sequence to those of Newcomen, and Newcomen's to those of Papin and Savery. Savery's engine, in its turn, was the reduction to practical form of an ancient scientific toy. Along another line of development, the modern steam turbine, which we owe to the genius of Charles Parsons, can be traced back to an early prototype.

In the *Pneumatica* of Hero of Alexandria (*c.* 130 B.C.) there is described the aeolipile, which may be called a primitive steam reaction turbine. It consists of a hollow globe pivoted so that it can turn on a pair of central trunnions, and supplied with steam through one of them, which is hollow. The steam escapes from the globe to the outside air through two bent pipes facing tan-

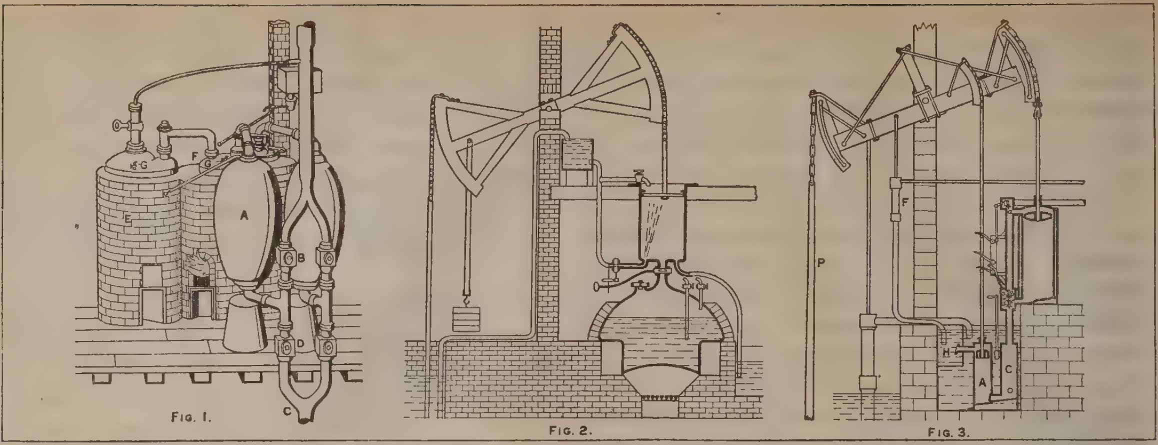


FIG. 1. FIG. 2. FIG. 3.

FIG. 1. SAVERY'S STEAM ENGINE (1698). FIG. 2. NEWCOMEN AND CAWLEY STEAM ENGINE (1705). FIG. 3. THE WATT PUMPING ENGINE

gentially in opposite directions at the ends of a diameter perpendicular to the axis. The globe revolves by reaction from the escaping steam. Hero's volume also mentions (Greenwood's translation of Hero's *Pneumatica*) another device which may be described as the prototype of the pressure engine. A hollow altar containing air is heated by kindling a fire on it; the air expands and by its pressure drives some of the water in a vessel below into a hanging bucket, which then descends, opening the doors of a shrine. When the fire is extinguished the air contracts, the bucket empties, and the doors close.

In a treatise on pneumatics (1601) by Giovanni Battista della Porta there is shown a somewhat similar apparatus, but with steam for working substance. Its pressure forces up water from a separate vessel. He also points out that the condensation of the steam may be used to produce a vacuum and thereby suck up water from a lower vessel. His suggestions go far to anticipate the engine which, a century later, in the hands of Savery, became the first commercially successful steam engine.

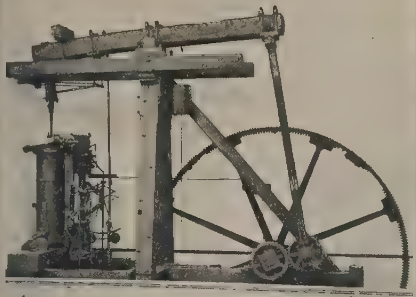
Meanwhile Edward Somerset, second Marquis of Worcester, described in his *Century of Inventions* (1663) a method of raising water by the agency of steam. His description is obscure, and no drawings of the device are extant. It appears to have consisted of a pair of displacement chambers, from each of which alternately water was forced, probably by admitting steam from an independent boiler, while the other vessel was allowed to refill.

Savery, 1698.—The earliest steam-engine to take a practical form and find employment in industry was that of Thomas Savery, who, in 1698, obtained a patent for a water-raising engine, shown in fig. 1. Steam is admitted to one of the oval vessels *A*, displacing water, which it drives up through the check-valve *B*. When the vessel *A* is emptied of water the supply of steam is stopped, and the steam already there is condensed by allowing a jet of cold water from a cistern above to stream over the outer surface of the vessel. This produces a vacuum and causes water to be sucked up through the pipe *C* and the valve *D*. Meanwhile steam has been displacing water from the other vessel, and is ready to be condensed there. The valves *B* and *D* open only upwards. The supplementary boiler and furnace *E* are for feeding water to the main boiler; *E* is filled while cold and a fire is lighted under it; it then forces a supply of feeding-water into the main boiler *F*. The gauge cocks *G, G* are an interesting detail. Another form of Savery's engine had only one displacement-chamber and worked intermittently. In the use of artificial means to condense the steam, and in the application of the vacuum so formed to raise water by suction from a level lower than that of the engine, as well as in practical features, Savery's engine marked an inventive advance. It found considerable employment in pumping mines and in raising water to supply houses and towns, and even to drive water-wheels. A serious difficulty which prevented its general use in mines was the fact that the height through which it would lift water was limited by the pressure the boiler and vessels could bear. Pressures as high as 8 or 10 atmospheres were employed—and that, too, without a safety-valve—but Savery found it no easy matter to deal with high-pressure steam. Apart from this drawback, the waste of fuel was enormous, from the condensation of steam which took place on the surface of the water and on the sides of the displacement-chamber at each operation; the consumption of coal was, in proportion to the work done, some twenty times greater than in a modern engine.

Before Savery's engine was displaced by its successor, Newcomen's, it was improved by J. T. Desaguliers who applied to the safety valve (invented by Papin), and substituted condensation by a jet of cold water within the vessel for the surface condensation used by Savery. To Savery is ascribed the first use of the term "horse-power" as a measure of performance.

In 1690 Denis Papin suggested that the condensation of steam should be employed to make a vacuum under a piston previously raised by the expansion of the steam. Papin's was the earliest cylinder and piston steam engine, and his plan of using steam was that which afterwards took practical shape in the atmospheric engine of Newcomen. But his scheme was made unworkable by the fact that he proposed to use but one vessel as both boiler and cylinder. A small quantity of water was placed at the bottom of a cylinder and heat was applied. When the piston had risen the fire was removed, the steam was allowed to cool, and the piston did work in its down-stroke under the pressure of the atmosphere. After hearing of Savery's engine in 1705 Papin turned his attention to improving it, and devised a modified form, with a floating diaphragm or piston on the top of the water to keep the water and steam from direct contact with one another. Papin's engine may be described as a non-condensing single-acting steam pump, with steam cylinder and pump cylinder in one.

Newcomen's Atmospheric Engine, 1705.—While Papin was thus going back from his first notion of a piston engine to Savery's cruder type, a new inventor had appeared who made the piston engine a practical success by separating the boiler from the cylinder and by using (as Savery had done) artificial means to condense the steam. This was Thomas Newcomen, who in 1705, with his assistant, John Cawley, gave the steam engine the form shown in fig. 2. Steam admitted from the boiler to the cylinder by the opening of a valve allowed the piston to be raised by a heavy counterpoise on the other side of the beam. Then the steam valve was shut and a jet of cold water entered the cylinder and condensed the steam. The piston was consequently forced down by the pressure of the atmosphere and did work on the pump. The next entry of steam expelled the condensed water from the cylinder through an escape valve. The piston was kept tight by a layer of water on its upper surface. Condensation was at first effected by cooling the outside of the cylinder, but an accidental leakage of the packing water past the piston showed the advantage of condensing by a jet of injection water, and this plan took the place of surface condensation. The engine used



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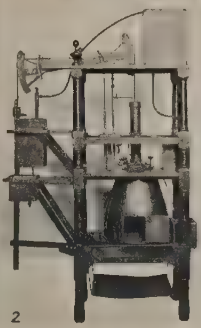

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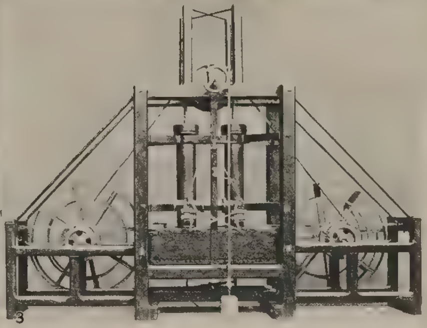

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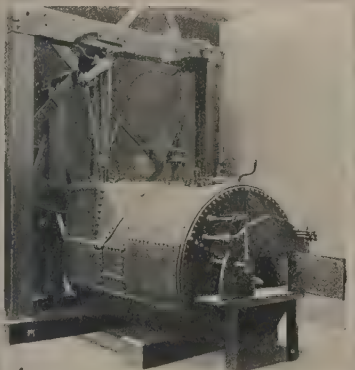

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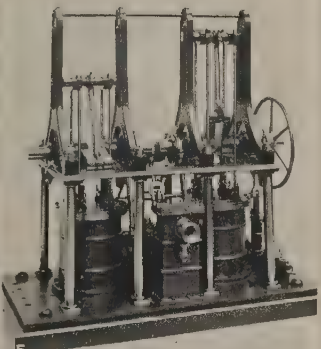

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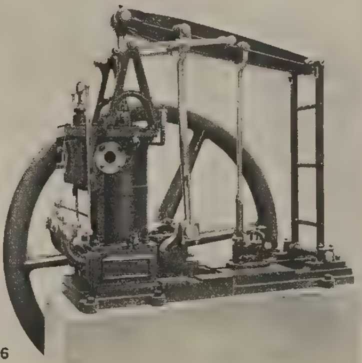

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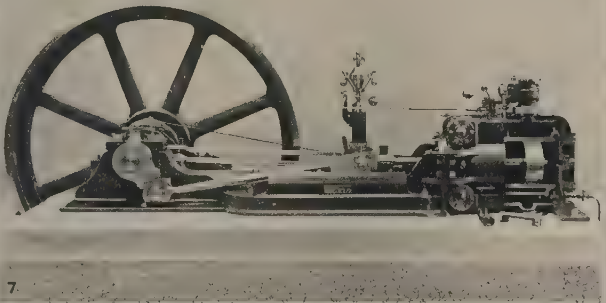

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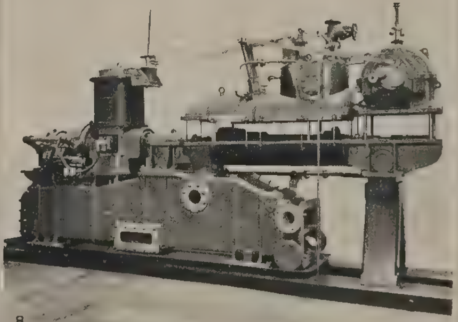

8

BY COURTESY OF THE SCIENCE MUSEUM, LONDON

THE PROGRESS OF THE STEAM ENGINE

1. One of Boulton and Watt's early (1789) rotative steam engines, among the first to utilize the double-acting principle
2. Model of Newcomen's steam engine (1719), the precursor of Watt's engine, and successfully used in pumping and mine drainage. Newcomen created a vacuum within the cylinder by the condensation of steam
3. Symington's original marine steam engine (1788), first used to propel a paddle-boat on Dalswinton Loch, Scotland, at a speed of about 4 m. per hour
4. Trevithick's high-pressure, or non-condensing engine (1811)
5. Quadruple piston-rod steeple paddle engine (1842)
6. Grasshopper engine (1862), so-called because of the obvious resemblance of its upper and right-hand portions to that insect
7. Model of single-cylinder horizontal engine (1898), with Corliss valve gear. A sectional view at the right end of cylinder reveals the piston and valve construction
8. Parsons' turbo-generator (1902), with upper turbine casing lifted to show rotor

steam whose pressure was little if at all greater than that of the atmosphere.

About 1711 Newcomen's engine began to be introduced for pumping mines. It is doubtful whether the action was originally automatic, or depended on the periodical turning of taps by an attendant. The common story is that in 1713 a boy named Humphrey Potter, whose duty it was to open and shut the valves of an engine he attended, made the engine self-acting by causing the beam itself to open and close the valves by suitable cords and catches. This device was simplified in 1718 by Henry Beighton, who suspended from the beam a rod called the plug-tree, which worked the valves by means of tappets. By 1725 the engine was in common use in collieries, and it held its place without material change for about three-quarters of a century in all. Near the close of its career Newcomen's engine was much improved in its mechanical details by John Smeaton, who built many large engines of this type about the year 1770, just after the great step which was to make Newcomen's engine obsolete had been taken by James Watt.

Compared with Savery's engine, Newcomen's had (as a pumping engine) the great advantage that the intensity of pressure in the pumps was not in any way limited by the pressure of the steam. It shared with Savery's, in a scarcely less degree, the defect already pointed out, that steam was wasted by the alternate heating and cooling of the vessel into which it was led. Though obviously capable of more extended uses, it was in fact almost exclusively employed to raise water—in some instances for the purpose of turning water-wheels to drive other machinery. Even contemporary writers complain of its great consumption of fuel.

James Watt, 1763, 1769, 1781, etc.—In 1763 James Watt, an instrument maker in Glasgow, while engaged by the University in repairing a model of Newcomen's engine, was struck with the waste of steam to which the alternate chilling and heating of the cylinder gave rise. He saw that the remedy, in his own words, would lie in keeping the cylinder as hot as the steam that entered it. With this view he added to the engine a new organ—namely the "separate condenser"—an empty vessel separate from the cylinder, into which the steam should be allowed to escape from the cylinder, to be condensed there by the application of cold water either outside or as a jet. To preserve the vacuum in his condenser he added a pump called the air pump, whose function was to extract from it the condensed steam and water of condensation, as well as any air which might come in by leakage or by solution in the steam or the injection water. Then, as the cylinder was no longer used as a condenser, he was able to keep it hot by clothing it with non-conducting bodies, and in particular by the use of what is called a steam-jacket—a layer of hot steam between the cylinder and an external casing. Further and still with the same object, he covered in the top of the cylinder, taking the piston-rod out through a steam-tight gland or stuffing-box, and allowed steam instead of air to press upon the piston's upper surface. After much experiment Watt patented his improvements in 1769; they are described in a specification from which the following extracts are taken:—

"My method of lessening the consumption of steam, and consequently fuel, in fire-engines, consists of the following principles:—

"*First*, That vessel in which the powers of steam are to be employed to work the engine, which is called the cylinder in common fire-engines, and which I call the steam vessel, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first by inclosing it in a case of wood, or any other materials that transmit heat slowly; secondly, by surrounding it with steam or other heated bodies; and, thirdly, by suffering neither water nor any other substance colder than the steam to enter or touch it during that time.

"*Secondly*, In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam-vessels or cylinders, although occasionally communicating with them; these vessels I call condensers; and, whilst the engines are working, these condensers ought at least to be kept as cold as the air in the neighbourhood of the engines, by application of water or other cold bodies.

"*Thirdly*, Whatever air or other elastic vapour is not condensed by the cold of the condenser, and may impede the working of the engine, is to be drawn out of the steam-vessels or condensers by means of pumps, wrought by the engines themselves, or otherwise.

"*Fourthly*, I intend in many cases to employ the expansive force of steam to press on the pistons, or whatever may be used instead of them, in the same manner in which the pressure of the atmosphere is now employed in common fire-engines. In cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the air after it has done its office."

The "common fire-engine" alluded to was the steam engine of Newcomen. Highly important as Watt's first inventions were, they resulted for a time in the production of nothing more than a greatly improved engine of the Newcomen type, much less wasteful of fuel, able to make faster strokes, but still only suitable for pumping, still single-acting, with steam admitted during the whole stroke, the piston, as before, pulling the beam by a chain working on a circular arc. The condenser was generally worked by injection, but Watt has left a model of a surface condenser made up of small tubes, in every essential respect like the condensers now used.

Fig. 3 is an example of the Watt pumping engine of this period. It should be noticed that, although the top of the cylinder is closed, and steam has access to the upper side of the piston, this is done only to keep the cylinder and piston warm. The engine is still single-acting; the steam on the upper side merely plays the part which was played in Newcomen's engine by the atmosphere; and it is the lower end of the cylinder alone that is ever put in communication with the condenser. There are three valves: the "steam" valve *a*, the "equilibrium" valve *b*, and the "exhaust" valve *c*. At the beginning of the down-stroke *c* is opened to produce a vacuum below the piston and *a* is opened to admit steam above it. At the end of the down-stroke *a* and *c* are shut and *b* is opened. This puts the two sides in equilibrium and allows the piston to be pulled up by the pump-rod P, which is heavy enough to serve as a counterpoise. C is the condenser, and A is the air-pump, which discharges into the hot well H, whence the supply of the feed-pump F is drawn.

In a second patent (1781) Watt describes the "sun-and-planet" wheels and other methods of making the engine give continuous revolving motion to a shaft provided with a flywheel. The crank and connecting-rod—already a familiar mechanical device from its use on the treadle of a lathe—would have been the natural means of doing this, but its application to the steam engine in a particular manner had been made the subject of a patent by James Pickard, and Watt, rather than make terms with Pickard, whom he regarded as a plagiarist of his own ideas, made use of his sun-and-planet motion until the patent on the crank expired. The reciprocating motion of earlier forms had served only for pumping; by making the steam engine drive a revolving shaft Watt opened up for it many other channels of usefulness. The engine was still single-acting; the connecting-rod was attached to the far end of the beam, and that carried a counterpoise which served to raise the piston when steam was admitted below it.

In 1782 Watt patented two further improvements of the first importance, both of which he had invented some years before. One was the use of double action, that is to say, the application of steam and vacuum to each side of the piston alternately. The other (invented as early as 1769) was the use of steam expansively, in other words the plan, essential to economy of fuel, of stopping the admission of steam when the piston had made only a part of its stroke, and allowing the rest of the stroke to be performed by the expansion of the steam already in the cylinder. To let the piston push as well as pull the end of the beam Watt devised his so-called parallel motion, an arrangement of links connecting the piston-rod head with the beam in such a way as to guide the rod to move in a very nearly straight line. He further added a throttle valve, for regulating the rate of admission of steam, and a centrifugal governor, in the form of a double conical pendulum, which controlled the speed by a throttle-valve.

Among other important devices associated with Watt was the "indicator," by which diagrams showing the relation of the steam pressure in the cylinder to the movement of the piston are automatically drawn: its invention seems to have been mainly due to his assistant John Southern.

In partnership with Matthew Boulton, Watt carried on in Birmingham the manufacture and sale of his engines with great success, and held the field against all rivals in spite of severe assaults on the validity of his patents. Notwithstanding his knowledge of the advantage to be gained by using steam expansively, he continued to employ only low pressures—seldom more than 7 lb. per square inch over that of the atmosphere. His boilers were fed, as Newcomen's had been, through an open pipe which rose high enough to let the column of water in it balance the pressure of the steam. He gave a definite numerical significance to the term "horse-power," defining it as the rate at which work is done when 33,000 lb. are raised one foot in one minute.

In the fourth claim of Watt's first patent, quoted above, the second sentence describes a non-condensing engine, which would have required steam of a higher pressure. This, however, was a line of invention which Watt did not follow up, perhaps because so early as 1725 a non-condensing engine had been described by Jacob Leupold in his *Theatrum machinarum.*

It was not till much later that the thermodynamic principles underlying the action of the steam engine came to be understood. Engineers were consequently slow to appreciate the fact that to obtain economy of fuel it was advantageous to employ a high initial pressure, in combination with much expansion in the cylinder and with the separate condenser of Watt.

Trevithick, Bull and Evans.—The introduction of the non-condensing and, at that time, relatively high-pressure engine was effected in England by Richard Trevithick and in America by Oliver Evans about 1800. Both Evans and Trevithick applied their engines to propel carriages on roads, and both used for boiler a cylindrical vessel with a cylindrical flue inside containing the fire —the construction now known as the Cornish boiler. In association with Edward Bull, Trevithick had previously made direct acting pumping-engines, with an inverted cylinder set over and in line with the pump-rod, thus dispensing with the beam that had been a feature in all earlier forms. But in these "Bull" engines, as they were called, the steam was condensed by a jet of cold water in the exhaust-pipe, and Boulton and Watt successfully opposed them as infringing Watt's patent. To Trevithick belongs the honour of being the first to use a steam carriage on a railway; in 1804 he built a locomotive in the modern sense, to run on what had formerly been a horse-tramway, in Wales. In this connection it may be added that as early as 1769 a steam carriage for roads had been built in France by Nicolas Joseph Cugnot, who used a pair of single-acting high-pressure cylinders to turn a driving axle step by step by means of pawls and ratchet-wheels. To the initiative of Evans may be ascribed the early general use of high-pressure steam in the United States, a feature which for many years distinguished American from English practice. (*See* LOCOMOTIVE.)

Compound Engine and Cornish Engine.—Among contemporaries of Watt the name of Jonathan Hornblower deserves special mention. In 1781 he constructed and patented what would now be called a compound engine, with two cylinders of different sizes. Steam was first admitted into the smaller cylinder, and then passed over into the larger, doing work against a piston in each. In Hornblower's engine the two cylinders were placed side by side, and both pistons worked on the same end of a beam overhead. This was an instance of the use of steam expansively, and as such was earlier than the patent, though not earlier than the invention, of expansive working by Watt. Hornblower was crushed by the Birmingham firm for infringing their patent in the use of a separate condenser and air-pump. The compound engine was revived in 1804 by Arthur Woolf, with whose name it is often associated. Using steam of fairly high pressure, and cutting off the supply before the end of the stroke in the small cylinder, Woolf expanded the steam to several times its original volume. Mechanically the two-cylinder compound engine has some advantage over a one-cylinder engine with the same amount of expansion, in exerting a more uniform driving effort. But another and more important merit of the system lies in the fact that by dividing the whole range of expansion into two parts the cylinders in which these are separately performed are subject to a reduced range of fluctuation in their temperature. This helps to limit a source of waste which is present in all piston engines, namely the waste which results from the heating and cooling of the metal by its alternate contact with hot and cooler steam. The introduction of compound expansion forms the most outstanding improvement which steam engines of the piston and cylinder type have undergone since the time of Watt.

Woolf introduced the compound engine somewhat widely about 1814 as a pumping engine in the mines of Cornwall. But here it met a strong competitor in the high-pressure single-cylinder engine of Trevithick, which had the advantage of greater simplicity in construction. Woolf's engine fell into comparative disuse, and the single-cylinder type took a form which, under the name of the Cornish pumping-engine, was for many years famous for its great economy of fuel. In this engine the cylinder was set under one end of a beam, from the other end of which hung a heavy rod which operated a pump at the foot of the shaft. Steam was admitted above the piston for a short portion of the stroke, thereby raising the pump-rod, and was allowed to expand for the remainder. Then an equilibrium valve, connecting the space above and below the piston, as in fig. 3, was opened, and the pump-rod descended, doing work in the pump and raising the engine piston. The large mass which had to be started and stopped at each stroke served by its inertia to counterbalance the unequal pressure of the steam, for the ascending rods stored up energy of motion in the early part of the stroke, when the steam pressure was greatest, and gave out energy in the later part, when the pressure was much lowered by expansion. The frequency of the stroke was controlled by a device called a cataract, consisting of a small plunger pump, in which the plunger, raised at each stroke by the engine, was allowed to descend more or less slowly by the escape of fluid below it through an adjustable orifice, and in its descent liberated catches which held the steam and exhaust valves from opening. A similar device controlled the equilibrium valve, and could be set to give a pause at the end of the piston's down-stroke, so that the pump-cylinder might have time to become filled.

The final revival of the compound engine did not occur until about the middle of the 19th century, and then several agencies combined to effect it. In 1845 John M'Naught introduced a plan of improving beam engines of the original Watt type, by adding a high-pressure cylinder whose piston acted on the beam between the centre and the fly-wheel end. Steam of higher pressure than had formerly been used, after doing work in the new cylinder, passed into the old or low-pressure cylinder, where it was further expanded. Many engines whose power was proving insufficient for the extended machinery they had to drive were "M'Naughted" in this way, and after conversion were found not only to yield more power but to show a marked economy of fuel. The compound form was selected by William Pole for the pumping engines of Lambeth and other waterworks about 1850; in 1854 John Elder began to use it in marine engines; in 1857 E. A. Cowper added a steam-jacketed intermediate reservoir for steam between the high- and low-pressure cylinders, which made it unnecessary for the stroke of the low-pressure piston to be just beginning when that of the other piston was just ending. As facilities increased for the use of high-pressure steam, compound expansion came into more general use, its advantage becoming more conspicuous with every increase in boiler pressure. In marine practice, where economy of fuel was from the first an obviously important factor in design, the principle of compound expansion was extended by the introduction of triple and even quadruple expansion engines.

Application to Locomotives and Steamboats.—The adaptation of the steam engine to railways, begun by Trevithick, became a success in the hands of George Stephenson, whose engine, the "Rocket," when tried along with others in 1829, distanced its competitors. The principal features of the "Rocket" were an improved steam-blast for urging the combustion of coal and a boiler (suggested by Henry Booth) in which a large heating surface was given by the use of many small tubes through which the hot gases passed. Further, the cylinders, instead of being vertical as in earlier locomotives, were set at a slope, which was afterwards altered to a position more nearly horizontal. To these features there was added later the "link motion," a contrivance which enabled the engine to be easily reversed, and the amount of expansion to be readily varied. In the hands of George Stephenson and his son Robert the locomotive took a form which in the main is retained by the far heavier locomotives (*q.v.*) now in use.

The first practical steamboat was the tug "Charlotte Dundas," built by William Symington, and tried in the Forth and Clyde canal in 1802. A Watt double-acting condensing engine, placed horizontally, acted directly by a connecting-rod on the crank of a shaft at the stern, which carried a revolving paddle-wheel. The trial was successful, but steam towing was abandoned for fear of injuring the banks of the canal. Ten years later Henry Bell built the "Comet," with side paddle-wheels, which ran as a passenger steamer on the Clyde; but an earlier inventor to follow up Symington's success was the American, Robert Fulton, who, after unsuccessful experiments on the Seine, fitted a steamer on the Hudson in 1807 with engines made to his designs by Boulton and Watt, and brought steam navigation for the first time to commercial success.

Rise in Steam Pressure and in Piston Speed.—With improvements in the details of design and construction it gradually became practicable to use higher steam pressures and higher piston speeds, and consequently to obtain not only greater efficiency, but also a greater amount of power from engines of given bulk. The triple expansion engine, introduced by A. C. Kirk in 1874, did not come into general use until after 1881. It became the normal type of marine engine, with pressures ranging, as a rule, from 150 to 200 lb. per sq. inch, piston speeds generally of 500 or 600 ft. per minute, but sometimes as high as 900 or 1,000, and coal consumption of about 1½ lb. per hour per indicated horsepower. It continues to be very largely used in steamships which are not driven by turbines. In some instances quadruple expansion has been preferred, with somewhat higher pressures, but when the pressure is much raised the tendency is to abandon the piston type in favour of the steam turbine. This is true both in marine and in land practice. The gigantic concentration of steam power that is found in a great steamship or in a power station has been made practicable by the turbine. The selection of Parsons turbines in 1907 as the motive engines of the Cunarders "Lusitania" and "Mauretania" constituted a new departure in steam engineering. It was then a novelty to develop some 70,000 horsepower in the engine room of a single ship. Many of the turbines in power stations now exceed this figure.

Introduction of the Steam Turbine.—The invention of the steam turbine has revolutionized marine engine practice, in respect especially of the largest and fastest vessels. For the generation of electricity the turbine has a notable advantage in directly developing the high speed of rotation which a dynamo requires, and, when designed on a large scale, its efficiency is unrivalled by steam engines of other kinds. To Sir Charles Parsons we owe not only the main idea of the modern steam turbine, but also the invention of many mechanical features and details essential to its practical success and general adaptation.

In the steam turbine, as we have seen, pressure, instead of being exerted on a piston, is employed in the first instance to set the fluid itself in motion. There is a conversion of pressure-energy into velocity-energy as a preliminary step towards obtaining the effective work of the machine. If this were done in a single step it would involve immensely high velocities in the steam jet and in the vanes on which the jet acts. Attempts to design a steam turbine were made by numerous inventors, but fell short of practical success mainly because of the difficulty of arranging for high enough velocity in the working parts to utilize a reasonably large fraction of the kinetic energy of the steam. There was a further difficulty in getting the energy of the steam into a suitable kinetic form, namely, to get the stream of issuing particles to take a single direction, without undue dispersion, when steam was allowed to expand through an orifice from a chamber at high pressure into a space where the pressure was greatly less.

In 1889 Dr. Gustaf de Laval introduced a form of steam turbine in which both of these difficulties were, to a considerable degree, overcome, partly by the special form of the nozzle used to produce the steam jet and partly by features of design which allowed an exceptionally high speed to be reached in the wheel carrying the vanes against which the steam impinged.

Parsons attacked the problem at an earlier date and in a different way, by his invention of the "compound" turbine. He divided the whole expansion of the steam into a great number of successive and separate steps and thereby limited the velocity acquired at each step to such an extent as to make it comparatively easy to extract the greater part of the kinetic energy as work done upon the moving blades, without making the velocity of these blades inconveniently high. Moreover, in Parsons's compound turbine the range of pressure through which the steam expands in each separate step is too small to cause any difficulty in the formation of the jets. The guide blades, which form the jets, are distributed round the whole circumference of the revolving wheel, and all the revolving blades are consequently in action at once. The steam streams from end to end of the turbine through an annular space between a revolving drum and the casing which surrounds it. Parallel rings of fixed guide blades project inwards from the casing at suitable distances, and between these are rings of moving blades which project outwards from the drum and revolve with it. At each step in the expansion the steam streams through a ring of fixed guide blades, and the streams so formed impinge on the next ring of moving blades, and so on. The construction, which is of great simplicity, is described, along with others, in the article TURBINE: STEAM. It lends itself well to the generation of power on a large scale, especially where a fairly high speed of rotation is wanted.

Parsons introduced his compound steam turbine in 1884. For some years it was made in small sizes only, and the steam was discharged to the atmosphere without condensation. So long, however, as this was done the steam turbine was sacrificing one of its most important advantages, namely, its exceptional capacity for utilizing the energy of low-pressure steam down to the lowest vacuum obtainable in a condenser. In 1891 it was first fitted with a condenser, and it then began to be used in electric supply stations. The first application to marine propulsion was in the "Turbinia," in 1897. The success of this little experimental vessel of 100 tons, which, with its horse-power of 2,100, made what was then a record in speed for any ship, was soon followed by the application of the turbine to war-ships and other steamers. In merchant vessels its use was at first limited to those of the highest speed, for the turbine shaft was directly coupled to the shaft of the screw propeller; but in 1910 Parsons introduced a mechanical reducing gear between the two, which allowed the turbine shaft to run much faster than the propeller shaft, to the great advantage in efficiency of both turbine and propeller. Later he followed this up by a "double-reduction" gearing which admitted of a still greater difference in speed of rotation between the propeller and the turbine. In most ships the single reduction system is sufficient for the purpose: its introduction greatly extended the range within which the turbine could be advantageously substituted for the three-cylinder or four-cylinder compound engine of the piston type in ocean-going steamships.

Enough has been said to show that the invention of the steam turbine is by far the most important step in steam engineering since the time of Watt. It solved the problem of using steam efficiently in an engine without reciprocating parts.

Early Theory.—In the early development of the steam engine inventors had little in the way of theory to guide them. Watt had the advantage of a knowledge of Joseph Black's doctrine of latent heat; but there was no philosophy of the relation of work to heat until long after the inventions of Watt were complete. The theory of the steam engine as a heat engine may be said to date from 1824, when N. L. Sadi Carnot published his *Réflexions sur la puissance motrice du feu*, a remarkable essay in which he showed that heat does work only by being let down from a higher to a lower temperature. But Carnot was not then aware that any of the heat disappears in the process, and it was not until the doctrine of the conservation of energy was established in 1843 by the experiments of James Prescott Joule that the theory of heat engines began a vigorous growth. From 1849 onwards the science of thermodynamics was developed with extraordinary rapidity by Rudolf Clausius, W. J. Macquorn Rankine and William Thomson (Lord Kelvin) and was applied, especially by Rankine, to practical problems in the use of steam. Rankine's *Manual of the Steam Engine*, published in 1859, was the first attempt at a systematic treatment of steam-engine theory. It involved the simplifying assumption that the cylinder and piston might be treated as behaving to the steam like non-conducting bodies, in other words, that the transfer of heat between the steam and the metal might generally be disregarded. One effect of this was to treat the volume of steam consumed per stroke as corresponding to the volume of the cylinder up to the point of cut-off. When steam enters the engine cylinder it finds the metal chilled by the previous exhaust, and a portion of it is at once condensed. This has the effect of increasing, often very largely, the volume of boiler steam required per stroke. As expansion goes on, the water that was condensed during admission begins to be re-evaporated, and this action is often prolonged into the exhaust. It is now recognized that exchanges of heat between the steam and its metal envelope cannot be ignored. They cause the actual performance to fall short, in some cases very much short, of the ideal limit. They may be reduced by suitable design.

ACTION OF RECIPROCATING ENGINES

Most, though not all, reciprocating engines are double-acting: that is to say, steam from the boiler is alternately admitted to each side of the piston. In each double stroke, or revolution, there are four events for each end of the cylinder:—(1) *Admission*, which begins by the opening of a steam-valve when the piston is at or very near the limit of its travel; (2) *Cut-off*, at which the steam-valve is closed and admission ceases. This may take place early in the stroke. The steam which is enclosed behind the piston then expands, with falling pressure, while the stroke continues, until (3) *Release* occurs; that is to say, an exhaust-valve opens, allowing the steam to escape from the cylinder. Its discharge generally continues for a large part of the back-stroke, until event (4), at which the exhaust-valve closes, and *Compression* begins: from there to the end of the back-stroke, the steam remaining in the cylinder is compressed into the clearance space behind the piston. This compression of the residue of steam, which is called cushioning, assists smoothness of working as the piston passes what is called the dead-point, at the limit of its stroke; and the cushioning effect is often augmented by giving the steam-valve what is called "lead,"—that is, causing it to open a little before the piston reaches the dead point.

Distribution of the Steam: Indicator Diagram.—Together, these various events of the stroke constitute what is termed the distribution of the steam. They are conveniently exhibited by drawing an indicator diagram of the action, such as that illustrated in fig. 4. There, on a base *PQ* which represents the stroke, lines are drawn to show the continuous changes of pressure that go on within the cylinder during the whole action. Starting from the beginning of the stroke at *a*, for one side of the piston, steam is admitted up to the point *b* which shows the cut-off. At (or near) the end of the forward stroke, at *c*, the steam is allowed to escape. Compression, in the return stroke, begins at *e*. From *b* to *c* the steam confined in the cylinder is expanding, with falling pressure, doing work on the piston. The whole work done in the revolution, namely the integral of the force acting on the piston and the distance through which it moves, is represented by the enclosed area of the indicator diagram, *a b c d*.

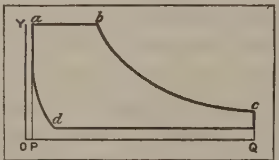

FIG. 4.—INDICATOR DIAGRAM SHOWING DISTRIBUTION OF STEAM

The diagram is idealised in the sense that the events are shown as if they happened suddenly, giving sharply defined changes from admission to expansion and so on. In any real engine the events are necessarily gradual, for no valve—whatever its type—can close or open quite instantaneously. A real indicator diagram accordingly has a smoother outline with rounded corners to mark the places of cut-off, release, compression and admission. In practice release always occurs before the piston has quite completed its stroke.

The distance *PQ* which represents the stroke may (by the use of an appropriate scale) be interpreted as a volume, namely the volume swept through by the piston, and a point *O* behind *P* may be so taken that *OP* represents, on the same scale, the volume of the clearance. The distance measured horizontally from the line *OY* to any point of the curve represents the whole volume of steam behind the piston at that point, and the curve between admission and release exhibits the relation of the pressure to the total volume of the steam enclosed behind the piston throughout its process of expansion.

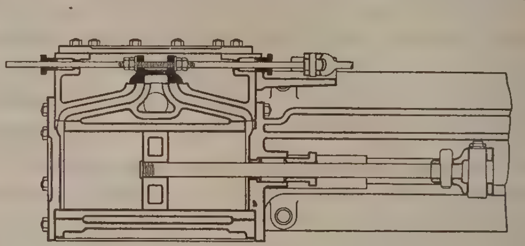

FIG.5.

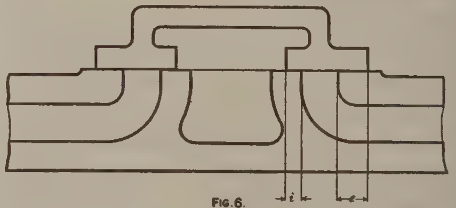

FIG.6.

FIG. 5.—CROSS SECTION DIAGRAM OF A SLIDE-VALVE SHOWING THE EXHAUST AND INLET PORTS BELOW IT, AND CYLINDER AND PISTON
FIG. 6.—CROSS SECTION OF SLIDE-VALVE IN MIDDLE POSITION: (I) INTERNAL LAP, (E) EXTERNAL LAP

Actual indicator diagrams may be automatically drawn by attaching to the cylinder of the engine a device in which a pencil is made to rise or fall proportionally to the variations of steam pressure, while a paper, on which it inscribes a record, moves back and forth horizontally through distances proportional to the movement of the engine piston. Many forms of indicator have been designed to give, in some such way, a diagram in which the coordinates represent respectively the displacement of the piston and the pressure of the steam against it. From such diagrams it is easy to infer the mean effective pressure throughout the stroke, and also to observe how the valves are working. By connecting the instrument successively to each of the two ends of the cylinder, in a double-acting engine, a complete record is obtained for the two strokes which make up a revolution. The "indicated horse-power" is determined by the formula

$$\text{I.H.P.} = \frac{nL(p_1A_1 + p_2A_2)}{33{,}000}$$

where A_1 and A_2 are the areas of the two sides of the piston, in square inches; p_1 and p_2 are the mean effective pressures on the two sides, in lb. per sq. inch, as determined from the diagrams; n is the number of revolutions per minute, and L is the stroke in feet. In trials of a steam engine such diagrams are taken during a considerable period. The amount and condition of the steam passing through the engine is observed, by measuring either the quantity of water discharged from the condenser (if of the surface type), or the quantity of feed-water required to be supplied to the boiler to keep the water level constant. From these data it becomes possible to compare the power developed with the heat supplied. Measurements of the heat rejected may also be made by observing the quantity of condensing water used and its rise in temperature; and together these figures give material for drawing up a balance sheet of the disposal of thermal energy.

The Slide-valve.—The admission and exhaust of steam, for each end of the cylinder, may be controlled by separate valves, but very commonly a single moving piece, called a slide-valve, serves to control the events for both ends. The slide-valve was invented by William Murdock, an assistant of Watt. A common form of it is illustrated in section in fig. 5, which also shows the cylinder, with the piston, and the steam ports and passages leading to each end of the cylinder. The face on which the valve slides is a plane surface on one side of the cylinder with three ports or openings which extend across the greater part of the cylinder's width. The central opening is the exhaust port, through which the steam escapes after doing its duty in the cylinder. The others, which are narrower, lead to the two ends. The valve itself is a box-shaped cover, sliding on the face, and contained in the valve-chest, or chamber to which steam is admitted from the boiler. When the valve moves a sufficient distance to either side of the middle position steam is admitted to one end of the cylinder, past the outer edge. Similarly steam escapes from the other end of the cylinder, through the cavity of the valve, to the exhaust port. The valve takes its motion from an eccentric on the engine shaft, which is set more than 90° ahead of the crank, so that the valve has already begun to uncover the port on one side when the piston is at the corresponding dead point, with the result that steam passes from the steam chest above the valve into the space behind the piston. Figure 6 shows a slide-valve in its middle position, and illustrates the internal lap *i* and the external lap *e* which the valve must have to make expansive working possible. At the beginning of the stroke it has already passed its middle position by an amount at least equal to *e*, so that steam may enter. It continues to move further, opening the port more widely, and then begins to return, while the piston is still advancing in the cylinder. At a particular point in its return the outer edge of the valve closes the port; this determines the instant of cut-off. The piston continues to advance, with expansion of the steam confined in the cylinder, while the valve continues to move back, until the inner edge of the valve begins to uncover the port, allowing steam from the cylinder to escape to the exhaust channel. This point, which depends on the internal lap *i*, determines the instant of release. The port then opens more widely to exhaust, and remains open during most of the back stroke of the piston, until the valve, again moving in the original direction, brings its inner edge again over the port and compression begins. Similar events for the other end of the cylinder are determined by the other side of the valve. The positions of the piston when the several events occur depend on the amounts of the laps *e* and *i*, and of the "angular advance" which is the excess over 90° in the angle by which the eccentric stands ahead of the crank. If there were no laps and no angular advance steam would be admitted during the whole forward stroke and exhausted during the whole backward stroke. By giving the valve laps and angular advance expansive working becomes possible. But the slide-valve is not well adapted to effect a cut-off early in the stroke, and when much expansion is desired, a device called a separate expansion valve is added, or valves of a different type are used to control the distribution of the steam.

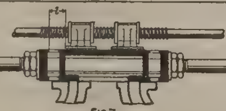

FIG.7.

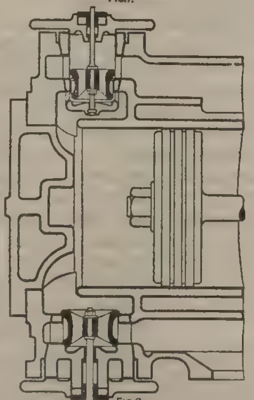

FIG.8.

FIG. 7.—SEPARATE EXPANSION VALVE

FIG. 8.—CROSS SECTION OF ONE END OF A CYLINDER SHOWING DROP VALVES

Separate Expansion Valves.—Fig. 7 shows Meyer's expansion valve, which consists of two blocks sliding on the back of a slide-valve. It is caused to reciprocate by an eccentric, generally set directly opposite the crank, so that it moves to the left while the piston moves to the right, and *vice versa.* The admission of steam ceases when the relative displacement of the expansion blocks over the slide-valve amounts to the distance *l*, and this can be arranged to happen early in the piston's stroke without affecting the release or the compression.

In this example the rod which carries the two blocks is fitted with right- and left-handed screws, so that by turning the rod the distance between the blocks may be adjusted, and the distance *l* consequently altered. This allows the valve to be set to give an earlier or later cut-off: when *l* is increased by bringing the blocks nearer together, the cut-off comes later in the stroke. The adjustment may be made while the engine is running. Another way to change the cut-off with a valve of the Meyer type is to alter its travel. Increasing the travel of the expansion valve, while *l* remains constant, makes the cut-off come later.

In many engines the events are controlled by using, at each end of the cylinder, separate valves for admission and exhaust (fig. 8). Sometimes these are drop valves which are "double-beat" in the sense that the valve when it drops into its seat closes simultaneously two passages. These are so arranged that the steam pressure tending to close or open the valve remains balanced, and no large force has to be exerted. Such valves are often worked by cams and levers from a lay shaft alongside the cylinder, driven from the main shaft so as to turn in unison. In many examples the valves giving admission are caused to close by a tripping device; that is to say they spring suddenly into the closed position, at the instant when cut-off is desired, through the action of a trigger which brings a closing spring into play; and the tripping device is connected with the governor of the engine in such a manner that the cut-off comes earlier or later when the speed exceeds or falls short of the normal. In this way the engine automatically adjusts the amount of power it develops to suit changes in the demand made upon it by the mechanism which it drives.

Balanced Valves.—Fig. 5 shows a slide-valve form usual in locomotives and small engines but in large sizes the objection is that the unbalanced pressure of steam on the back of the valve would cause much friction and wear in the movement of the valve over the working face on which it slides. In large engines, such as those of steamships, it is usual to relieve the pressure of the valve on the working face by fitting the back of the valve with what is called a relief frame, extending between the valve and the steam-chest cover, the effect of which is to prevent the steam of the steam-chest from having access to the whole back surface of the valve. Another device, often resorted to, is to substitute for the flat form of slide-valve a piston form in which the effective sliding portions of the valve extend all round the surface of a cylinder and slide over cylindrical fixtures in the valve chest, round which the steam-ports extend.

Reversing Gears.—The slide-valve is a particularly convenient means of controlling the admission of steam when, as in locomotives or marine engines, etc., the engine's direction of motion has frequently to be reversed. It is only necessary to provide means by which the valve may be actuated by either of two eccentrics, one set at the angle suitable for forward running and the other set at the angle suitable for backward running.

In Stephenson's link motion which is an early and familiar device for this purpose, the engine shaft carries two eccentrics, one of which is set ahead of the crank at a suitable angle for one direction of running, and the other at a suitable angle for the other direction. Their rods are connected to the ends of a link which gives its name to the contrivance. The link is a slotted bar curved to a circular arc, and capable of being moved up or down, being suspended from a rod which can be raised or lowered by means of the hand lever above. The valve rod ends in a block which slides within the link. This device allows either the forward eccentric or the backward eccentric to determine the motion of the valve, and so allows the engine to be reversed. But it does more, for if the link be set to an intermediate position, in which it takes its motion chiefly from one eccentric but partly from the other, the valve receives a motion virtually the same as that which it would get from a single eccentric of shorter travel and greater angular advance. The effect is to give a distribution of steam in which the cut-off is hastened and the expansion and compression are increased. Thus besides allowing of "full forward" and "full backward gear" the link may be "notched up" to give a much shorter admission of steam along with more compression, a matter of practical value in the running of a locomotive, where frequent large variations in the demand for driving effort have to be met.

Various other forms of link-motion have been devised which share this advantage. It is also shared by a group of equivalent mechanical devices, called by the general name of "radial valve gears," in which only one eccentric is employed but the valve is caused to take a motion capable of being varied in the same way. Of these the most widely used is the Walschaert's gear, very common in locomotives, a skeleton diagram of which is shown in fig. 9. There *A* is a projection moving with the engine piston. The valve *V* takes motion partly from it, through the rods *AB* and *BV*; but *BV* has a fulcrum at *D*, the position of which varies through the movement of the rod *DG*. That rod is supported by a suspension rod *J*, and its end at *G* can slide in a link *HI* rocking about a fixed fulcrum at *O*. There is one eccentric, *CF*, set at right angles to the crank *CK*, and giving motion to the rocking link *HI* by the rod *FH*. The block *G* can be shifted from near *H* to *I* by raising the suspension rod *J*. This reverses the motion, and allows also of notching up to any intermediate position.

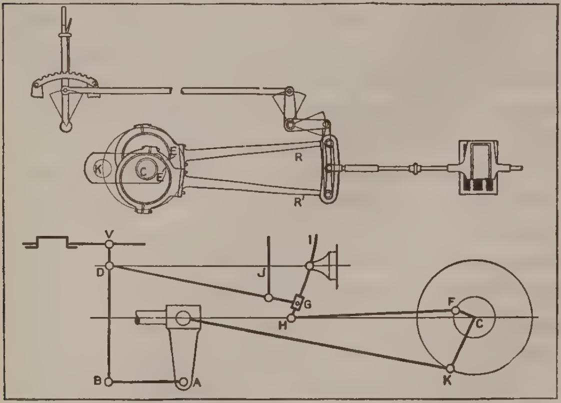

Fig. 9.—(Above) Stephenson's Link-Motion; (E, E') Eccentrics, (R, R') Rods Connected to Eccentrics: (Below) Walschaert's Gear

Governing.—To keep a steam engine running at a uniform speed, notwithstanding variations in the demand for power, hand regulation may to some extent serve, but in very many cases an automatic regulator called a governor is provided. Regulation, whether by hand or by automatic governor, may be effected in two ways: the steam may be throttled more or less on its way from the boiler to the engine, so that the pressure of admission is reduced when the speed tends to rise, and increased when the speed tends to fall: or the point of cut-off may be varied, with the result of admitting a greater or less volume of steam in each stroke. In small engines the governor often acts on a throttle valve, but at engines which aim at efficiency it is preferable to govern by altering the cut-off. In such engines, to secure in any case a proper amount of expansion, there is an early cut-off, and a small change in its position largely affects the amount of steam admitted and consequently the amount of work done.

Watt's original governor was a pair of balls revolving about a vertical spindle as conical pendulums under the combined effect of their own weight and the "centrifugal force" due to their speed of revolution. Any increase of speed sufficient to overcome the slight friction of the attached gearing made them take up a higher position, and in so doing they partially closed a throttle valve. This went on till, at a slightly greater speed than before, equilibrium was established between the supply of steam and the demand for power. Here, as in all governors, the effect is not to maintain a strictly constant speed, but to prevent the variation, either way, from exceeding narrow limits.

In modern governors the "centrifugal force" of the balls generally acts not simply against their own weight, but against an extra load or against the force of a spring.

In many factory and other engines the governor determines the position of cut-off by means of a trigger action of the type already mentioned: the admission valve, which has been opened and held open by a cam turning with the engine shaft, is suddenly disconnected by the release of a trigger, at a point depending on the exact height of the governor balls.

Function of the Fly Wheel.—The function of the governor is, generally, to keep the engine running at a nearly uniform rate, measured in turns per minute: the function of the flywheel is to keep the rate nearly uniform within the limits of any one revolution. For this purpose it must act as a reservoir of energy, alternately storing and restoring the excess amounts which result from periodic variations of turning moment in the operation of the piston on the crank. At the dead points the piston's rate of doing work is zero, and it rises to a maximum at an intermediate point the position of which may be much affected by an early cut-off. The flywheel is drawn upon for energy during those parts of the revolution in which the work done by the piston (or pistons) on the engine shaft is less than the work done by the shaft on the mechanism which the engine drives; and it takes up the surplus during the other parts of the revolution. To effect this alternate give and take of energy the flywheel must undergo small variations of speed, the magnitude of which may be kept down to any assigned amount by giving the rim a sufficient mass and speed.

Inertia of Reciprocating Parts.—The effective effort on the crank is greatly influenced, especially in high-speed engines, by the inertia of the piston, piston-rod and connecting rod. At the beginning of the stroke, when the piston is coming towards the crank-shaft, these reciprocating masses are acquiring motion; from a point near the middle to the end of the stroke they are losing motion. Hence in the early part the effort on the crank is reduced below what is due to the steam-pressure on the piston and in the later part it is increased. In a high-speed engine the forces due to acceleration become so large as seriously to affect questions of design. In direct-acting steam pumps the inertia of pump rods and buckets forms an additional item in the consideration of reciprocating mass: its effect there is on the whole beneficial in tending to equalize the force which is exerted on the pump throughout the stroke.

Balancing of Engines.—Another aspect of the acceleration of reciprocating parts is its effect on the balance of the engine as a whole. This is specially important in locomotives and marine engines (*q.v.*). In a locomotive the forces on the engine frame arising from the inertia of the pistons and rods tend to make the engine sway laterally: this is to some extent prevented by placing "balance masses" on the wheels. But such masses, although they may be adjusted nearly to balance the horizontal forces, introduce unbalanced vertical forces, causing what is called hammerblow. In extreme cases these vertical forces might even lift the wheels from the rails: short of that, however, they are objectionable in causing periodic variations in the pressure on the rails, which tend to set bridges into oscillation and may add substantially to the stresses for which the railway engineer must provide.

TYPES OF RECIPROCATING ENGINES

In classifying engines with regard to their general arrangement of parts and mode of working, account has to be taken of a considerable number of independent characteristics. We have first a general division into *condensing* and *non-condensing* engines, with a subdivision of the condensing class into those which act by surface condensation and those which use injection. Next there is the division into *compound* and *non-compound*, with a further classification of the former as double-, triple-, or quadruple-expansion engines. Again, engines may be classed as *single* or *double-acting*, according as the steam acts on one or alternately on both sides of the piston. Again, a few engines—such as steam hammers and certain kinds of steam pumps—are *non-rotative*, that is to say, the reciprocating motion of the piston does work simply on a reciprocating piece; but generally an engine does work on a continuously revolving shaft. In most cases the crank-pin of the

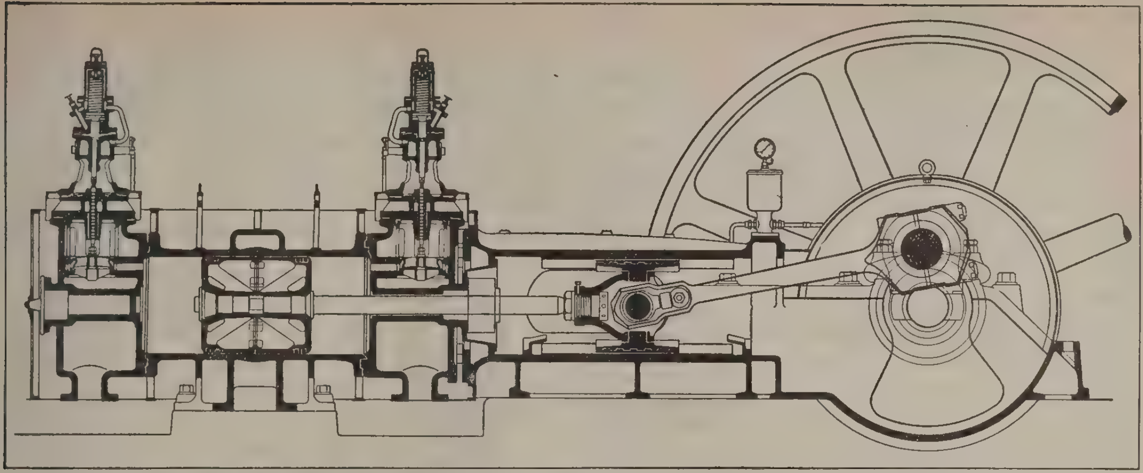

FIG. 10.—UNIFLOW ENGINE IN WHICH THE PISTON ACTS AS EXHAUST VALVE AND THE ADMISSION VALVES ARE IN THE CYLINDER ENDS

revolving shaft is connected directly with the piston-rod by a connecting-rod, and the engine is then said to be *direct-acting;* in other cases, of which the beam engine is an historical example, a lever is interposed between the piston and the connecting-rod. The same distinction applies to non-rotative pumping engines, in some of which the piston acts directly on the pump-rod, while in others it acts through a beam. The position of the cylinder is another element of classification, giving *horizontal, vertical* and *inclined cylinder* engines. In most vertical engines the cylinder is above the connecting-rod and crank. In *oscillating cylinder* engines (a type still found in some river boats) the connecting-rod is dispensed with; the piston-rod works on the crank-pin, and the cylinder oscillates on trunnions to allow the piston-rod to follow the crank-pin round its circular path. In *rotary* engines there is no piston in the ordinary sense; the steam does work on a revolving piece, and the necessity is thus avoided of afterwards converting reciprocating into rotary motion.

Beam Engines.—In the single-acting atmospheric engine of Newcomen the beam was a necessary feature; the use of water-packing for the piston required that the piston should move down in the working stroke, and a beam was needed to let the counterpoise pull the piston up. Watt's improvements made the beam no longer necessary; and in one of the forms he designed it was discarded—namely, in the form of pumping engine known as the Bull engine, in which a vertical inverted cylinder stands over and acts directly on the pump-rod. However, the beam formed a convenient driver for pump-rods and valve-rods; and the parallel motion invented by Watt as a means of guiding the piston-rod, which could easily be applied to a beam engine, was, in the early days of engine-building, an easier thing to construct than the plane surfaces which are the natural guides of the piston-rod in a direct-acting engine. In modern practice the direct-acting type has almost wholly displaced the beam engine.

Direct-acting Engines.—Of direct-acting engines the horizontal arrangement has in general the advantage of greater accessibility, but the vertical economises floor space. In small forms the engine is generally self-contained, that is to say, a single frame or bedplate carries all the parts including the main bearings in which the crank-shaft with its flywheel turns. The frame often takes what is called a girder shape, which brings a portion of it into a favourable position for taking the thrust between the cylinder and the crank-shaft bearings and allows two surfaces to be formed on the frame to serve as guides for the cross-head. When a condenser is used with a horizontal engine it is often placed behind the cylinder, and the air-pump, which may be within the condenser, has a horizontal plunger or piston on a "tail-rod" or continuation of the main piston-rod through the back cover of the cylinder. In large horizontal engines the condenser generally is in a well below, and its pump is driven by a mechanism linked with the crosshead.

Coupled Engines.—When uniformity of driving effort or the absence of dead points is important, two independent cylinders often work on the same shaft by cranks at right angles to each other. Such engines, which are called "coupled," can start readily from any position; the ordinary locomotive engine is an example. In some engines three cylinders, set to work on cranks 120° apart, co-operate in giving a still more uniform drive. Winding engines for mines and collieries, in which ease of starting, stopping and reversing is essential, are very generally made by coupling a pair of cylinders on opposite sides of the winding drum.

Compound Engines, Coupled or Tandem.—Large direct-acting engines are usually compounded either by having a high- and a low-pressure cylinder side by side, with cranks at right angles, or by putting one cylinder behind the other with a common centre line. The latter is called a *tandem* arrangement. In a tandem engine, since the pistons agree in phase, the steam may expand directly from the small into the large cylinder. But the connecting-pipe and steam chest form a receiver of considerable size, and it is preferable to cut off the supply of steam to the large cylinder at an earlier stage of the stroke. For mill engines the compound tandem and compound coupled types of engine are very usual. The high-pressure cylinder is often fitted with some form of trip-gear.

The chief advantage of compounding, as was pointed out in the historical section, is that it reduces the condensation which hot steam undergoes in the cylinder through contact with metal which has been chilled by the exhaust of the previous stroke. Compound working acts beneficially by narrowing the range through which the temperature periodically fluctuates in the metallic surfaces exposed to contact with the operative steam. The amount of steam that is at once condensed on admission depends on the extent to which the surface with which it comes in contact has been chilled during the previous exhaust. For this reason there is less loss through initial condensation in a compound engine giving the same total ratio of expansion.

Uniflow Engine.—The periodic give and take of heat between the steam and the metallic surfaces, which is a serious source of loss in any reciprocating engine, can be reduced by having separate valves for admission and exhaust, so that the same port-surfaces and valve-surfaces are not brought into contact with hot and comparatively cold steam. This idea is carried further in what is called the "uniflow" engine, by an ingenious arrangement which secures that the ends of the cylinder, where the steam is admitted, shall always be kept hot, the exhaust taking place at the middle of the cylinder through ports in the circumference which are uncovered by the motion of the piston.

The uniflow design is a recent but conspicuously successful departure from earlier practice. It allows high pressure steam to be expanded in a single cylinder without the drawbacks ordinarily entailed in non-compound working. There is, however, still enough exchange of heat between the metal and the steam to make superheating highly advantageous.

Condensation.—In land engines a jet form of condenser is common, but surface condensation is resorted to when the available water-supply is unsuited for boiler feed. When there is no large supply of condensing water a very fair vacuum can be obtained by using an *evaporative condenser*, consisting of a stack of pipes into which the exhaust steam is admitted and over which a small amount of cooling water is allowed to drip. This water is evaporated by the heat which the condensing steam gives up. Such a condenser is placed in the open, generally on a roof where the air has free access. The amount of water it uses need not exceed the amount of steam that is condensed, and is a small fraction of the amount that would be required in a jet or surface condenser.

High-speed Direct-acting Engines.—Prior to the development of the steam turbine the demand for engines suitable for driving electric generators without the intervention of a belt led to the introduction of various forms of direct-acting engine adapted to run at a high speed. Some of these were *single-acting*, steam being admitted to one side of the piston only, generally the back, with the result that the rods could be kept in a state of thrust throughout the revolution, and alternations of stress in them and at the joints thereby avoided, together with the knocking and wear of the bearing brasses which it is apt to cause. To secure, however, that the connecting-rod should always push and never pull against the crank-pin there had to be much cushioning during the out stroke on account of the fact that from about the middle of that stroke to the end the reciprocating mass was being retarded. In engines of this class designed by P. W. Willans, which were at one time much used, but are now displaced by turbines, the cushioning was provided by means of a supplementary piston which compressed air during the out stroke; the energy which the reciprocating masses had to part with in losing their motion during the second half of the out stroke was stored in this air and was restored in the succeeding down stroke. The engine was entirely enclosed in a casing the bottom of which formed an oil bath in which the cranks splashed to ensure ample lubrication. This feature is retained in many modern high-speed engines.

Pumping Engines.—In engines for pumping or for blowing air it is not essential to drive a revolving shaft, and in many forms the reciprocating motion of the steam piston is applied directly to produce the reciprocating motion of the pump-piston or plunger. Often an inverted vertical triple expansion engine is used, resembling the usual marine form, with a pump-plunger under each of the three cylinders. Most of the power is directly transmitted from the piston to the pump, but there is an auxiliary crank for each cylinder, driving a shaft with a flywheel to equalize the effort on the pump.

A familiar example of direct-acting pump is the small donkey pump used for feeding boilers, in which the steam-piston and pump-plunger are on one and the same rod. In some of these pumps a rotative element is introduced, partly to secure steadiness of running and partly for convenience in working the valves. But many pumps of this class are entirely non-rotative, and in such cases the steam is generally admitted throughout the stroke without expansion. The valve may be actuated by tappets from the piston-rod. In some cases a tappet worked by the piston as it reaches each end of its stroke throws over an auxiliary steam-valve, which admits steam to one or other side of an auxiliary piston carrying the main slide-valve.

Pulsometer.—Hall's "pulsometer" is a peculiar pumping engine without cylinder or piston, which may be regarded as the modern representative of the engine of Savery. The sectional view, fig. 11, shows its principal parts. There are two chambers, *A, A′*, narrowing towards the top, where the steam-pipe *B* enters. A ball-valve *C* allows steam to pass into one of the chambers and closes the other. Steam entering (say) the right-hand chamber forces water out of it past the clack-valve *V* into a delivery passage *D*, which is connected with an air-vessel. When the water level in *A* sinks so far that steam begins to blow through the delivery passage, the water and steam are disturbed and so brought into intimate contact, the steam in *A* condenses, and a partial vacuum is formed. This causes the ball-valve *C* to rock over and close the top of *A*, while water rises from the suction-pipe *E* to fill that chamber. At the same time steam begins to enter the other chamber *A′*, discharging water from it, and the same series of actions is repeated in each chamber alternately. While the water is being driven out there is comparatively little condensation of steam, partly because the shape of the vessel does not promote the formation of eddies, and partly because there is a cushion of air between the steam and the water. Near the top of each chamber is a small air-valve opening inwards, which allows a little air to enter each time a vacuum is formed. When any steam is condensed, the air mixed with it remains on the cold surface and forms a non-conducting layer. The pulsometer is, of course, far from efficient as a thermodynamic engine, but its adaptability to situations where other steam-pumps cannot easily be applied, and the simplicity of its working parts, sometimes make it practically useful.

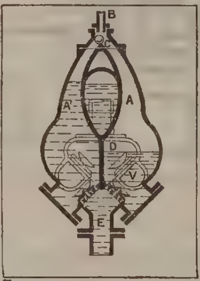

FIG. 11.—HALL'S PULSOMETER

Marine Engines.—The early steamers were fitted with paddle-wheels, and the engines used to drive them were for the most part modified beam engines. Bell's "Comet" was driven by a species of inverted beam engine, and another form of inverted beam, known as the *side-lever* engine, was for long a favourite with marine engineers. An old form of direct-acting paddle-engine was the *steeple* engine, in which the cylinder was set vertically below the crank. Two piston-rods projected through the top of the cylinder, one on each side of the shaft and of the crank. They were united by a cross-head sliding in vertical guides, and from this a return-connecting-rod led to the crank. Most modern paddle-wheel engines are direct-acting engines of the ordinary connecting-rod type, with the cylinders fixed on an inclined bed and the guides sloping up towards the shaft.

When the screw-propeller began to take the place of paddle-wheels in ocean steamers, the increased speed which it required was at first obtained by using spur-wheel gearing in conjunction with one of the forms of engines then usual in paddle steamers. Types of engine better suited to the screw were introduced later, and were driven fast enough to be connected directly to the screw-shaft. After passing through various forms, now obsolete, the marine engine settled into one which is now universal in all screw steamships that are not driven by steam turbine.

This is the inverted vertical direct-acting engine, with two or more cylinders placed side by side directly over the shaft. It has the great advantage that the shaft can readily be put at the low level necessary for screw propulsion. Two, three and four cranks are employed, the arrangement with four cranks being specially suitable, as has already been pointed out, when a balance of the engine at high speeds has to be secured. In vessels of high speed and power the engines are often arranged in twin sets, on two shafts with twin screw propellers.

The marine engine is always furnished with a surface condenser, consisting of a multitude of brass tubes about $\frac{3}{4}$ inch in diameter cooled by sea-water which is caused to circulate through the condenser by means of a circulating pump. This pump and the air pump are often driven independently of the main engine.

It is in marine practice that the most powerful reciprocating engines are still to be found, although in the largest and fastest vessels the turbine has taken their place. Another and more recent rival is the internal combustion engine, using the Diesel cycle of action, which by 1928 had found favour in many new liners. The reciprocating engine continues, however, to be much used for sea-going vessels, especially those of the "tramp" class, most commonly in the triple expansion form. Often the third stage of the expansion is performed in two cylinders, making four in all. This avoids the use of a very large cylinder, and secures an advantage in the better balance which can be obtained with four cranks.

Locomotive Engines.—The ordinary locomotive consists of a pair of direct-acting horizontal or nearly horizontal engines, fixed in a rigid frame under the front end of the boiler, and coupled to the same shaft by cranks at right angles, each with a single slide-valve worked by a link-motion, or by a form of radial gear. The engine is non-condensing, except in a very few special cases, and the exhaust steam, delivered at the base of the funnel through a blast-pipe, serves to produce a draught of air through the furnace. In some instances a portion of the exhaust steam, amounting to about one-fifth of the whole, is diverted to heat the feed-water.

On the shaft are a pair of driving-wheels, whose frictional adhesion to the rails furnishes the necessary tractive force. Nearly always a greater tractive force is secured by having two or more driving-wheels on each side, connected by a coupling-rod between pins on the outside of the wheels.

It is general to have under the front of the engine a group of smaller wheels which do not form part of the driving system. These are carried in a *bogie,* that is, a small truck upon which the front end of the boiler rests by a swivel-pin or plate which allows the bogie to turn, so as to adapt itself to curves in the line, and thus obviate the grinding of tyres and danger of derailment which would be caused by using a long rigid wheel base.

In *inside-cylinder* engines the cylinders are placed side by side within the frame of the engine, and their connecting-rods work on cranks in the driving shaft. In *outside-cylinder* engines the cylinders are spread apart far enough to lie outside the frame of the engine, and work on crank-pins on the outsides of the driving wheels. Many modern locomotives combine the outside and inside arrangement, in order to get greater power, placing one or in some cases two cylinders within the frame, as well as two outside.

The principle of compounding has often been applied to locomotive engines, but without much advantage. (*See* LOCOMOTIVES.)

THEORY OF THE STEAM ENGINE AS A HEAT ENGINE

Properties of Steam.—Steam-engine theory is an application of the principles of thermodynamics (*q.v.*) to a machine using steam as its working substance. The relevant properties of the substance have been briefly described in the article STEAM. They include the pressure, temperature, and density (or volume per unit of mass); also (per unit of mass) the entropy ϕ and the total heat I. For definitions of these quantities reference should be made to that article. Numerical values will be found in Callendar's or other steam tables, over a sufficiently wide range of conditions to meet the purposes of the engineer.

Given steam in any initial state, we have to consider what happens when it expands, doing work, as in the cylinder of a steam engine. It is easy to imagine steam expanding without turbulence in an ideal cylinder which is a perfect non-conductor of heat. Under these conditions no heat is being taken in, and there is no change of entropy: such expansion is said to be *adiabatic.* Adiabatic expansion, and adiabatic compression, although never strictly realized owing to the influence of the conducting cylinder walls, are ideal actions important in the theory of the steam engine.

During adiabatic expansion the substance is doing work at the expense of its stock of internal energy, and its temperature falls. Steam expanding adiabatically becomes partly condensed: the substance then becomes a mixture of saturated steam with water at the same temperature, and the energy or the total heat of one pound is to be found by considering what fraction is present as water and what fraction is steam. Such a mixture is often called wet steam. The degree of wetness reached at any stage of adiabatic expansion is readily calculated by taking account of the fact that the expanding mixture keeps its entropy unchanged.

From the general principles of thermodynamics it is easy to assign an upper limit to the efficiency of a steam engine, when the temperatures are known at which the working substance takes in and rejects heat. By "efficiency" is here meant the ratio of the work done to the quantity of heat supplied. Suppose, to simplify the problem, that there is no superheating, that is to say no supplementary taking in of heat after the steam has been formed at the constant temperature T_1 of the boiler. Suppose also that the only rejection of heat is at the constant temperature T_2 of the condenser. Then the principle of Carnot (*see* THERMODYNAMICS) shows that under ideally favourable conditions of working the fraction of the heat supplied which is converted into work cannot exceed $1-T_2/T_1$, when the temperatures are expressed on the absolute scale.

Carnot Cycle.—This result would be attained in an engine working in a strictly reversible manner, where the whole change from T_1 to T_2 occurs as a result of adiabatic expansion, and the whole change from T_2 to T_1 as a result of adiabatic compression. The indicator diagram of an ideal engine working in this manner is shown in fig. 12. The engine there imagined is one whose cylinder also serves as boiler and condenser. It is supposed to have perfectly non-conducting sides, but a conducting bottom to which any one of three bodies A, B, or C may be applied. B is a non-conducting cover, to be applied during the two adiabatic stages. A is a hot "source," maintained at a high temperature T_1, and C is a cold "sink" or receiver of heat, maintained at a low temperature T_2. Imagine the cylinder to contain one lb. of water at T_1 and A to be applied, while the piston begins to move towards the right. The "isothermal" (constant temperature) line *ab* is traced out during the evaporation of the water. At *b* the substance is all steam. A is then removed, B is applied, and the adiabatic expansion *bc* takes place, until the temperature of the working substance falls to T_2. C is then applied and the piston is pressed back, giving an isothermal line *cd* during which most of the steam is condensed. At *d* there is a mixture, chiefly water, which is adiabatically compressed. If this point *d* has been properly chosen, the operation *da* completes the cycle, bringing the substance back to the condition *a* in which it is all water at temperature T_1. The whole process is called Carnot's cycle.

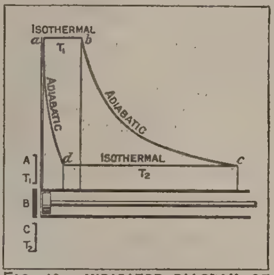

FIG. 12.—INDICATOR DIAGRAM OF CARNOT'S CYCLE

The formula $1-T_2/T_1$ which expresses the efficiency in this ideal operation shows the importance of making T_1 high and T_2 low. No real engine attains this limit of efficiency, for no engine completely expands the steam down to the condenser temperature in a strictly adiabatic manner. Further, no engine has an adiabatic compression stage corresponding to *da*: the use of a separate condenser makes that impracticable.

The action in an engine cylinder may be more appropriately idealized as in fig. 13 where *AB* represents the admission of the steam at T_1, *BC* its adiabatic and complete expansion to T_2, and *CD* its rejection to the condenser. Under these conditions it is easy to show that the work done, which corresponds to the area of this ideal diagram, is equal to

$$I_1-I_2$$

for each lb. of steam admitted to the engine, where I_1 is the total heat (per lb.) on admission, and I_2 is the total heat (per lb. of mixture) in the condition *C,* when expansion is complete. This applies whatever be the state of the steam on admission, whether superheated or not. The quantity I_1-I_2 is called the *adiabatic heat-drop,* and measures the greatest amount of work theoretically obtainable from each lb. of steam. In practice about 70 per cent. of the adiabatic heat-drop may be realized in favourable cases. Tables of the adiabatic heat-drop, for steam in various assumed initial states as to pressure and temperature, expanding to various assumed condenser pressures, have been compiled, and are of great service in problems of engine design.

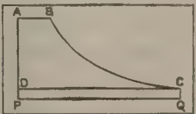

FIG. 13.—DIAGRAM OF THE ACTION OF AN AVERAGE ENGINE

Rankine Cycle.—The process exhibited in fig. 13 becomes a complete cycle when, in addition, account is taken of the action by which the feed-pump restores the condensed steam to the boiler. Thus completed the process is called the Rankine cycle. Its efficiency is necessarily somewhat less than that of the Carnot cycle of fig. 12. Superheating, which is not in practice carried beyond a temperature of 400° C, and rarely so far, adds to the heat-drop by increasing I_1. But its chief effect on the efficiency of the process is indirect. By tending to keep the steam in a drier state it greatly reduces the losses that arise through exchange of heat between the working substances and the cylinder walls: in effect superheating makes the expansion more nearly adiabatic than it would otherwise be, and therefore gives a better approach to the ideal conditions of fig. 12. In a turbine superheating is beneficial by reducing the friction of wet steam on the blades.

Entropy-temperature Diagrams.—In exhibiting graphically the action of an engine under assumed conditions of working we may adopt various alternatives to the pressure-volume or "indicator" diagram. One interesting form takes for its two co-ordinates the temperature and the entropy: another (introduced by Mollier) takes the entropy and the total heat. Both of these diagrams are instructive in allowing the action to be traced through its several stages and in exhibiting the differences which result from varying the conditions of supply and of condensation. They show the direct influence of superheating, and the amount of wetness to be expected at any stage in the expansion. They allow, in some cases, measurement from a chart to take the place of numerical calculation; but their greatest merit is that they enable the operation of the working fluid to be visualized. No account of such diagrams can, however, be attempted within the limits of this article.

Modern High-efficiency Steam Plants.—In modern steam engines, especially of the turbine class where a very large range of expansion may be effectively carried out, efficiency is aimed at by using the best possible vacuum, to make T_2 low, and by raising the pressure of supply to make T_1 high. Pressures approaching 1000 lb. per square inch are not uncommon; occasionally that figure is exceeded, and even at the highest pressures some additional high-temperature heat is taken in by superheating. Reheating at one or more stages during expansion is resorted to, in order to prevent the expanding steam from becoming unduly wet. Another device, which is also applied in the most economical large-scale turbine plants, is to remove a portion of the expanding steam at each of two or three stages, and apply it in heating the feedwater on its way back from the condenser to the boiler. This progressive heating of the feedwater, by "bleeding" the turbine of steam which has already done more or less work, is called "cascade" feed-heating. Its effect is to make the whole cycle approach more nearly to the ideal cycle of Carnot, for the progressive feed-heating is nearly reversible and serves as a substitute, in this respect, for the adiabatic compression which makes that cycle differ from the cycle of Rankine. (*See* also TURBINE: STEAM; LOCOMOTIVE; MARINE ENGINEERING.)

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STEAM-GAUGE is an instrument which by utilizing the elasticity of a metal indicates the pressure of steam in a boiler or other vessel. The action is explained in the article PRESSURE-GAUGE. The gauge must be fixed above the highest water level of the boiler, and stand away from it to avoid heating. A gauge is unduly hot if it cannot be touched by the hand without discomfort, and the U-tube or syphon is therefore used for connection to the boiler. In order to avoid straining the action, a gauge is generally graduated to twice the working pressure. Then the pointer stands vertically at the normal working pressure. High-pressure steam-gauges are those graduated for pressures between 200 lb. and 1,000 lb.

STEAM GENERATION. In a modern plant the course of operation can be traced broadly as follows: The water operates in a closed system and circulates in the form of steam or vapour and returns to its original state in the form of condensation. The water is first heated in feed water heaters, then goes through the tubes in the boilers and is changed to steam, then through a superheater that adds heat to it and from there to the utilizing equipment, a turbine for example. Finally it reaches the condenser from which it is returned to the starting point. The fuel usually starts through some preparation process such as crushing. From there it is usually conveyed to bunkers that provide a continuous feed to the stokers under the boilers. It is burnt on the stoker grates in the furnaces with natural or forced draft and the gases are used as they leave the boiler in superheaters, economizers and air preheaters. From there they finally escape through the stack. The economizers, superheaters and air preheaters are means by which some of the waste heat in the gases is reclaimed. In steam generating plants is found all or some of this equipment and much other auxiliary equipment.

Subjects dealing with the generation of steam and with the equipment used in that process will be found in the articles: BOILERS; STEAM; COMBUSTION; ECONOMIZERS; ELECTRICAL POWER GENERATION; FUEL; HEAT; HEATING AND VENTILATION; PULVERIZED FUEL; STEAM ACCUMULATORS; STEAM CHEST; STEAM ENGINES; STEAM TURBINES, etc. The present article attempts to co-ordinate the above references under the following headings: *Fuel; Combustion; Boilers; Mechanical Stokers; Other Equipment;* and *Selection of Steam Generating Equipment.*

DEVELOPMENT OF STEAM GENERATORS

When steam units were first used industrially the boiler was purchased, a brickmason employed to set the boiler in place and a labourer indiscriminately secured to shovel fuel under the boiler to generate enough steam for the process in question. Fuel, labour and material were cheap. It was not then economical to seek refinements in equipment or labour-saving devices; steam demands and pressures were low and in many cases, return tubular boilers answered the necessary requirements. The industrial development of the 20th century caused rapidly increasing demands for power. These were first met by the improvement in the design of steam turbines, and the application of mechanical stokers to the existing boilers. This met the needs for a few years but about 1916 steam turbine units began to increase rapidly in size and in 1929 single turbines of 60,000 kw. were in operation and compound units of 200,000 kw. turbines in course of construction. In 1929 power houses containing 200,000 kw. were in operation and power houses designed for 1,000,000 kw. output were in process of erection. In 1920 there were a few stations operating above 250 lb. pressure. In 1929 there were several score of stations operating at over 500 lb. pressure and others in course of erection.

With these changes steam boilermakers discarded rule of thumb methods and employed research engineers, metallurgists and various specialists, installed machine tools, and adopted scientific methods of manufacture. It was found at this time that the kind of water introduced into the boiler was of considerable importance; that the superheater should be located in a position that would give a wide range of load with very little change of temperature; that an evaporation of from 13 to 21 lb. of steam per square foot of heating surface per hour should be the minimum; that the use of pulverized coal to secure these high ratings was desirable. Air-cooled refractory furnaces to burn pulverized coal at high ratings were tried but it was seen that, with water-cooled furnaces, a unit could be designed that would combine economy and efficiency with low maintenance cost and maximum continuous hours of service. With new and larger plants, the question of the best cycle to be used became of paramount importance affecting the boiler, superheater, feed water heater and economizer design. Means were needed to remove free oxygen from water to prevent corrosion. The water entering the economizer was of higher temperature than when exhaust steam alone was used and the temperature of the gases leaving the economizer were too high for the best efficiency. Consequently air preheaters were developed to recover heat from the escaping gases, to provide hot air for drying the coal in the course of pulverization and to preheat the air for combustion before being introduced into the furnace. This cut down the time required for complete combustion and raised the temperature of the furnace.

A 200,000 kw. plant will burn 100 tons of coal per hour and roughly one-tenth of this will be ash which must be removed. Methods of handling such quantities of materials, to provide for continuous and uninterrupted service, needed to be designed and installed. Safety consideration, abatement of smoke and noise, consideration of the design of the plant to fit in with surrounding buildings and landscape, were additional problems to be solved. It will be seen then that the problem of generation of steam to meet the requirements of modern industrial civilization has become extremely complex. (J. B. C.)

FUELS

The principal fuels for the generation of steam are coal and oil and these are treated under the articles: FUELS; PULVERIZED FUEL; PETROLEUM; COAL AND COAL MINING. There are, however, many localities where there is a limited supply of certain other materials which are sometimes used for fuel. *Coke breeze* is the small size coke and dust which is burned successfully on chain grate stokers. *Lignites* (*q.v.*) are burned on chain grate stokers and in pulverized form. *Wood* is usually put through a hogger to reduce it to small sizes for greater ease in handling and better burning in the furnace. The furnace must be large to provide sufficient time for complete combustion. *Bagasse* is the residual sugar cane, left after the juice has been extracted. The furnace is especially constructed for admitting air around its sides. The silica in the bagasse runs on to the grate and prevents air coming in from underneath. *Bonecoal* is the name given to coal taken off the top of coal seams and contains a large amount of impurities. Formerly discarded, it is now being burned on stokers and in pulverized form. *Anthracite coal* is used for household use in the districts adjacent to the anthracite fields. There is, however, a large amount of small sizes and dust that is now being burnt on travelling grate stokers, especially built for this purpose. *Natural gas* (*q.v.*), *blast furnace gas* (*q.v.*), *coke oven gas* (*q.v.*) and *producer gas* (*q.v.*) are also frequent boiler fuels.

Boilers are used to generate steam from the otherwise waste heat of cement kilns, metallurgical furnaces, coke ovens, gas generators and other such processes where high exit temperatures of the products of combustion prevail. In the McEwen-Runge process of coal carbonization, the coke in pulverized form serves as a fuel for boilers as does also the screened coke residue from the K.S.G. process which is burnt on forced draft chain grate stokers.

COMBUSTION

Combustion within the furnace of a steam generator consists in the chemical combination of the elements of the fuel with oxygen from atmospheric air supplied for that purpose. Corresponding to the weights of carbon (C), hydrogen (H), oxygen (O) and sulphur (S) in the fuel fired, the weight of air theoretically required for combustion is given by

$$A = \frac{2{\cdot}67\,C + 8\,(H - O/8) + S}{0{\cdot}232}$$

since atmospheric air contains 23·2% of oxygen by weight.

It is necessary to supply "excess air" above this theoretical minimum, however, and "free oxygen" always occurs in the products of combustion. Even with excess air, some combustible will escape unburnt from the furnace and a small amount of carbon monoxide may simultaneously be found in the products of combustion. The unburnt combustible is generally carbon with a corresponding combustion loss of 14,600 B.T.U. per pound. The formation of carbon monoxide (CO) instead of carbon dioxide (CO_2) is named "incomplete combustion." One pound of carbon burned completely to CO_2 liberates 14,600 B.T.U. One pound of carbon burned incompletely to CO liberates only 4,400 B.T.U., hence the loss is the difference between these values or 10,160 B.T.U. per pound of carbon burnt to carbon monoxide. While these losses are reduced by increasing the percentage of excess air, the gain in combustion efficiency is more or less counteracted by the increase in another loss, namely, the heat content of the excess air at the temperature of the products of combustion escaping to the stack. Leakage of air through the walls of the furnace and boiler setting increases the excess air loss to the stack without effecting, in general, any corresponding gain in combustion efficiency. Considerable saving in fuel may often be made simply by reducing leakage through cracks or openings in boiler settings.

For each kind of fuel, type of furnace and method of firing, there is a certain percentage of excess air which results in a minimum loss. The most economical percentage of excess air is determined for any given installation from analyses of the products of combustion, and it corresponds to that percentage of carbon dioxide at which the carbon monoxide amounts to only a few tenths of 1%. For hand-fired coal furnaces and older stoker installations with restricted furnace volume, the best carbon dioxide percentage is around 12% which represents about 50% excess air. Larger combustion chambers were later employed because it was thereby possible to reduce the excess air below 50% without producing much carbon monoxide. At high operating capacities, however, furnace temperatures became so high that slagging of refractory walls and formation of clinkers in fuel beds became excessive. Water-cooled walls have eliminated refractory troubles and permitted the most economical percentage of excess air to be used without reaching excessively high temperatures, so that in some of the most modern steam generator furnaces as high as 15 to 16% of carbon dioxide is attained in daily operation.

With gases and oils, the most economical percentage of carbon dioxide will, in general, be less than mentioned above for coal, although the excess air percentage may be lower by reason of the more intimate mixture of fuel and air that can be obtained with proper burners and furnaces. This is due to the larger percentage of hydrogen in these fuels which combines with oxygen-forming water that is not ordinarily included in analyses of products of combustion.

When burning pulverized coal, thorough mixing in the furnace of the fuel particles with the air is conducive to complete combustion with low excess air. This may be secured by means of turbulent firing where the coal and air streams impinge upon one another in the furnace; but while the volatile matter may be burnt within a small volume, a much larger furnace must be provided to give time for the fixed carbon particles to burn before they escape from the furnace. Finer pulverization will reduce the unburnt combustible loss at the expense of the use of more power for grinding the coal. For solid fuels burned on grates and stokers, the furnace shape as well as its size is important in securing thorough mixture.

Smoke is often taken as an indication of poor combustion, and so it may be. However, smoke is often due to the presence of fine particles of soot resulting from breaking down volatile matter by heating with insufficient air rather than to larger particles of unburnt fixed carbon. Hence a smoking furnace may be working at fairly high efficiency, while one with a clear stack may have a large excess air loss. Smoke may be prevented by using a low volatile fuel such as anthracite coal and coke, or by mixing air with the volatile matter more thoroughly and thereby insuring its complete combustion in the furnace.

Combustion losses are reduced by preheating the air. The maximum permissible preheat temperature is determined by the durability of grates or stoker parts. In pulverized coal firing, the preheat temperature is limited only by the durability of the preheater elements. There is an economic relation, however, between the cost of air preheater surface, economizer surface and boiler tube surface, which results in a minimum cost for the complete steam generating unit corresponding to a moderate air preheat temperature between 400° and 500° F.

If all the heat liberated by combustion and carried into the furnace in the preheated air were imparted to the products of combustion, very high furnace temperatures would be reached. Much lower temperatures actually obtain in boiler furnaces due to radiation. Radiation from the incandescent fuel and flames varies approximately as the fourth power of their absolute temperature. With water-cooled walls, over one-half the heat of combustion is absorbed in the furnace by radiation from the incandescent fuel and flames. This radiant heat will fuse any particles of ash which cannot be kept cool by adjacent water-cooled surfaces. Hence refractory baffles must be protected by two or more rows of boiler tubes on the furnace side or particles of ash adhering to them will fuse and form large slag masses. With pulverized coal firing, ash will melt on the furnace bottom unless cooled below its fusing temperature and protected from radiation by "screen tubes." While the melted ash may be run out of the furnace as molten slag, there is an additional furnace loss in the latent heat of fusion of this slag.

Boiler test codes adopted by engineering societies in various countries, define boiler efficiency as the ratio of the heat absorbed by the steam produced per unit weight of fuel burned, to the gross, or upper, heating value of the fuel as determined in a calorimeter where the moisture present in the fuel and formed from the hydrogen therein is condensed to water. In England, efficiencies are often guaranteed as based on the lower heating value, which is equal to the upper heating value minus $1,050 \times (M+9H)$, where M = lb. of moisture and H = lb. of hydrogen per lb. of fuel burned and 1,050 = latent heat of steam at atmospheric temperatures. (W. L. De Ba.)

BOILERS AND STEAM GENERATORS

Boilers are of the following designs: return tubular, water tube, electric, steam generator.

Return Tubular boilers consist of a shell 60 in. to 108 in. in diameter. The shells are made of several plates riveted together with the tubes acting as stay bolts for the heads. The gases pass through the tubes. The boilers are limited in size to about 3,000 square feet. This type of boiler is used where small quantities of steam are required, at pressures not exceeding 250 lb. per square inch. It is also used extensively for waste heat in the manufacture of open hearth steel and other processes, in marine work and for locomotives.

Water Tube Boilers are boilers in which the water passes through the tubes and the gases are on the outside of the tubes. One of the main advantages of this type of boiler is safety. The latent heat in hot water under pressure has a particularly destructive effect in case the pressure in the vessel is suddenly released. By confining the water to tubes, the quantity of water in any particular part of the boiler is kept to a minimum and if a tube bursts, the resulting damage will be small. Another advantage is that the size of the unit is limited only by the size of plates available. Individual boilers containing 42,000 sq.ft. of heating surface were in operation in 1929 and single units containing 59,000 sq.ft. of heating surface in process of manufacture. This boiler is made in several different classes; *straight tubes with box headers* and both longitudinal and horizontal drums, *straight tubes with sectional headers,* and both longitudinal and horizontal drums, *bent tubes with vertical and semi-vertical tubes* and drums.

For box header boilers the headers are formed by riveting together two plates, spaced apart to form a boxlike structure. This construction is usually limited to 10,000 sq.ft. on account of the difficulty of shipping larger plates and to pressures of about 400 lb. per square inch. The straight tube sectional header boiler is substantially of the same general cross-section as the box header except that in some cases there is a greater inclination of the tubes. The headers are made of cast or forged steel and contain one or more vertical rows of tubes. This type of boiler has been built in sizes up to 35,000 sq.ft. and can be built larger and for pressures up to 1,400 lb. per square inch.

Electric Boilers.—The electric boiler is used to generate steam or hot water where a small quantity of steam is required or in larger sizes where electricity can be secured at reasonable rates to improve the load factor of plants.

Steam Generators.—The advent of pulverized coal (*see* Pulverized Fuel) crystallized the design of complete steam generating units giving consideration to the proper furnace volume and co-ordination of radiant and convection heating surface, superheater, economizer and air preheater. Such construction can be fired by oil, gas or pulverized fuel. It can readily be built for pressures up to 2,000 lb. per square inch. The fuel may be introduced at several points and sometimes the burners are located at the top of the furnace with the gases passing downward. In other designs the fuel is introduced at the bottom with the gases passing upward through the furnace. The economizer and fan may be placed directly back of the convection surface and the fans directly above the air preheater so that the duct work, with its chances for radiation and leakage, is reduced to a minimum. Some steam generator units give efficiencies of 89%.

Drums.—When built for pressure of 100 to 350 lb. all boiler drums were constructed of rolled plates formed on bending machines and riveted together. As the pressure increases the plate is necessarily thicker, making it more difficult to form plates and drive the rivets. It is generally accepted in 1929 that riveted drums should be limited to not more than 2½ inches. Up to 1928 a few boiler drums less than 2 in. thick have been constructed by forge welding. In Europe, but not in the United States up to 1929, drums have been constructed of drawn seamless tubes. For drum thickness of 2½ in. and over the most satisfactory method in use in America, is forged steel drums. An ingot, containing nearly twice the metal necessary for the completed drum, is pierced and hammered out over a mandrel, until the required length and diameter are obtained. The forging is then bored to the required diameter and the outside of the shell is turned to the proper diameter. The ends are heated and necked in so that the heads are integral with the drum. After the forging process is completed the drums are normalized by heating and proper cooling to remove stresses set up by forging. There are drums as large as 40 in. in diameter and with shells 5¼ in. thick.

In the United States the steel for riveted and forge-welded boiler drums must conform with the chemical and physical characteristics given in the A.S.M.E. boiler code. Alloy steels containing copper have been tried in one or two individual cases. Some experiments have been made using other alloy steels in an effort to prevent scale and corrosion but the results of such tests are not yet available (1929).

Large Units.—For large capacity units, the bent tube boiler has been found to give the most economical results. At low ratings, below 300%, the straight tube boiler has been found to give lower exit temperature but above these ratings the bent tube boiler gives approximately the same and in some cases lower exit temperatures. At high ratings the draft loss of the bent tube boiler is much less. It is customary in designing large boilers to place two bent tube boilers in the same setting and facing each other. With this method of construction, firing is usually done from two sides. There are no bridge walls. The radiation losses are low, the gases are most thoroughly mixed before entering the boiler surface, the unit is compact and the drums are practically one-half the length that would be required for a single unit with firing from one side. Such units are now in operation delivering over 600,000 lb. of steam per hour and there are in process of construction, units to deliver 1,000,000 lb. of steam per hour. (*See* Boiler Making; Boilers.) (J. B. C.)

MECHANICAL STOKERS

A mechanical stoker is a device for stoking or firing a furnace by mechanical means. In its broadest interpretation mechanical stoking would include the mechanical feeding of any kind of fuel to a furnace, but in common usage the term is limited to the firing of solid fuels such as coal and coke. The earliest form of mechanical stoker was an endless conveyor with two endless chains situated near the sides of the furnace and engaging sprockets mounted on shafts situated at the front and rear. Transverse grate bars were attached to these chains to form the fuel-supporting surface, one shaft was provided with means for driving the chains and grate so that the top surface moved through the furnace from front to rear. A hopper fixed at the stoker front supplied fuel to the grate and natural or chimney draft provided air for combustion which was admitted through the grate and fuel bed. The speed of the grate was regulated so that the fuel was burnt out during its travel through the furnace and the resultant ash and refuse was discharged into a pit as the grate made the return bend around the sprockets on the rear shaft. A natural draft chain stoker is applicable to non-coking or free burning bituminous coals.

A modification of this type of stoker provides for the use of forced draft supplied by a fan or blower for admitting the air for combustion. With this provision, higher rates of combustion are made possible, and, with suitable forms of grate surface, a wide variety of fuels may be burned successfully. The forced draft travelling grate stoker is frequently used for burning anthracite fines, coke fines and lignite coals. A similar stoker differing in detail is used successfully with free burning bituminous coal.

The overfeed, inclined grate natural draft stoker is used to a limited extent for burning bituminous coals at moderate ratings under small boilers. The fuel is fed from the hopper usually at the front, to stepped grates which are rocked by mechanical means to impart a downward travel of the fuel during combustion and to deposit the ash and refuse at the rear, on dump trays which are lowered by hand at intervals to discharge the ash into a pit below.

Underfeed stokers, as the name suggests, introduce the fuel below the surface of the fuel bed. The volatile constituents of the coal are distilled off and pass up through the incandescent fire where they are rapidly ignited and burned without producing smoke. Forced draft is used with this type of stoker. While practically every kind of bituminous coal has been successfully burnt on underfeed stokers, this method of firing finds its greatest field for use with coking coals which during combustion tend to form cohesive coke masses that must be broken up to insure uniform fuel bed conditions. Underfeed stokers may be broadly subdivided into two general classes—single retort stokers and multiple retort stokers.

In single retort stokers the coal is commonly fed from a hopper at the stoker front into a centrally situated trough or retort by means of a pusher driven by a steam actuated piston or by an electric motor. The bottom of the retort is movable and is slid back and forth so as to distribute the fuel uniformly through the retort from front to back. Each new charge of coal introduced serves to push an equal volume of fuel out of the top of the retort and on the grate bars which extend transversely from the sides of the retort. Alternate grate bars are movable and are connected to the stoker drive so as to impart a slight slicing motion which serves to maintain a porous fuel bed, to distribute the burning fuel across the stoker and to carry the ash and refuse to dump trays placed along each furnace side wall. Air for combustion is supplied under pressure by a fan or blower and is admitted to the fuel bed through openings along the sides of the retort and between the grate bars.

The multiple retort underfeed stoker comprises a series of retorts (usually inclined) mounted side by side across the furnace width. Coal is fed from a hopper, fixed at the stoker front, by rams connected to a crank shaft and driven through proper reducing gearing by an electric motor or other means. Secondary rams, situated in the bottom of the retorts, serve to break up the coke masses, to distribute the fuel over the stoker and to deposit the ash and refuse either on dump grates or into a pit at the rear where grinder rolls crush the refuse and discharge it into a pit below. Air for combustion is supplied under pressure by a fan, through nozzles or tuyeres arranged in longitudinal rows between adjacent retorts.

Mechanical stokers are usually controlled by regulators which are set to maintain a predetermined steam pressure and which are actuated by changes in this pressure. A drop in steam pressure causes an increase in stoker and fan speed so that more coal and air are admitted to correct the falling steam pressure. An increase in steam pressure causes a decrease in the amount of coal and air admitted. Stokers so equipped maintain constant steam pressure automatically and are called "automatic mechanical stokers." Mechanical stokers are principally used for firing stationary steam boilers and metallurgical furnaces. However, types have been developed and satisfactorily applied to locomotives and marine boilers. (C. Str.)

OTHER EQUIPMENT

Superheaters are used to increase the temperature of steam without increasing its pressure. The furnace gases furnish the heat, either in the furnace, among the boiler tubes or in the exhaust to the stack where some lost heat can be recovered. For a discussion of superheaters and superheat *see* Boilers; Steam.

Reheaters are used to prevent loss of superheat and the formation of moisture when steam is used in turbines. (*See* Boilers.)

Air Preheaters.—The exhaust gases coming directly from the furnace or from the economizers are used in air heaters or preheaters to heat the air that is to be used for combustion in the furnace, thus making use of otherwise lost heat. (*See* Boilers.)

Feed Water Heaters.—Before water fed to a boiler can be converted into steam it must first be heated to the temperature corresponding to the pressure in the boiler. This feed water is heated in open heaters, closed heaters or economizers, either to that or to a lesser temperature, depending on the plant. The first two types of feed water heaters use live or exhaust steam to obtain heat, the last uses the exhaust gases from the furnaces. (*See* Economizers; Boilers; Electrical Power Generation.)

Evaporators and De-aerators are used to supply loss in feed water and to remove the air dissolved in the water in the condenser. (*See* Electrical Power Generation.)

SELECTION OF STEAM GENERATING EQUIPMENT

Steam generating equipment may be considered as comprising not only the boiler and furnace but all auxiliaries necessary or desirable from the point of delivery of the coal to the stop valve on the boiler. A proper evaluation of factors which determine the correct selection of the necessary or desired equipment can only be made by an engineer thoroughly familiar with all the factors, their relations and a knowledge of costs, values and economics.

In a modern utility plant the steam end may and frequently does include in addition to the boiler a water-cooled furnace—steam superheaters and re-heaters—mechanical stokers of various types; burners for pulverized coal or oil; economizers and air preheaters; induced and forced draft fans or blowers and their necessary motor or turbine drive; ducts and flues for conducting the air and flue gas to desired points; chimney and dampers; cinder or dust catchers; boiler feed pumps and feed water regulators; soot blowers for the boilers; economizers and air-heaters; condensers; blow down valves; heat inter-changers to abstract heat from boiler blow down; open or closed feed water heaters; deaerators; a feed water treating plant or evaporators.

The complete coal and ash handling system from the railroad siding to the coal bunkers may include a car dumper, track hopper, screens, crushers, magnetic separators, conveyors, skip hoists, locomotive-crane and all equipment necessary for storing and reclaiming coal. If coal is pulverized there will be dryers, pulverizing mills with piping collectors, conveyors, feeders, burners and necessary motors. Ash may be handled by cars, conveyors or by water in sluices or grab buckets. Other auxiliary equipment may include a combustion control system with elaborate inter-locking of the electrical equipment. Pressure and draft gauges, thermometers, steam flow meters and gas analysers, all of the indicating or recording type, will also be found.

The problem of the selection of proper equipment may be very simply stated. Equipment should be selected that will produce steam at the lowest total cost for the expected life of the plant, with the required reliability. The weight given to various factors will differ in various types of plants. In public utility plants where the fuel cost is about half the total cost of operation greater weight is given to economy, this factor being modified by the cost of fuel. In some industrial plants operating only ten hours per day with cheap coal, first cost may be a major factor. There are certain processes requiring continuity of steam pressure or power in which a failure of either or both for a few minutes may ruin material valued at thousands of dollars. In such cases reliability usually secured by duplication or excess spare capacity should be one of the major factors considered. The total cost of steam generation is made up of fixed or capital costs and operating costs. The fixed charges or costs are made up of interest on first cost, taxes, insurance, depreciation or obsolescence. The operating costs include fuel; water; maintenance material-repairs; supplies of oil, tools and chemicals; operating labour; maintenance labour; clerical salaries and operating supervision. Generally, by increasing the capital cost, the operating cost may be reduced. High efficiency can be obtained by high capital expenditure. However, depending on the fuel cost and many other factors, a point is reached where the fixed charges of additional equipment equal the saving obtained by that equipment and any additions beyond that point result in fixed charges in excess of savings.

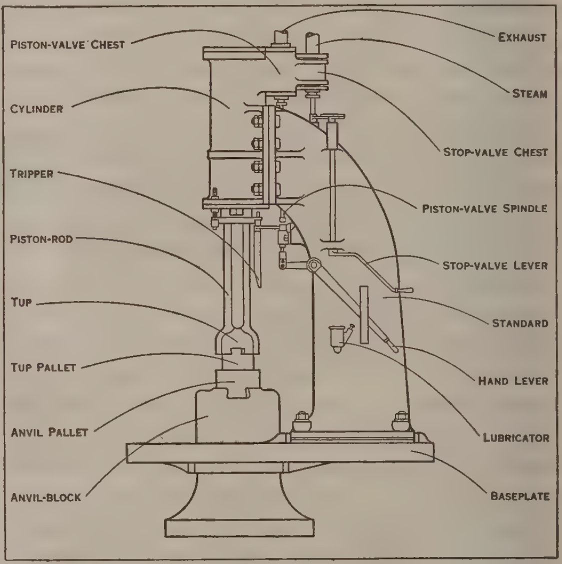
One of the important factors having a major bearing on economy and in capital costs is the plant capacity factor, sometimes named load factor. The capacity factor is the total load per year expressed in any suitable units divided by the rated or normal capacity of the units times 8,760 hours per year or the relation of the actual annual load carried to the annual load if units were operated at normal capacity every hour of the year.

In view of the complexity of the many factors affecting the selection of steam generating equipment and their interrelation it is only possible to list them in their major relations and group these relations as logically as possible. The considerations listed below are the most usual. There may be others peculiar to certain specific problems.

- Type of load
  - Power
    - Utility
    - Industrial
  - Power and Heating
    - Utility
    - Industrial
  - Process
  - Heating
- Capacity factor
  - Relation of—to economy
  - Effect of—on type
  - Effect of—on first cost
  - Effect of—on number of units
  - Effect of—on rate of operating
- Fuel
  - Cost
  - Quality
  - Variety
  - Fusing temperature of ash
  - Burning quality
  - Reliability of supply
  - Possibility of change in quality or price
- Water
  - Abundance
  - Cost
  - Quality, suitability for boilers*
  - Use of feed water treating equipment
- Location of plant
  - Foundations
  - Type of building
  - Cost or value of land
  - Type of coal handling or storage
  - Use of cinder catchers
  - Accessibility
  - Labour supply
- Probable life of plant
  - Nature of business permanency
  - Probable growth
  - Effect of full cost or steam cost on cost of product
  - Exhaustion of natural resources

*The size, type and operating rate of boilers may be limited by quality of water. (J. Van Br.)

STEAM-HAMMER. Steam-hammers are made in sizes ranging from ½ cwt. to about 12 tons. The size is merely a nominal rating, being the weight of the falling parts—piston, rod, tup, pallet—and takes no account of the pressure of steam which drives the piston down for the blow. As an approximate guide, however, it may be stated that the steam pressure in a 5-cwt. hammer gives a crushing effect on hot iron equal to a load of about 30 tons. Types of hammers are classified in three principal forms, the overhanging with slide, the arch and the Rigby (*see* drawing). In the last-named there is plenty of clearance space for the smith to manipulate work above and around the anvil-block, and the piston has a longer stroke and gives more power than corresponding hammers of other types. The overhanging type hammer has slides reaching down to guide the tup accurately, an advantage in many cases of forging, including that done in dies. The arch form has two standards between which the tup is also run in guides, and it is much used for forgework of heavy description, being a very rigid construction. The frame is often built of rolled steel plates and angles instead of cast-iron or cast-steel. The operating mechanism of the B. and S. Massey hammer shown comprises the stop-valve lever which regulates the quantity of steam admitted to the hammer, and the hand-lever that is moved to strike light or heavy blows, or to hold work between the pallets as in a vice, for bending purposes, etc. The steam is used expansively, with resulting economy, by the action of the tripper, which begins to close the piston-valve after the tup has moved a certain distance. A self-acting valve-gear can be applied to any type of hammer, so as to cause the hammer to work automatically. Many special shapes of hammer framings and anvils are built for specific purposes. Control is in some cases effected by a treadle, so that one man can use the hammer. Compressed air may be utilized instead of steam, should it not be convenient to furnish a supply of the latter. The lubricator attached to the side of the frame consists of a hand pump with which the cylinder and valves can be oiled at any moment without stopping the hammer. To secure efficient results the anvil-block must be of great weight, and supported on a mass of timbering resting on deep concrete or rock. The base also rests on timbers and concrete. (*See* Presses and Presswork and Drop Forging.) (F. H.)



B and S Massey steam hammer which delivers blows in accordance with the movements of the hand lever

STEAM PLOUGH: *see* Cultivating Machinery.

STEAM-ROLLER: *see* Road Roller.

STEAMSHIP: *see* Shipbuilding.

STEAMSHIP LINES: *see* Shipping Lines and Groups.

STEAM SHOVEL or **NAVVY.** A form of excavator which drags a bucket or shovel, at the end of a pivoted arm, from a surface position up to the top of a cutting or other place to be excavated, filling the bucket meanwhile. The mouth has steel cutting teeth or tines for easy penetration. When the bucket is filled, discharge is made into wagons or elsewhere by opening a door at the bottom. The machine is a very powerful modified type of jib crane, specially constructed for fast and severe duty, with a great amount of steel construction, and extra hard parts of manganese steel for those subjected to excessive friction and exposure to grit. The pivoted arm either has a fixed swing from its pivotal point about half-way up the jib, or the swing may be varied by racking the arm to or fro. As the crane stands still during a succession of cuts the depth of penetration has to be regulated to suit the capacity of the bucket. With the fixed arm design this is done by varying the radius of the jib, and with the racking arm by the movement of the latter alone. Bucket capacity varies from ½ cubic yard to about 15 cubic yards. The drive is by steam (the oldest system) but alternatively may be by petrol or paraffin motor, by electric motors, or Diesel-electric. The last-mentioned possesses the advantage of flexibility similar to the steam drive, *e.g.*, it will give a sudden access of power (not possible with a direct Diesel drive) due to the high torque characteristic of an electric motor. Shovels are either mounted on plain wheels, or on railway wheels; or caterpillar tracks are fitted, to transfer the machine as required on any ground. Some of the largest shovels are built for "stripping" or removing a deep overburden of earth covering ironstone or coal. The biggest machine yet built, a Marion, for this duty weighs 1,400 tons, and carries a 15 cubic yard bucket at the end of an arm 120 feet long. Eight caterpillar tracks sustain the shovel, with hydraulic devices to compensate for uneven ground. The three motions, hoisting the bucket, crowding or thrusting it into the cut, and rotating, are performed by separate electric motors. This is similar to the practice in steam shovels, which carry separate engines for the three functions.

Shovels can be adapted to work grabs when this provision is necessary for handling piles of material and loose excavation. The *dragline* excavator is either a machine solely used for this special kind of excavating, or is a modified shovel, the change being made rapidly. Instead of thrusting a bucket, it drags it towards the machine, being suitable for reclamation, canalization, drainage, foundation work, etc. The *skimmer scoop* acts in a horizontal direction, the jib of the navvy being set parallel with the ground, and the bucket dragged along under it, so that the surface of a road can be torn up. Also the loose debris may be scooped up and loaded into a lorry. A *back-acting trencher* has the bucket arm pivoted at the top end of the jib, the latter being lowered to a suitable distance above the ground. As the bucket is reversed to the normal direction for a steam navvy it is dragged towards the machine excavating a trench, and the machine retreats as the work progresses. Narrow and deep trenches can be cut rapidly with this adaptation of the navvy. *See* the article EXCAVATION. (F. H.)

STEAM TURBINE: *see* TURBINE, STEAM.

STEARIC ACID: *see* FATTY ACIDS.

STEARIN: *see* CANDLES.

STEDMAN, EDMUND CLARENCE (1833–1908), an American poet and critic, was born of Puritan stock at Hartford (Conn.), Oct. 8, 1833. From his mother he inherited his gift for writing; but at six years of age, his father having died, he was separated from her and reared by his father's people. A sensitive, lonely, rather rebellious youth, although he won several prizes for composition, he was rusticated after two years at Yale, and was not allowed to return. In 1871, however, the college conferred on him the B.A. and M.A. degrees, and in 1895 the degree of LL.D. After directing two Connecticut papers and embarking in business in New York, Stedman became connected with the New York *Tribune*, and in 1860 went to the *World* as editor, later becoming its war correspondent. A clerkship in Washington formed an interlude, but much of his life was spent in trading on the New York Stock Exchange, of which he edited a history (1905). He edited a volume of *Cameos* from Landor (with T. B. Aldrich, 1873), *A Library of American Literature* (11 vol. 1887–90), *The Works of Edgar Allan Poe* (with G. E. Woodberry, 10 vol. 1894–95), *A Victorian Anthology* (1895) and an *American Anthology* (1900). In addition to a large number of ephemeral reviews, he published *Victorian Poets* (1875), *Poets of America* (1885), and *The Nature and Elements of Poetry* (1892), books which show the poet's critical insight, technical knowledge, and high standards of workmanship. His most enduring place in literature, however, is due to his poetry—the deep serious note of his war lyrics or the whimsical fantasy of "Pan in Wall Street." The title of his rather conventional first book, *Poems, Lyrical and Idyllic* (1860), sounds the keynote of his work. Always a lover of beauty, he refused to be swayed from his ideals by the contemporary popularity of such *jeux d'esprit* as "The Diamond Wedding." As a result he has to his credit a group of fine and true lyrics such as the "Creole Lover's Song" and some commendable longer poems—*Alice of Monmouth; An Idyl of the Great War* (1863), *The Blameless Prince* (1869), and the elaborate commemorative ode on Hawthorne (read before the Harvard Phi Beta Kappa Society, 1877). He died in New York on Jan. 18, 1908.

STEED, HENRY WICKHAM (1871–), British journalist, was born on Oct. 10, 1871, at Long Melford, Suffolk. He studied economics, philosophy and history at Jena, Berlin and Paris universities, and in 1896 joined the staff of *The Times* as acting correspondent in Berlin, and was appointed correspondent in Rome in 1897. Transferred thence to Vienna in 1902 as correspondent for Austria-Hungary, he remained there until 1913 when he returned to London, and was appointed foreign editor of *The Times*, in Jan. 1914. In 1913 he published *The Habsburg Monarchy*, in which the internal condition of Austria-Hungary was critically examined and the possibility of a European war discussed. During the World War, Steed was mainly responsible for the foreign policy of *The Times* and, in 1918, was chosen to frame the policy of Lord Northcliffe's Department for Propaganda in Enemy Countries. He was sent on an official mission to the Italian front where he was authorized by the Allied Governments to promise independence to the subject Habsburg peoples. He helped also to arrange, in April 1918, the Rome congress of the oppressed Austro-Hungarian races. In Feb. 1919 he was appointed editor of *The Times*, and held this post until Nov. 1922. After relinquishing the editorship of *The Times* Steed published *Through Thirty Years* (1924), in which he related his experiences of European politics between 1892 and 1922. In 1923 he acquired the control of *The Review of Reviews*, of which he became editor.

STEEL: *see* IRON AND STEEL; WIRE ROPE; BESSEMER STEEL; STRUCTIONAL ENGINEERING; OPEN HEARTH STEEL; HIGH SPEED STEEL; MANGANESE STEEL; MOLYBDENUM STEEL; MUSHET STEEL; NICKEL STEEL; NICKEL CHROME STEEL; TOOL STEELS; TUNGSTEN STEEL; VANADIUM STEEL; NITROGEN HARDENING; STAINLESS STEEL; STEELS, ALLOY; ALLOYS; PRESSED METAL; SHEETS, IRON AND STEEL; and other specific headings.

STEELE, SIR RICHARD (1672–1729), Irish man of letters in the reign of Queen Anne, is inseparably associated in the history of literature with his personal friend Addison. The two were born in the same year. Steele, the senior by less than two months, was baptized on March 12, 1672 in Dublin. His father, also Richard Steele, was an attorney. He died before his son had reached his sixth year, but the boy found a protector in his maternal uncle, Henry Gascoigne, secretary and confidential agent to two successive dukes of Ormonde. Through his influence he was nominated to the Charterhouse in 1684, and there first met with Addison. Five years afterwards he proceeded to Christ Church, Oxford, and was a postmaster at Merton when Addison was a demy at Magdalen. Their schoolboy friendship was continued at the university, and probably helped to give a more serious turn to Steele's mind than his natural temperament would have taken under different companionship. Without waiting for a degree he volunteered into the army, and served for some time as a cadet "under the command of the unfortunate duke of Ormond" (*i.e.*, the first duke's grandson, who was attainted in 1715). This escapade was made without his uncle's consent, and cost him, according to his own account, "the succession to a very good estate in the county of Wexford in Ireland." He found a patron in Lord Cutts, to whom he dedicated a poem on the funeral of Queen Mary (1695). Cutts took the gentleman trooper into his household as secretary, made him an officer in his own regiment, and ultimately procured for him a captaincy in Lord Lucas's regiment of foot. A duel which he fought with Captain Kelly in Hyde Park in 1700, and in which he wounded his antagonist dangerously, inspired him with the dislike of duelling that he showed to the end of his life. Steele won William III.'s favour (too late to be of practical use) by a timely reference to him in *The Christian Hero*, his first prose treatise, published in April 1701. Steele complained that the reception of *The Christian*

Hero by his comrades was not so respectful; they persisted in trying him by his own standard, and would not pass "the least levity in his words and actions" without protest. He therefore determined to clear his character of the charge of undue solemnity by writing a comedy, *The Funeral* (1701). With this play he began his work of reconciling wit, good humour and good breeding with virtuous conduct which he was afterwards to accomplish in the famous essays in the *Tatler* and the *Spectator*. In his next comedy, *The Lying Lover; or, the Ladies' Friendship* (1703), based on Corneille's *Menteur*, Steele's moral purpose was directly avowed, and the play, according to his own statement, was "damned for its piety." *The Tender Husband*, an imitation of Molière's *Sicilien* (in April 1705), was more successful. It was seventeen years before Steele again tried his fortune on the stage with *The Conscious Lovers*, the best and most successful of his comedies, produced in December 1722.

The Tatler and the Spectator.—In 1707 Steele was given the office of gazetteer. The *Gazette* gave little opening for the play of Steele's lively pen, his main duty, as he says, having been to "keep the paper very innocent and very insipid"; but the position gave him insight into journalism. The *Tatler* made its first appearance on April 12, 1709. It was partly a newspaper, a journal of politics and society, published three times a week. Steele's position as gazetteer furnished him with special advantages for political news, and as a popular frequenter of coffeehouses he was at no loss for social gossip. He gradually introduced into the *Tatler* as a special feature essays on general questions of manners and morality.

Steele was always in want of money. He had £300 a year from his gazetteership (paying a tax of £45), £100 as gentleman waiter to Prince George, £850 from the Barbadoes estates of his first wife, a widow named Margaret Stretch, and some fortune by his second wife—Mrs. Mary Scurlock, the "dear Prue" of his charming letters. But he lived in considerable state after his second marriage, and before he started the *Tatler* was borrowing money. The assumed name of the editor was Isaac Bickerstaff, but Addison discovered the real author in the sixth number, and began to contribute in the eighteenth. The success of the *Tatler* was established before Addison joined him, and Addison contributed to only forty-two of the two hundred and seventy-one numbers that had appeared when the paper was stopped, obscurely, in January 1711.

Only two months elapsed between the stoppage of the *Tatler* and the appearance of the *Spectator*, which was the organ of the two friends from March 1, 1711 to Dec. 6, 1712. Addison was the chief contributor to the new venture, and the history of it belongs more to his life. Nevertheless, it is to be remarked as characteristic of the two writers that in this as in the *Tatler* Addison generally follows Steele's lead in the choice of subjects. The first suggestion of Sir Roger de Coverley was Steele's although it was Addison that filled in the outline.

Steele projected various journals in the next years, most of them, such as the *Englishman* (1733), and the *Reader* (1714), *Town Talk*, *Tea Table* and *Chit Chat*, very short lived; though the *Guardian* (1713) had 176 numbers. Steele's most famous political paper, the *Plebeian* (1718) embroiled him in a controversy with Addison. A pamphlet, *An Apology for Himself and his Writings* (1714) is important biographically.

Later Life.—The fortunes of Steele as a zealous Whig varied with the fortunes of his party. Over the Dunkirk question he waxed so hot that he threw up a pension and a commissionership of stamps, and went into parliament as member for Stockbridge to attack the ministry with voice and vote as well as with pen. But he had not sat many weeks when he was expelled from the house for the language of his pamphlet on the *Crisis*, which was stigmatized as seditious. The *Apology* already mentioned was his vindication. With the accession of the House of Hanover his fortunes changed. Honours and substantial rewards were showered upon him. He was made a justice of the peace, deputy-lieutenant of Middlesex, surveyor of the royal stables, governor of the royal company of comedians—the last a lucrative post—and was also knighted (1715). After the suppression of the Jacobite rebellion he was appointed one of the commissioners of forfeited estates, and spent some two years in Scotland in that capacity. In 1718 he obtained a patent for a plan for bringing salmon alive from Ireland. Differing from his friends in power on the question of the Peerage Bill he was deprived of some of his offices, but when Walpole became chancellor of the exchequer in 1721 he was reinstated. With all his emoluments however the imprudent, impulsive, ostentatious and generous Steele could never get clear of financial difficulties, and he was obliged to retire from London in 1724 and live in the country. He spent his last years on his wife's estate of Llangunnor in Wales, and, his health broken down by a paralytic seizure, died at Carmarthen, Sept. 1, 1729.

A selection from Steele's essays, with a prefatory memoir, has been edited by Austin Dobson (1885; revised 1896). *See* also *Selected Essays* (1907) ed. L. E. Steele; and *Letters of Richard Steele* (1928), ed. R. B. Johnson. Dobson contributed a biography to Andrew Lang's series of *English Worthies*, in 1886. In 1889 an exhaustive life was published by G. A. Aitken, who also edited Steele's plays (1898) and the *Tatler* (1898).

STEELS, ALLOY. Alloy steels may be divided into two main groups, namely:—(*a*) Alloy tool steels, which are dealt with under "tool steels," and other headings; (*b*) Alloy steels for engineering purposes, which are here briefly described. This group includes the high tensile steels, with useful mechanical properties developed by heat treatment, the alloy case-hardening steels, which are carburized and hardened before putting into service, and the non-magnetic, austenitic steels, the mechanical properties of which cannot be varied greatly by any form of heat treatment.

High Tensile Alloy Steels.—The chief use of the hardenable alloy steels lies in their ability to be made both strong and tough by suitable heat treatment, that is to say, they can combine high tensile properties with superior resistance to shock, thus permitting the engineer to design various parts of considerably smaller size than would otherwise be possible.

It has been found, as the result of the work of many investigators, that the desired combination of strength and toughness is most highly developed when the constituents of the steel are in the finest state of division. This condition is secured by heating the steel to such a temperature as will cause the different constituents to completely interdiffuse with each other, producing what the metallurgist calls a solid solution, and retaining this by cooling at a sufficiently rapid rate and then reheating to cause a partial or complete re-precipitation of the constituents from this solid solution.

The addition to steel of other metals like nickel, chromium, molybdenum, etc., increases the amount of lag, that is the difference between the temperatures of the change points on heating and cooling. The greater the amount of this lag, the more easy is it to retain the steel in the state of solid solution, *i.e.*, to harden it, so that quenching in oil is sufficiently rapid with many of these alloy steels, and if still larger amounts of certain elements are present, as for example with some nickel-chromium steels, the amount of lag is so great that bars of normal size are hard even if allowed to cool in air.

Nickel steels, which are amongst the most commonly used high tensile alloy steels, may contain 1 to 5% nickel, with a carbon content varying from ·25 to ·45%, according to the mechanical properties required. The presence of only 1% nickel makes the steel more responsive to heat treatment, producing, in smaller sizes, excellent mechanical properties of the order of 35 to 45 tons tensile strength with high resistance to shock as expressed by the notched bar impact test. Steel containing 3% nickel is, however, more popular, and readily gives a tensile strength of 45 to 55 tons per square inch with an izod impact figure of 40 ft. lb. The addition of 5% nickel produces a still stronger steel, having a tensile strength of 55 to 65 tons per sq.in. with a similar impact value.

These nickel steels do not harden intensely when cooled in air, and this offers certain advantages for some purposes, as for instance in the making of drop forgings, which can be laid down after forging without any great fear of cracking. The nickel steels are hardened in oil from temperatures of 800° C to 850° C and tempered in the range 550° C to 650° C, according to the mechanical properties required.

The addition of chromium along with nickel increases the intensity of hardening, thus producing steels of higher tensile strength capable of hardening through their section in larger masses. There are a number of nickel-chromium steels in everyday use, which contain carbon ranging from ·25 to ·45%. The most generally used compositions are 1% nickel with 1% chromium, 2% nickel with 1% chromium, 3% nickel with ·5 to 1% chromium, 3·5 to 4·5% nickel with 1 to 2% chromium. Although the steels containing the lower amounts of nickel and chromium harden in air to a greater extent than nickel steels without chromium, they are generally hardened in oil from temperatures of 800° C to 830° C and tempered in the range 600° C to 650° C.

Steels containing the higher amounts of nickel and chromium will harden, in sizes up to say 3 in. diameter, to 100 to 110 tons per square inch when cooled in air from 800° to 820° C, whilst larger sizes are quenched in oil. Such steels are sometimes used in the hardened condition, but for other purposes are tempered to give 55 to 65 tons per square inch. To be always sure of obtaining good impact values with the nickel-chromium steels they should be rapidly cooled from the tempering heat. If allowed to cool slowly, some of them show a peculiar type of brittleness known as "temper-brittleness." Further, such steels when tempered in the range of 250° to 550° C are apt to be brittle. A small amount of vanadium is sometimes added to the nickel-chromium steels.

The addition of molybdenum to nickel-chromium steels produces a still higher tensile strength when tempering at similar temperatures, and has the further advantage of preventing the occurrence of temper-brittleness, so avoiding the necessity of rapid cooling after tempering, and also permitting the steel to be tempered at lower temperatures, thus enabling mechanical properties of the order of 65 to 80 tons per square inch to be obtained when desired, with an impact value of 40 to 20 ft. lb.

Another type of high tensile alloy steel is the chrome or chrome vanadium steels containing 1 to 1·75% chromium and 0 to ·3% vanadium. Such steels do not air harden but can be oil hardened from 840° C to 870° C and tempered from 600 to 700° C to give 45 to 65 tons per square inch. The effect of the small amount of vanadium on the mechanical properties is not very marked.

Other alloy steels such as chrome-molybdenum and nickel-molybdenum are made, which can be oil hardened and tempered to give similar mechanical properties to the earlier mentioned steels, but they are not at present so generally used. One of the chief advantages of the addition of molybdenum to steel lies in the influence it has, in the same way as tungsten, in producing a fine grained steel.

The previously mentioned steels are used for a variety of engineering purposes such as piston rods, axles, connecting rods, crankshafts, driving and propeller shafts, screw couplings, nuts and bolts, gears, steering levers, spindles, pinions, brake rods, gun tubes, torpedo air vessels, armour plates, etc.

In addition to the foregoing, the stainless steels containing 12 to 20% chromium, with 0 to 2% nickel, can be included in the category of high tensile alloy steels. They are capable of being hardened from temperatures of 900 to 950° C in air or oil up to a tensile strength of 70 to 100 tons per square inch, and can be tempered to give 40 to 65 tons, according to their composition.

The addition of silicon to steel also increases its hardening capacity and such steels are used particularly for the manufacture of springs. They contain ·40 to ·65% carbon, 1 to 2% silicon, and ·40 to 1·0% manganese, and are referred to as silico-manganese steels. The lower compositions are used for hardening in water, and the higher composition for oil-hardening. A silico-chromium steel is also used for springs which are oil hardened and tempered. Such steel contains ·50 to ·60% carbon, ·7% to 1·3% silicon and ·60 to 1·0% chromium.

Case-hardening Alloy Steels.—The most generally used alloy steels for case hardened parts are of low carbon content—·10 to ·20%—and may contain 1, 2, 3 or 5% nickel. Steels containing 3 to 4% nickel with ·60 to 1·5% chromium are also used to a less extent.

When carburizing, the parts are packed with a carbonaceous material in boxes, and heated. Experiments have shown that the most suitable temperature for rapid penetration without the formation of an excess of carbon on the extreme skin, is just above the upper critical temperature in the case of plain carbon steels. The time of carburizing depends upon the depth of penetration required, and is usually between 2 and 8 hours for general purposes. After carburizing, the part consists of a high carbon case and a low carbon core.

Owing to the temperature and length of time occupied in the carburizing operation, the steel is overheated, both in the case and the core, and if quenched directly from the carburizing box the steel would be brittle, and the case would be apt to shell off or crack. It is advisable to allow the carburised parts to cool in the box and reheat them to just above the upper critical temperature and cool in oil to refine the core, and then to reheat again to just above the lower critical temperature to refine and harden the case by quenching either in water or oil, depending upon the size of article and its composition. From what has been stated before, it will be seen that the upper critical temperature is lower the higher the nickel content of the steel. The refining temperature for steels containing say ·15% carbon with 1% nickel is 880° C, 2% nickel 860° C, 3% nickel 840° C, 5% nickel 800° C and the nickel chrome steels 850° C. The final hardening temperature varies from 760° C to 730° C according to the nickel content.

What composition of steel is used for any part depends upon what strength of core is required, and in choosing the steel the size of the article should be carefully considered, as the influence of mass upon the hardening effect is very marked.

Austenitic Alloy Steels.—This is a class of alloy steels characterized by low elastic limit values, and high ductility as revealed by the elongation in the tensile test. They are non-magnetic, and are not hardenable by quenching. Their hardness can be increased by cold working, with loss of some ductility, and after such treatment they become slightly magnetic, but can be fully softened again by heating to 1,000° to 1,100° C and cooling rapidly. They are more difficult to machine than other steels, and some of them—notably the high manganese steels, are commercially unmachinable although special drills have recently been perfected in America. Because of their low elastic limit they cannot be used for parts which are heavily stressed.

There are three well-known types of austenitic steels in use, firstly the manganese steels containing 12 to 14% manganese, which because of the rapidity with which they work-harden, are useful for such purposes as tramway points and crossings, which demand resistance to abrasion, combined with toughness.

Steel containing high amounts of nickel are also austenitic. A steel containing 25% nickel is used chiefly for parts of electrical machinery, and in some cases for its resistance to certain forms of corrosion and a special alloy containing about 36% nickel is useful because of its extremely low coefficient of expansion.

In the same class are the stainless steels containing 10 to 20% chromium and 6 to 25% nickel which are finding an extended use because of their superior resistance to many forms of corrosion, and also because of their strength at high temperatures, and resistance to oxidation.

(*See* also IRON AND STEEL, ALLOYS, and the various types of steels under their own headings.) (F. A.)

STEELTON, a borough of Dauphin county, Pennsylvania, U.S.A., 3 m. S.E. of Harrisburg, on the Susquehanna river; served by the Pennsylvania, the Reading and the Steelton and Highspire railways. Pop. (1920) 13,428 (21·6% foreign-born white and 14·7% negroes). It has vast steel works and various smaller manufacturing industries, and there is a large limestone quarry within its limits. A town called Baldwin was laid out here in 1866, and the present name was adopted for the borough in 1880.

STEEL WOOL, a mild abrasive commonly used to clean or polish metals and metallic objects. It is of great practical use in the japanning, plating and moulding rooms of factories. In rubbing down metallic articles to attain a fine finish, steel wool achieves much the same results as pumice. Steel wool is also used to clean rusty and tarnished hollow-ware.

STEELYARD, MERCHANTS OF THE, Hansa merchants who settled in London in 1250 at the steelyard on the riverside, near Cosin lane, now Ironbridge Wharf. Henry III. in 1259, at the request of his brother Richard of Cornwall, king of the Romans, conferred on them important privileges, which were confirmed by Edward I. It was chiefly through their enterprise that the early trade of London was developed, and they continued to flourish till, on the complaint of the Merchant Adventurers in the reign of Edward VI., they were deprived of their privileges. They succeeded in maintaining a footing in London till 1597.

See Stow, *Survey of London* (1598); Lappenburg, *Urkundliche Geschichte des hansischen Stahlhofes zu London* (Hamburg, 1851); Pauli, *Pictures of Old London* (1851); Ehrenberg, *Hamburg und England im Zeitalter der Königin Elizabeth* (Jena, 1896).

STEEN, JAN HAVICKSZ (1626–1679), Dutch subject-painter, was born at Leyden in 1626, the son of a brewer. According to Houbraken he studied under Nicolas Knupfer, a German artist, at Utrecht, and under Jan van Goyen, whose daughter he married in 1649. In November 1646 he enrolled himself as a student of the university at Leyden and in 1648 he was one of the founders of the Guild of St. Luke in that city. He settled at The Hague in 1649, and at Delft in 1654. In 1657 he is said to have been a brewer at Delft. He is repeatedly mentioned in documents in the Delft archives during 1656–57. He was a resident of Haarlem during the years 1661–69. He then moved to Leyden, where he received permission to open a tavern in 1672. In 1673 he took a second wife, Maria van Egmont, the widow of a Leyden bookseller. He died at Leyden Feb. 3, 1679.

The works of Jan Steen are distinguished by correctness of drawing, admirable freedom and spirit of touch, and clearness and transparency of colouring. But their true greatness is due to their intellectual qualities. In the wide range of his subjects, and their dramatic character, he surpasses all the Dutch figure-painters, with the single exception of Rembrandt. His productions range from the stately interiors of grave and wealthy citizens to tavern scenes of jollity and debauch. He painted chemists in their laboratories, doctors at the bedside of their patients, card-parties, marriage feasts—even religious subjects, though in these he was least successful. His rendering of children is especially delightful. Portraits from his brush are comparatively rare.

The National Gallery contains three pictures by Jan Steen, of which the "Music Master" is the most important, and other excellent examples of his art in England are preserved in the Royal, the Bute, and the Northbrook collections, at Apsley House and Bridgewater House, and in the galleries of The Hague, Amsterdam, and the Hermitage, St. Petersburg (Leningrad). A remarkably fine example of his work is the "Grace Before Meat" in the collection of Charles Morrison, London.

See Hofsteede de Groot, *Catalogue of Dutch Painters* (1907); F. Schmidt Degener, *Jan Steen* (1927) (trans. by G. Renier).

STEENKIRK or **STEENKERKE,** a village in the Belgian province of Hainaut, on the river Senne, famous for the battle of Steenkirk (Steinkirk, Estinkerke) fought on July 23–Aug. 3, 1692 between the Allies (*see* Grand Alliance, War of the) under William III. of England and the French commanded by the duke of Luxemburg. Previous to the battle the French army lay facing north-west, with its right on the Senne at Steenkirk and its left towards Enghien, while the army of William III. was encamped about Hal. William, seeing the opportunity of surprising a part of the enemy's forces and having forced a detected spy to give Luxemburg misleading news, set his army in motion before dawn on Aug. 3 to surprise the French right about Steenkirk. The advanced guard, mainly English and Danish infantry, under the duke of Württemberg, deployed close to the French camps ere Luxemburg became aware of the impending blow; at this moment the main body of the army farther back was forming up after the passage of some woods. When the fight opened, Luxemburg was completely surprised, and could do no more than hurry the nearest foot and dragoons into action as each regiment came on the scene. But the march of the Allies' main body had been mismanaged; while Württemberg methodically cannonaded the enemy, waiting for support and for the order to advance, the Allies' main body, which had marched in the usual order, one wing of cavalry leading, the infantry following, and the other wing of cavalry at the tail of the column, was being hastily rearranged in rear. A few battalions only had come up to support the advanced guard when the real attack opened (12.30). The advanced guard had already been under arms for nine hours, and the march had been over bad ground, but its attack swept the first French line before it. The English and Danes stubbornly advanced, the second and third lines of the French infantry giving ground before them, but Luxemburg was rapidly massing his whole force to crush them, and meanwhile the confusion in the allied main body had reached its height. Count Solms, who commanded it, ordered the cavalry forward, but the mounted men, scarcely able to move over the bad roads and heavy ground, only blocked the way for the infantry. Some of the English foot, with curses upon Solms and the Dutch generals, broke out to the front, and Solms, angry and excited, thereupon refused to listen to all appeals for aid from the front. No attempt was made to engage and hold the centre and left of the French army, which hurried, regiment after regiment, to take part in the fighting at Steenkirk. William's counter-order that the infantry was to go forward, the cavalry to halt, only made matters worse, and by now the advanced guard had at last been brought to a standstill. At the crisis Luxemburg had not hesitated to throw the whole of the French and Swiss guards into the fight, and as, during and after this supreme effort, more and more French troops came up, the Allies were driven back, contesting every step against weight of numbers. Those troops of the main body, foot and dragoons, which succeeded in reaching the front, served only to cover and to steady the retreat of Württemberg's force, and, the *coup* having manifestly failed, William ordered the retreat. The Allies retired as they had come, their rear-guard—of grenadiers from the British regiments—showing too stubborn a front for the French to attack. The latter were indeed in no state to pursue. Over eight thousand men out of only about fifteen thousand engaged on the side of the Allies were killed and wounded, and the losses of the French out of a much larger force were at least equal. Contemporary soldiers affirmed that Steenkirk was the hardest battle ever fought by infantry.

STEEPLECHASING, a type of horse-racing not run on the flat, but either across country or on a made course with artificial fences, water-jumps, etc. The name is sometimes used in connection with cross-country running on foot or of a race on a made course over hurdles and other obstacles. In Great Britain point to point Steeplechases held under the control of the M.F.H. Association, now represent the nearest approach to steeplechasing in its earlier days. The proficiency in jumping which ought to be characteristic of a first-class steeplechaser is often conspicuous by its absence nowadays when all too often a course of racing over hurdles is thought to be a sufficient preparation for racing over the regulation fences, built up in accordance with the instructions of the British National Hunt Committee.

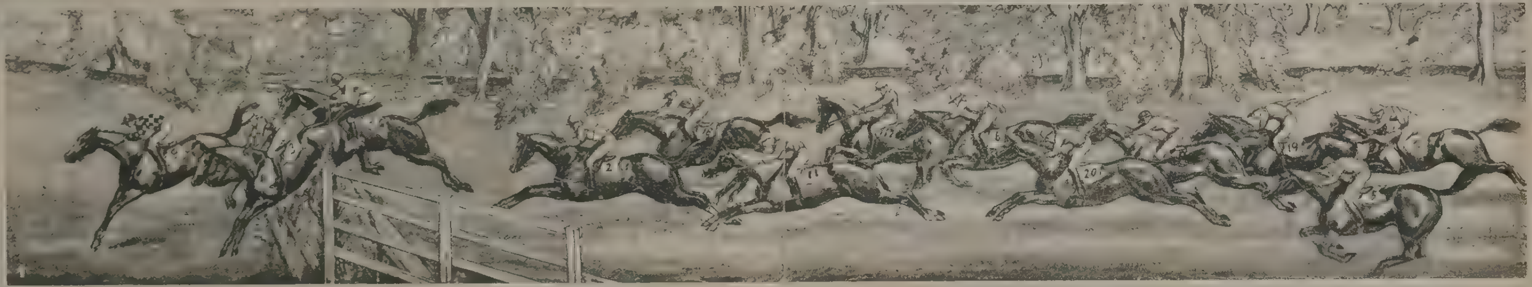
For steeplechasing in Great Britain *see* Horse-Racing and Breeding, section *Steeplechasing and Hurdle-Racing*. Steeplechasing in America is treated below.

UNITED STATES AND CANADA

Steeplechasing in North America began in Canada, where English officers, quartered at Montreal and Toronto, gave meetings. The Montreal hunt, founded in 1826, doubtless raced across country, and in 1850 a great steeplechase was held near the St. Pierre course. The race was for £100 over hurdles, stone walls, three double jumps, ditches and rasping fences. J. P. Dawes was a leading owner, and his Charlemagne, in 1882, carrying 175 lb., won at Mystic Park, Boston, and later at The Country Club, ridden by Strathey. The next year, carrying Baron von Zedlitz, he again won at Mystic Park, and the day following carried off The Country Club steeplechase handicap. Dawes' Rose, in 1882, won ten and finished second six times in 21 starts, seven in the United States.

A Grand Military Steeplechase, competed for by six officers, was run in London, Ontario, on May 9, 1843, of which a print was published by Ackermann, in London, England, in 1845, from a drawing by Lady Alexander.

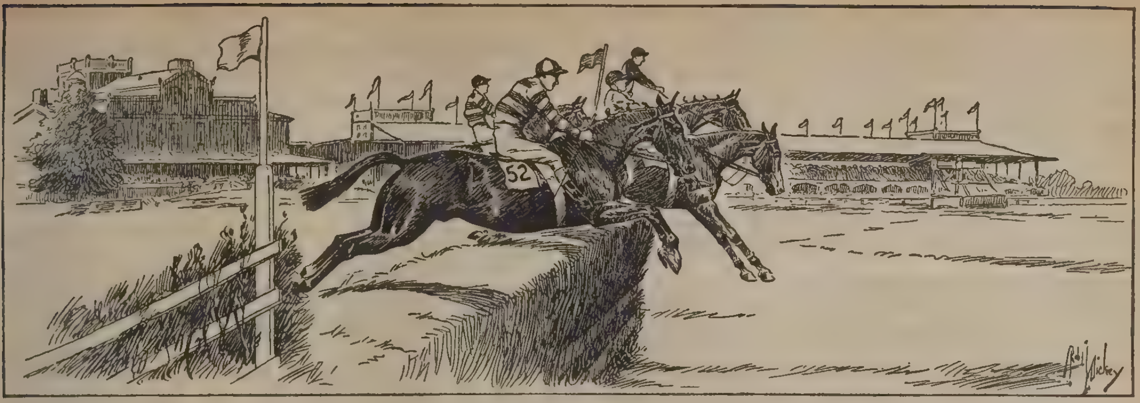
In the same year a meeting was given at Toronto, the course



(1) FROM A LITHOGRAPH BY GORDON ROSS; PHOTOGRAPHS, (2, 3, 4) EDWIN LEVICK

STEEPLECHASING IN THE UNITED STATES

1. The twenty-sixth running of the Challenge Cup in 1926 at the Country Club, Brookline, Mass., under the auspices of the Eastern Horse Club
2. The Virginia Gold Cup, 1927, first offered in 1922. Won by Dum Dum, Mr. Donald Pearse up
3. Maryland Hunt Cup, 1926, first raced for in 1894. Won by Billy Barton, Mr. A. G. Ober, Jr. up—the winner leading
4. Meadow Brook Cup, 1927, first offered in 1883. Won by Billy Barton, Mr. Ober up



DRAWN BY ROBERT L. DICKEY

THE CAD (NO. 52) WINNING THE $10,000 CHAMPION STEEPLECHASE OF AMERICA, IN 1900, WITH OWNER, "MR. SMITH," UP

being near Shepherd's Golden Lion, Yonge street. One race was won by Grasshopper, Black Douglas second, Aemilius Irving up. That fall a heavyweight steeplechase was won by Samuel P. Jarvis, Jr., riding Gaylad. Both Aemilius Irving and Samuel P. Jarvis were forebears of the well-known Canadian sportsman, Aemilius Jarvis. Canada boasts of the oldest steeplechase stake in America, "The Woodbine," won in 1882 by Rose, and in 1928 (the 44th running) by Wych Elm, owned by George W. Beardmore, master of the Toronto hunt.

W. S. Vosburgh writes that the first steeplechase in the States was at Paterson, N.J., June 7, 1865, a three-mile handicap, over 27 jumps, though the real beginning was an extra day's steeplechasing at Jerome Park in Nov. 1869. Vosburgh wrote articles for *The New York Sportsman* in 1880, telling of races won by Oysterman, Postguard, Trouble, Waller, Lobelia, Tammany, Diavolo, Major Pickett and Bourke Cockran, and of steeplechasing in New Orleans in 1871 and 1872.

The Driving Park, Chicago, in 1880, "had jumping races," and in 1884 the July stakes, a handicap, received 18 entries. Edward Corrigan owned a number of splendid jumpers and laid out a beautiful course at Hawthorne Park in 1891.

Hunt and Country Clubs.—Steeplechasing in America has always received its strongest backing from the hunt and country clubs, and the most valuable stake offered up to 1883 was given by the Rockaway hunt, with a guaranteed value of $5,000, which was won by Major Pickett. The Rosetree hunt raced across country about 1877. The Country club, Brookline, had 36 consecutive meetings from 1880. The Meadow Brook hunt cup was offered in 1883, and has been won by such well-known gentlemen riders as Stanley Mortimer, George Work, T. Hitchcock, "Billy" Hayes, "Mr. Smith," F. S. von Stade and others. Swan Latrobe gave a silver pitcher for the Genesee Valley point to point, which was won on Oct. 13, 1885, by Seward Cary's Patchen, Tom Cary up. "Mr. Smith" later won this race four times. The Maryland hunt cup, given by Ross Whistler, was first raced for in 1894. The Maryland grand national dates from 1900, and the race for My Lady Manor cup from 1908. In Virginia open steeplechases were given here and there. At Ivy City track, the most noted gentleman rider of his time, Harry Harwood, was killed. The Deep Run Hunt Club, at Chantilly, west of Richmond, gave the first amateur meeting in Virginia in 1895. In 1922 the Virginia Gold Cup was offered by the Warrenton Hunt Club, and at the Middleburg and Orange County Hunts of Piedmont Valley, sport "Between the Flags" has taken strong hold.

About Philadelphia there have been hunt races at the Radnor, White Marsh Valley club, Wissahickon Farms, and in other hunting countries, two of the leading patrons of sport being William Clothier and William Kerr, the latter's Algie and other cracks for years having made steeplechase history. Good sport has been provided by the Essex hunt since 1920 and elsewhere in New Jersey. The Bloomfield hunt held its first meeting in 1920 near Detroit, and the Onwentsia, near Chicago, the same year. Fine sport was shown by the Westchester-Biltmore Association at Bowman Park, Rye, in 1927, and in 1928 a meeting was held for the cavalry school at Ft. Riley, Kansas. In Massachusetts, the Willowdale cup has become a prominent feature, and in 1927 a splendid inaugural meeting was given by the Norfolk hunt. The Eastern horse club, founded by Augustus F. Goodwin and others, continuing the work of The Country Club in Massachusetts, has held three most successful meetings, and for a number of seasons the United Hunts Racing Association has held important meetings on Long Island. Private meetings were given by Joseph E. Widener at Elkins Park, Pa., and in 1927 and 1928 by John R. Macomber at his racing plant at Raceland, Framingham, Mass., and by Robert C. Winmill at Warrenton, Pa.

The National Steeplechase Association.—In 1891, the National Steeplechase Association was founded by S. S. Howland, August Belmont and others, and was later merged into the National Steeplechase and Hunt Association, providing rules for racing which have been accepted by a number of the clubs, but their efforts have been small compared with what might have been accomplished. The chief work on behalf of sport has always been done by individual endeavour. In 1899 Robert Chamblet Hooper, Thomas Hitchcock and others founded the Champion Steeplechase of America and the Grand National, the former worth about $10,000 and the latter $8,000. The first Champion was won by James W. Colt's Van Ship, the second by Harry Worcester Smith's hunter The Cad, owner up, and the third by Self Protection, Harry Page up. "Billy" Hayes won the Grand National on Trillion, and in 1906 Thomas Hitchcock's Good and Plenty, carrying 170 lb., made a show of his field. At that period Hooper's stable were also consistent winners.

For a time without individual effort the sport deteriorated, except at the hunt clubs, until 1926 when Bayard Warren of Boston planned the rejuvenation of the Grand National, which was won at Belmont Park in 1927 by Jolly Roger, owned by Mrs. Payne Whitney, one of the strongest patrons of steeplechasing in America. Joseph E. Widener's colours, carried by Fairmount and others, have been prominent over the Park courses at Saratoga, Pimlico, Aqueduct and elsewhere, but to the Maryland Hunt Cup Association must be given the credit of upholding the true importance of sport "between the flags," for with their course of 4 m. over solid post and rails, averaging almost 5 ft., only first-rate horses and riders can conquer, and the list shows such great sportsmen as Jarvis Spencer, Jr., Redmond Stewart, A. Devereux, G. Mather, Arthur White, Raymond Belmont, J. N. Ewing, J. T. Bowen, A. B. Ober, F. A. Bonsal, Jr., and such horses as Princeton, Landslide, Sacandaga, Oracle, Burgoright, Billy Barton and Bon Master. Billy Barton has to be acknowledged as in a class by himself over timber courses, and his gallant showing, when he finished second in the English Grand National of 1928, shows that steeplechase horses can be made in America, but not when raced over low park courses such as Belmont, where the water jump is but 9 feet wide, and the hedge is in proportion.

Vosburgh has so truly said: "Put up the fences and put up the weights. Weight seldom breaks down a horse, and never has broken down one-tenth as many as speed has. By raising the weights we can have men in the saddle instead of boys, and by raising the fences we will have less falls and better races. It will stop the speed and make the contest steeplechases where they are now little better than hurdle races."

See W. S. Vosburgh, *Racing in America 1866–1921* (1922); *The Toronto Herald; Toronto Turf Club, Union and Niagara Races Race Cards; American Turf Register; The Turf, Field and Farm; The Spirit of the Times.* (H. W. Sm.)

STEER, PAUL WILSON (1860–), English painter, was born at Birkenhead. He was trained first at the Gloucester school of art and afterwards in Paris at the Académie Julian, and in the École des Beaux Arts under Cabanel. After 1886, before which date he had shown three pictures at the Royal Academy, practically the whole of his work was seen in the exhibitions of the New English Art Club. In his early work he appears as an adherent of the French Impressionist movement, and as a teacher at the Slade School he exercised an important influence on the development of English contemporary art. His figure subjects and landscapes show great technical skill.

STEEVENS, GEORGE (1736–1800), English Shakespearian commentator, was born at Poplar on May 10, 1736, the son of an East India captain, afterwards a director of the company. He was educated at Eton and at King's College, Cambridge. Leaving the university (1756) without a degree, he settled in chambers in the Temple, removing later to a house on Hampstead Heath, where he collected a valuable library, rich in Elizabethan literature. He walked from Hampstead to London every morning before seven o'clock, discussed Shakespearian questions with his friend, Isaac Reed, and, after making his daily round of the booksellers' shops, returned to Hampstead. He published in 1766 reprints of the quarto editions of Shakespeare's plays, entitled *Twenty of the Plays of Shakespeare. . . .* Dr. Johnson suggested to him the preparation of a complete edition of Shakespeare. The result, known as Johnson's and Steevens's edition, was *The Works of Shakespeare with the Corrections and Illustrations of Various Commentators* (10 vols., 1773), Johnson's contributions to which were very slight. This early attempt at a variorum edition was revised and reprinted in 1778, and further edited in 1785 by Isaac Reed; but in 1793 Steevens, who had asserted that he was now a "dowager-editor," was persuaded by his jealousy of Edmund Malone to prepare an edition of fifteen volumes. He made somewhat reckless emendations, but the edition showed a wide knowledge of Elizabethan literature. He died at Hampstead on Jan. 22, 1800.

Steevens's Shakespeare was re-issued by Isaac Reed in 1803, in 21 volumes, with additional notes left by Steevens. This, which is known as the "first variorum" edition, was reprinted in 1813. Steevens's notes are also incorporated in the edition of 1821, begun by Edmund Malone and completed by James Boswell the younger.

STEEVENS, GEORGE WARRINGTON (1869–1900), English journalist, was born at Sydenham, near London, on Dec. 10, 1869, and was educated at the City of London School and Balliol College, Oxford, of which he was a scholar. In 1893 he was elected a fellow of Pembroke College, Oxford. In September 1899 he went to South Africa and joined Sir George White's force in Natal as war-correspondent, being subsequently besieged in Ladysmith. He died during the siege, of enteric fever, on Jan. 15, 1900. The best of his books were *With Kitchener to Khartoum* (1899), and *From Capetown to Ladysmith* (1900).

STEFANI, ALBERTO DE (1879–), Italian statesman, lectured on economics at Venice, Ferrara and Padua, and only entered politics in 1921, when he stood as an independent candidate for Verona. After he entered the Chamber he rapidly gravitated to the Fascist group. He was appointed minister of finance in Mussolini's cabinet (Oct. 28, 1922), and on the death of Professor Tangorra on Dec. 21, combined the Treasury with this office. He was responsible for establishing equilibrium of the budget in 1924, in place of the large deficit of 1922–3. Before de Stefani retired in 1925 he was able to show a solid reduction in the national debt.

STEFANIE, BASSO NAEBOR or **CHUWAHA,** a lake of East Africa, lying in 37° E., between 4° 25′ and 5° N., and measuring some 40 m. by 15. It is the southernmost and lowest (1,880 ft.) of a series of lakes which lie in the north-easterly continuation of the great East African rift valley (*see* Abyssinia: *River and Lake System*). The character of the lake, which has no outlet, varies greatly according to the amount of water brought down by its principal feeder, the Dulei, which enters at its north end, being there a rapid stream 50 yd. wide and 3½ ft. deep.

Lake Stefanie was discovered by Count Samuel Teleki in 1881, and has since, with others of the series, been explored by Donaldson Smith, V. Bottego, M. S. Welby, Oscar Neumann, Arnold Hodson and others. An agreement of 1907 with Great Britain recognized the lake as within the Abyssinian empire.

See *Geographical Journal* (Sept. 1896, Sept. and Dec. 1900, Sept. 1901, Oct. 1902, July 1922); L. von Höhnel, *Discovery of Lakes Rudolf and Stefanie* (1894); L. Vannutelli and C. Citerni, *L'Omo* (Milan, 1899); British War Office map, Africa, 1·2,000,000 (1924).

STEFANSSON, VILHJALMUR (1879–), Arctic explorer, was born on Nov. 3, 1879, at Arnes, Manitoba, Canada, of Icelandic parents. He graduated from the University of Iowa and later studied theology and anthropology for three years at Harvard university. After two archaeological voyages to Iceland in 1904 and 1905 he turned to Arctic research and had by 1928 spent altogether 10 winters and 13 summers in scientific work north of the polar circle. In 1906–07 he was ethnologist of the Leffingwell-Mikkelsen expedition on the north coast of Alaska and at the mouth of Mackenzie river; in 1908–12 he commanded an expedition on which he discovered certain Eskimo groups and visited others who had not seen a white man for half a century. From 1913 to 1918 he commanded an arctic expedition under the auspices of the Canadian Government. During more than five years continuously north of the Arctic Circle (the longest Arctic expedition on record) he explored vast regions north of Canada and Alaska, sometimes sledging for months over moving ice, accompanied by two or three companions and living exclusively by hunting. He discovered between 1915 and 1917 the islands now known as Borden, Brock, Meighen and Lougheed, and several smaller islands. In 1918 his then second in command, Storker Storkerson, taking charge while Stefannson was ill with typhoid fever, explored by sledge, with four companions, the Beaufort sea north of Alaska. They were absent from shore about eight months, during six of which they were encamped, and lived by hunting, on a floe more than five miles in diameter while it drifted with them 450m. over a previously unexplored ocean from 1m. to 3m. deep. They found an abundance of seals everywhere, had therefore plenty of food and fuel, suffered no hardships, and reported on their return that they felt sure they could have spent several years on this floe safely. This confirmed the conclusions of all the previous sledge journeys of the expedition over the moving ocean ice—that seal life, and therefore probably other water life, does not necessarily decrease, as was previously believed, farther north in the Arctic. Stefansson has laid great stress on the economic value of the Arctic regions, chiefly as meat-supplying countries through the cultivation of the domestic reindeer and the domestication of the ovibos or musk-ox. In 1924 Stefansson visited the Macdonnell ranges of central Australia.

His principal publications are: *My Life with the Eskimo* (1913); *Anthropological Report* (1914); *The Friendly Arctic* (1921); *The Northward Course of Empire* (1922); *Hunters of the Great North* (1922); *The Adventure of Wrangel Island* (1926); *The Standardization of Error* (1927).

STEFFANI, AGOSTINO (1653–1728), Italian ecclesiastic, diplomatist and musical composer, was born at Castelfranco on July 25, 1653. At a very early age he was admitted as a chorister at St. Mark's, Venice. Count Tattenbach took him in 1667 to Munich, where his education was completed at the expense of Ferdinand Maria, elector of Bavaria, who gave him a court appointment. He was sent in 1673 to study in Rome, where Ercole Bernabei was his master, and among other works he composed six motets, the original manuscripts of which are now in the Fitzwilliam Museum at Cambridge. On his return to Munich in 1674 he published his first work, *Psalmodia vespertina,* a part of which was reprinted in Martini's *Saggio di contrappunto* in 1674. In 1675 he was appointed court organist. The date when he was ordained priest, with the title of Abbate of Lepsing, is not precisely known. Steffani's first opera, *Marco Aurelio,* which was written for the carnival and produced at Munich in 1681, was followed by other works now lost. In 1688 he became Kapellmeister at the court of Hanover, where he made many friends. He wrote for the opening of the new opera house in 1689, an opera called *Enrico il Leone,* which was produced with extraordinary splendour. For the same theatre he composed *La Lotta d'Ercole con Achilleo* in 1689, *La Superbia d'Alessandro* in 1690, *Orlando generoso* in 1691, *Le Rivali concordi* in 1692, *La Libertà contenta* in 1693, *I Trionfi del fato* and *I Baccanali* in 1695, and *Briseide* in 1696. Elevation of Ernest Augustus to the electorate in 1692 led to difficulties with the various German courts; Steffani was sent round as an envoy in 1696 and as a result received from Innocent XI. the bishopric of Spiga for his services in securing privileges for Hanoverian Catholics. In 1698 he was sent as ambassador to Brussels, and after the death of Ernest Augustus in the same year he entered the service of the elector palatine, John William, at Düsseldorf, where he held the offices of privy councillor and protonotary of the Holy See.

Steffani did not accompany the elector George to England; but in 1724 the Academy of Ancient Musick in London elected him its honorary president for life; and in return for the compliment he sent the association a magnificent *Stabat Mater,* for six voices and orchestra, and three fine madrigals. The manuscripts of these are still in existence, and the British Museum possesses a very fine *Confitebor,* for three voices and orchestra, of about the same period. All these compositions are very much in advance of the age in which they were written; and in his operas Steffani shows a remarkable appreciation of the demands of the stage. Notable too are his beautiful chamber-duets, which, like those of his contemporary Carlo Maria Clari (1669–1745), are chiefly written in the form of cantatas for two voices, accompanied by a figured bass. The British Museum (Add. MSS. 5,055 *seq.*) possesses more than a hundred of these compositions, some of which were published at Munich in 1679. Steffani visited Italy for the last time in 1727. He died at Frankfurt on Feb. 12, 1728.

STEFFEN, ALBERT, Swiss novelist and dramatist, was born at Murgental (Canton Aargau) on Dec. 10, 1884. He is an imaginative, spiritual, mystical and idealistic writer, showing little of the concrete and disciplined methods that are so characteristically Swiss. His nearest spiritual kinsman is, perhaps, Dostoievski (*q.v.*); he has also something in common with Carl Spitteler (*q.v.*). His special quality reveals itself in his novels, such as *Ott, Alois, und Werelsche* (1907), *Die Bestimmung der Roheit* (1912), *Der Rechte Liebhaber des Schicksals* (1916), *Sibylla Mariana* (1917) and *Die Erneuerung des Bundes* (new ed., 1925); in his shorter stories, such as *Die Heilige mit dem Fische* (1919) and *Verhängnisse* (1927); in his plays, such as *Das Viergetier* (1924) and *Der Chef des Generalstabs* (1927); and in his essays, such as *Die Krisis im Leben des Künstlers* (1922), *Der Künstler zwischen Westen and Osten* (1925) and *Begegnungen mit Rudolf Steiner* (1926).

STEFFENS, HENRIK (1773–1845), German philosopher, of Norwegian extraction, was born on May 2, 1773, at Stavanger. He studied in Germany, and began to lecture at Copenhagen in 1802. His lectures were appreciated by Grundtvig and Oehlenschläger, but the authorities regarded them with disfavour, and Steffens removed to Germany, where he fought in the Napoleonic wars on the German side. He was professor of physics at Breslau (1811–32) and at Berlin (1832–45). He died in Berlin on Feb. 13, 1845. Steffens was the friend and adherent of Schelling and Schleiermacher. His profound knowledge of physics modified the speculations of Schelling. His chief works were *Beiträge zur innern Naturgeschichte der Erde* (1801); *Grundzüge der philos. Naturwissenschaft* (1806); *Anthropologie* (1824). He also wrote novels and poetry and an autobiography, *Was ich erlebte,* and after his death there was published *Nachgelassene Schriften* (1846).

See M. Tietzen, *Zur Erinnerung an Steffens* (1871); Petersen, *Henrik Steffens* (1884); W. Dilthey, *Leben Schleiermachers* (1870).

STEGANOPODES or **PELICANIFORMES,** an order of birds characterized by the fact that the hind toe is united to the second toe by a web. Most species are gregarious and live on fishes. The order includes the pelicans, cormorants, gannets, snake-birds, frigate-birds and tropic-birds (*q.v.*).

STEGOCEPHALIA, a class of extinct Amphibia (*q.v.*).

STEGOSAURUS, the name given to a Jurassic group of reptiles (*q.v.*). The name (plated lizard) refers to the armour of heavy bony plates on the back. These animals, which belonged to the class Dinosauria, were vegetarian. The plates of bone projected in two rows along the back, and the tail was armed with spikes. The head was small. It is surmised from the fact that the hind legs are much longer than the fore legs that the stegosaurs were descended from bipedal forms which were compelled to re-adopt a quadrupedal gait to enable them to support the weight of their bony armour. They reached a length of 30ft.

STEIN, SIR AUREL (1862–   ), British archaeologist, was born at Budapest on Nov. 26, 1862. Educated at Budapest and Dresden and at the Universities of Vienna and Tübingen, he went to England for further study and then to India, where he became principal of the Oriental college, Lahore, and registrar of the Punjab university in 1888. He was appointed in 1899 to the Indian Education Service, and for the next two years carried out archaeological explorations for the Indian Government in Chinese Turkistan. In 1906–08 he made further explorations in central Asia and western China, receiving the gold medal of the Royal Geographical Society. From 1910 he was superintendent of the Indian Archaeological Survey, and in 1913–16 carried out explorations in Persia and central Asia, described by him in *The Geographical Journal* (1916). He was created K.C.I.E. in 1912. In 1926 he continued his explorations on the Northwest Frontier and identified the site of Aornus, thus correcting Abbott's view. His other works include: *Chronicle of Kings of Kashmir* (1900); *Ancient Khotan* (1907); *Ruins of Desert Cathay* (1912); *Serindia* (5 vols., 1921); *The Thousand Buddhas* (1921); and articles in the present edition of the *Encyclopædia Britannica.*

STEIN, CHARLOTTE VON (1742–1827), the friend of Goethe, was born at Weimar on the 25th of December 1742, the eldest daughter of the Hofmarschall (master of the ceremonies) von Schardt. She became in her sixteenth year lady-in-waiting to the duchess Anna Amalia, the accomplished mother of Duke Karl August of Saxe-Weimar. In 1764 she married Freiherr Friedrich von Stein, master of the horse to the duke, and seven children were the issue of the union.

Goethe's *Briefe on Frau von Stein aus den Jahren 1776–1820* were edited by A. Schöll (3 vols., 1848–1851; 2nd ed. by W. Fielitz, 1883–1885; 3rd ed. by J. Wahle, 1900). *See* H. Düntzer, *Charlotte von Stein* (2 vols., 1874); id., *Charlotte von Stein und Corona Schröter* (1876); G. H. Calvert, *Charlotte von Stein* (Boston and New York, 1877); and A. Sauer, *Frauenbilder aus der Blütezeit der deutschen Literatur* (1885); W. Bode, *Charlotte von Stein* (1910).

STEIN, HEINRICH FRIEDRICH KARL, BARON VOM UND ZUM (1757–1831), German statesman, was born at the family estate near Nassau, on Oct. 26, 1757, the ninth child of Karl Philipp, Freiherr vom Stein. He studied law at Göttingen, Wetzlar, Regensburg and Vienna, and settled in Berlin in 1780. There he entered the Prussian service.

After holding various diplomatic and other appointments he became (1787) Kammerdirektor, *i.e.,* director of the board of war and domains for the king's possessions west of the river Weser; and in 1796 he was appointed supreme president of all the Westphalian chambers dealing with the commerce and mines of those Prussian lands. Among the benefits of his administration was the canalization of the river Ruhr, which became an important outlet for the coal of that region. He also improved the navigation of the Weser, and kept up well the main roads committed to his care. On June 8 1793 he married the countess Wilhelmine von Wallmoden-Gimborn, daughter of a natural son of King George II. of Great Britain.

Stein's early training, together with the sternly practical bent of his own nature, made him completely impervious to the enthusiasm which the French Revolution had aroused in many minds in Germany. He disliked its methods as an interruption to the orderly development of peoples. Nevertheless he carefully noted the new sources of national strength which its reforms called forth in France. Under the untoward circumstances which followed the Peace of Basel Stein in 1804 took office at Berlin as minister of state for trade. He protested against the effects of the Gallophil policy of the chief minister, Haugwitz, and the evil influences which clogged the administration. Little, however, came of Stein's protests, though they were urged with his usual incisiveness and energy. Prussian policy continued to progress on the path which led to the disaster at Jena (Oct. 14, 1806).

The king then offered to Stein the portfolio for foreign affairs, which he declined, because he desired to see Hardenberg take that office and effect, with his own help, the necessary administrative changes. The king refused to accept Hardenberg, and, greatly irritated by Stein's unusually outspoken letters, dismissed him altogether, adding that he was "a refractory, insolent, obstinate and disobedient official." Stein now spent in retirement the months during which Napoleon completed the ruin of Prussia; but he saw Hardenberg called to office in April 1807 and important reforms effected in the cabinet system. During the negotiations at Tilsit, Napoleon refused to act with Hardenberg, who thereupon retired. Strange to say, the French emperor at that time suggested Stein as a possible successor, and on Oct. 4, 1807, Frederick William called Stein to office with very wide powers.

Stein's strong convictions led him to press on drastic reforms in a way which could not otherwise have been followed. First came the Edict of Emancipation, issued at Memel on Oct. 9, 1807, which abolished the institution of serfdom throughout Prussia from Oct. 8, 1810. All distinctions affecting the tenure of land (noble land, peasants' land, etc.) were also swept away, and the principle of free trade in land was established forthwith. The same famous edict also abrogated all class distinctions respecting occupations and callings of any and every kind, thus striking another blow at the caste system which had been so rigorous in Prussia. Stein's next step was to strengthen the cabinet by wise changes and he also furthered the progress of the military reorganization which is connected more especially with the name of Scharnhorst (*q.v.*). Stein's efforts were directed more towards civil affairs; and in this sphere he was able to issue a measure of municipal reform (Nov. 19, 1808) which granted local self-government on enlightened and practical lines to all Prussian towns.

In August 1808 the French agents, who swarmed throughout the land, had seized one of his letters, in which he spoke of his hope that Germany would soon be ready for a national rising like that of Spain. On Sept. 10 Napoleon gave orders that Stein's property in the new kingdom of Westphalia should be confiscated, and he likewise put pressure on Frederick William to dismiss him. The king evaded compliance; but the French emperor, on entering Madrid in triumph, declared (December 16) *le nommé Stein* to be an enemy of France and the Confederation of the Rhine; and ordered the confiscation of all his property in the Confederation. Stein saw that his life was in danger and fled from Berlin (Jan. 5, 1809) to Bohemia.

For three years he lived in the Austrian Empire, generally at Brünn; but in May 1812 he received an invitation from the emperor Alexander I. to visit St. Petersburg, seeing that Austria was certain to range herself on the side of France in the forthcoming Franco-Russian War. At the crisis of that struggle Stein may have been one of the influences which kept the tsar determined never to treat with Napoleon. When the miserable remains of the Grand Army reeled back into Prussia at the close of the year, Stein urged the Russian emperor to liberate Europe.

Events now brought Stein rapidly to the front. On Dec. 30, 1812, the Prussian general Yorck signed at Tauroggen a convention with the Russian general Diebitsch for neutralization of the Prussian corps at and near Tilsit, and for the free passage of the Russians through that part of the king's dominions. The tsar thereupon requested Stein to act as provisional administrator of the provinces of East and West Prussia. In that capacity he convened an assembly of representatives of the local estates, which Feb. 5, 1813, ordered the establishment of a militia (*Landwehr*), a militia reserve and a final levy (*Landsturm*). He took part in the drafting of a Russo-Prussian convention (March 19, 1813) respecting the administration of the districts which should be delivered from French occupation. During the varying phases of the campaign of 1813 Stein continued to urge the need of war *à outrance* against Napoleon. The Allies conferred on Stein the important duties of superintending the administration of the liberated territories. After the battle of Leipzig (Oct. 16–19, 1813) Stein entered the city.

He now desired to see Germany reconstituted as a nation, in a union which should be at once strong for purposes of defence and founded on constitutional principles. His statesmanlike projects were foiled, partly by the short-sightedness of German rulers and statesmen, but also by the craft with which Metternich gained the alliance of the rulers of south and central Germany for the Austrian empire. During the Congress of Vienna Stein pressed in vain for an effective union of the German people. Austria and the secondary German states resisted all proposals in this direction; and Stein blamed the Prussian chancellor Hardenberg for an indefiniteness of purpose which probably resulted from the same defect in Frederick William of Prussia. Stein shared in the desire of all Prussian statesmen at that time to have Saxony wholly absorbed in their kingdom. In that, as in other matters, he was disappointed.

Stein passed into retirement after the Congress of Vienna, and saw with pain and disgust the postponement of the representative system of government which Frederick William had promised to Prussia in May 1815. His chief interest was in the study of history, and in 1818–1820 he worked hard to establish the society for the encouragement of historical research and the publication of the *Monumenta Germaniae historica,* of which his biographer, Pertz, became director. Stein died on June 29, 1831.

Possibly there has been a tendency to magnify the achievements of Stein. Research has shown that the credit for originating his reforms must be shared with Heinrich Theodor von Schön and many others.[1] The king himself rendered large services to this cause, but Stein's enlightenment, insight and almost superhuman energy ensured the triumph of these principles.

BIBLIOGRAPHY.—For biographies of Stein, *see* G. H. Pertz (6 vols., 1849–55); Sir J. Seeley (3 vols., 1878); M. Lehmann (Leipsic, 1902–03). *See* also H. F. K., Baron vom Stein, *Lebenserinnerungen* (Hagen, 1901); C. T. Perthes, *Politische Zustände und Personen in Deutschland zur Zeit der französischen Herrschaft* (2 vols., Gotha, 1862); *Denkwürdigkeiten des Staatskanzlers Fürsten von Hardenberg,* ed. by L. von Ranke (5 vols., Leipzig, 1877); Varnhagen von Ense, *Denkwürdigkeiten* (6 vols., Mannheim, 1837–42); English ed., London (1847); A. Stern, *Abhandlungen und Aktenstücke aus der preussischen Reformzeit 1807–15* (Leipzig, 1885); M. Philippson, *Geschichte des preussischen Staatswesens 1786–1813* (2 vols., Leipzig, 1880); M. Lehmann, *Knesebeck und Schön* (Leipzig, 1875); J. P. Hassel, *Geschichte der preussischen Politik, 1807–1815* (Leipzig, 1881); Jean d'Ussel, *Études sur l'année 1813; la défection de la Prusse* (Paris, 1907); A. D. White, *Seven Great Statesmen* (1910); G. Hasse, *Theodor von Schön und die Steinische Wirtschaftsreform* (Leipsic, 1915); G. S. Ford, *Stein and the Era of Reform in Prussia, 1807–15* (Princeton, 1922); E. M. Arndt, *Meine Wanderungen und Wandelungen mit dem Reichsfreiherrn vom Stein* (Leipsic, 1925); R. Huch, *Stein* (Vienna, 1925); H. M. Elster, *Freiherr vom Stein* (1927).

STEINER, JAKOB (1796–1863), Swiss mathematician, was born on March 18, 1796, at the village of Utzendorf (Berne). At eighteen he became a pupil of Heinrich Pestalozzi, and afterwards studied at Heidelberg. Thence he went to Berlin and became one of the chief contributors to Crelle's *Journal* founded in 1826. In 1834 a new chair of geometry was founded for him. This he occupied till his death on April 1, 1863.

Steiner was one of the great developers of synthetic geometry.

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[1] Thus Schön's memorandum on the abolition of serfdom was the basis of the law of emancipation; and Stein's *Politisches Testament* was also based on a draft by Schön. Schön was born in 1773, entered the Prussian civil service in 1793, and subsequently held various high ministerial appointments. He was made castellan (*Burggraf*) of Marienburg on his retirement in 1842, and died in 1856. The share claimed by him in Stein's reforms has been the subject of some controversy.

In his *Systematische Entwickelung der Abhängigkeit geometrischer Gestalten von einander* he introduces the geometrical forms (the row, flat pencil, etc.), and establishes between their elements a one-one correspondence, or, as he calls it, makes them projective.

See C. F. Geiser's pamphlet, *Zur Erinnerung an J. Steiner* (Zürich, 1874).

STEINER, RUDOLF (1861–1925), German philosopher, was born on Feb. 27, 1861, at Kraljevic, Austria, the son of a small railway employee. From 1890 to 1897 he worked in Weimar at the "Goethe-Schiller Archive," editing Goethe's works on natural history. In 1902 the German section of the theosophic association was founded and Steiner was called upon to become its spiritual leader. As such he developed for some years an astonishing activity as regards lectures and writings, but then became opposed to theosophy altogether, and was therefore excluded from the theosophical centre under English leadership. Steiner now developed his own teaching in a series of writings. He called this "anthroposophy," *i.e.*, wisdom of humanity: mankind is regarded as the centre of all perceptions of this "spiritual science," and an attempt is made to deduce the nature of the world from the nature of humanity. In 1913 the Anthroposophical society was formed to further spiritual research on Steiner's principles. In order to try his educational and political views in practice, Steiner founded the Waldorf School, near Stuttgart, and the "free high school for spiritual science" known as the "Goetheanum" at Dornach near Basle, which was burnt a few years later. All Steiner's works are published by the *Philosophisch-anthroposophischer-Verlag*, Berlin, and *Der kommende Tag*, Stuttgart. He died at Dornach on May 30, 1925.

His chief works include: *Goethe, als Vater einer neuen Aesthetik* (1888), Eng. ed. in preparation; *Die Philosophie der Freiheit* (1894), Eng. trans. ed. H. Collinson, *The Philosophy of Freedom* (1916); *Friedrich Nietzsche* (1895); *Goethes Weltanschauung* (1897); *Theosophie* (1904), Eng. trans. by E. D. S., *Theosophy* (1910); *Haeckel, die Welträtsel und die Theosophie* (1905), Eng. trans. *Haeckel, The Riddles of the Universe;* and *Theosophy in Three Essays on Haeckel, and Karma* (1914); *Wie erlangt man Erkenntnisse der höhern Welten* (1909); Eng. ed. trans. Clifford Bax, 2 vol., *The Way of Initiation* and *Initiation and its Results* (1909–10); *Die Aufgabe der Geisteswissenschaft und deren Bau in Dornach* (1916); Eng. ed. trans. A. M. Wilson, *The Mission of Spiritual Science and of its Building at Dornach, Switzerland* (1917); *Die Kernpunkte der sozialen Frage* (1919); Eng. ed. *The Threefold State—The True Aspect of the Social Question* (1920); *In Ausführung der Dreigliederung des Sozialen Organismus* (1920), Eng. trans. in *The Threefold Commonwealth* (1921 *seq.*).

See E. Boldt, *Von Luther bis Steiner* (1921), Eng. trans. (1923); F. Rittelmeyer, *Von Lebenswerk R. Steiners* (1921); G. Kaufmann, *Fruits of Anthroposophy; an Introduction to the Work of Dr. R. Steiner* (1922).

STEINLE, EDUARD (1810–1886), Austrian painter, was born in Vienna on July 2, 1810. In 1828 he joined the "Nazarene" groups, started by Overbeck and Cornelius in Rome. It was not, however, a congenial atmosphere for one of his romantic temperament, and in 1833 he returned to Vienna, moving in 1838 to Frankfurt, where he was professor of historical painting at the Staedel institute from 1850, and where he died on Sept. 19, 1886. He had the freshness and poetical fancy of the Viennese, and his best work is found in such legendary subjects as "Loreley" (Shack gallery, Munich), "The Violinist," and the illustrations to fairy-tales by Brentano and others.

See O. Berggruen, *Die Galerie Shack* (*Graphische Künste*, iv. 3, 4); C. v. Wurzbach, *E. Steinle, ein Madonnenmaler unserer Zeit* (Vienna, 1879).

STEINMETZ, CHARLES PROTEUS (1865–1923), American electrical engineer, born at Breslau, Germany, April 9, 1865. He was educated at Breslau, Zürich and Berlin, specializing in mathematics, electrical engineering and chemistry. His activities as a Socialist led him into difficulties with the authorities, and, after a short sojourn in other countries, he emigrated in 1889 to the United States and found work with the Osterheid and Eickemeyer factory at Yonkers. In 1893 when that factory was absorbed by the General Electric Co., Schenectady, he was given an appointment as consulting engineer. His knowledge won him speedy promotion and he soon became recognized as one of the outstanding electrical geniuses of America. After 1902 he served also as professor of electrical engineering at Union College. Steinmetz regarded his three greatest contributions to electrical science to be: (1) his investigations on magnetism resulting in his discovery of the law of hysteresis, which enabled losses of electric power due to magnetism to be accurately forecast before starting the construction of motors, generators, transformers, and other electrical apparatus employing iron; (2) the development of his symbolic method of calculating alternating-current phenomena which simplified an extremely complicated field, understood by few, so that the average engineer could work with alternating-current, an accomplishment which was largely responsible for the rapid progress made in the commercial introduction of alternating-current apparatus; (3) his investigation of lightning phenomena which resulted in his theory of electrical transients, and opened the way for his development of lightning arresters to protect high-power transmission lines. Though primarily a mathematical genius and a student of theory, he had some 200 patents to his credit, including improvements on generators, motors, transformers, in electro-chemical operations, and the invention of the induction regulator, the method of phase transformation and the metallic electrode arc lamp. Besides a large number of scientific papers he was the author of a number of standard text-books. He died at Schenectady, N.Y., Oct. 26, 1923.

See J. W. Hammond, *Charles Proteus Steinmetz, a biography* (1924), and J. N. Leonard, "Steinmetz, Jove of Science," in *World's Work*, vol. 53, nos. 2, 3 and 4 (1929).

STEINMETZ, KARL FRIEDRICH VON (1796–1877), Prussian general field-marshal, was born at Eisenach on Dec. 27, 1796. At the outbreak of the War of Liberation he and his elder brother made their way through the French posts to Breslau, where they at once received commissions. The brothers took part in the hardest fighting of the campaign of 1813, the elder being killed at Leipzig and the younger being more than once wounded. After the peace he entered Paris but once, fearing to infringe upon the ten ducats that he saved monthly from his pay to send to his mother. His character and physique were strengthened by his Spartan way of life, but his temper suffered. From 1820 to 1824 he studied at the General War Academy.

Steinmetz was promoted general of infantry in 1864, and led the V. Corps to the war against Austria in 1866. This was the chance of his lifetime. His skilful and resolute leadership was displayed in his three battles, won on three successive days, of Nachod, Skalitz and Schweinschädel (*see* Seven Weeks' War).

At the outbreak of the war of 1870 Steinmetz was appointed to command one of the three armies assembled on the Rhine, the others being led by Prince Frederick Charles and the crown prince. Serious differences arose between Steinmetz and Prince Frederick Charles. After the battle of Gravelotte he was relieved of the command of the I. Army and was sent home as governor-general of the V. and VI. Army Corps districts. In April 1871 he was retired at his own request, but his great services were not forgotten, and he was promoted general field-marshal. He died at Bad Landeck on Aug. 2, 1877.

STELE, a non-structural pillar or vertical slab of stone, metal or marble, usually set up for votive or commemorative purposes, sometimes decorated with bas-reliefs and bearing inscriptions, and generally terminated with a cresting enriched in classic examples with the anthemion plant with a small pediment. Stelae are common in Chinese tombs and temples, and usually these consist of an inscribed panel crowned by the dragon, and supported on the back of a great turtle.

STELLAR DISTRIBUTION: *see* Star.

STELLAR EVOLUTION. A star cannot shine unchanged for ever. It must have a life-history, an evolution of some sort. For a star is not a mere lump of inert matter; it is actively radiating energy—heat and light—into the unsounded depths of space, and at a tremendous rate. This energy, according to our present understanding of nature, can be no new creation—it must have come from some storehouse within the star. Such a store of energy cannot be inexhaustible; unless it is in some way replenished from without, the star must ultimately cease to shine.

Though a star's life is thus probably of limited duration, it is doubtless so long that the span of human history is too short to afford hope of detecting even a trace of change by direct observation. Yet, as a visitor to a forest might, in a few moments, see trees in all stages of youth, maturity and decay, we may reasonably expect to find among the stars in the heavens examples of every stage of their evolution. The problem becomes, therefore, that of picking out, among the various types of stars known to observation, those which, on some reasonable physical theory, should represent the earlier and later stages of the process. Such a theory must depend on some knowledge, or at least some hypothesis, concerning the nature of the store of energy which the stars are expending; and hence the problems of the source of stellar energy and the course of stellar evolution are inseparable.

The Contraction Theory.—Of the known stores of energy, calculable by familiar physical principles, which a star possesses the greatest is the gravitational potential energy, arising from the mutual attraction of its parts. These attractive forces tend to compress the star. If they were not balanced by the internal pressure of the gases of the interior the star would contract, the gravitational forces would do work, and a corresponding amount of potential energy would be liberated, appearing as heat of compression in the gas. If, at a given instant, the internal pressures just balanced those due to gravity, nevertheless, as the star lost heat by radiation from its surface, the interior would tend to cool and the gas-pressure to diminish. Contraction would then begin and continue till enough heat had been produced to raise the pressure and restore the balance. The evolution of a star, on this conception, would be a gradual shrinkage—part of the heat liberated by transformation of the gravitational potential energy maintaining the internal equilibrium and the rest keeping up the radiation.

This first rational theory of stellar evolution owes its origin to Hermann von Helmholtz. What proportion of the liberated energy is stored inside the star, and how much remains available to keep it shining, can be calculated from the known laws of gases. Much of the internal energy is the *kinetic energy* of motion of the atoms of the gas, to which it owes its high temperature. Part is energy of *ionization.* The collisions between the atoms are so violent that the outer electrons which normally belong to their structure are detached and fly about independently. To remove them against the electrical attraction of the residue of the atoms demands a large expenditure of energy which would be released again if the gas should cool and the collisions become less violent. Finally, the *radiation* imprisoned within the star, flying from atom to atom and gradually working its way out to the surface, carries an amount of energy which, especially in the stars of greatest mass, is a considerable fraction of the whole.

All told, it appears that more than half of the energy liberated by contraction, and sometimes a good deal more, must be stored inside the star in these three forms; but that, under actual conditions, a surplus will be available to meet the loss by radiation.

Lane's Law.—As the star contracts its internal temperature rises. In the simplest case, when the laws of a "perfect" gas hold good and the density at all points within the star is increased in the same proportion by the contraction, it can easily be proved that the temperatures at corresponding points vary inversely as the radius of the star (Lane's Law, first stated by J. Homer Lane in 1870); *thus* this law should indicate the order of magnitude of the change in more complex cases.

Limiting Density.—Such a process of contraction and rise in temperature obviously must have a limit. Sooner or later the atoms of the gas must get so close together that there is little room for further compression. Under such conditions the rise of internal temperature would slow up and then cease and the star would ultimately cool down, behaving more like a liquid than a gaseous mass. Until within a few years it was supposed that this change would begin to happen when the mean density of the star was less than that of water; and a theory of stellar evolution, proposed originally by Sir Norman Lockyer and reconstructed by H. N. Russell, held the field for some time. But in 1924 A. S. Eddington pointed out that the ionized atoms throughout the main mass of a star, being stripped of all their outer electrons, must occupy far less space than under ordinary conditions, so that serious departures from the simple gas-laws should not be anticipated till their density had become many thousands of times greater than that of water. The range of possible contraction of a star must therefore be very great.

This conclusion of theory is fully confirmed by observation. It is now possible to calculate the diameters of hundreds of stars, and the densities of a great number. The latter range from less than a thousandth part that of ordinary air in the case of great red stars like Antares to more than a thousand times that of platinum in the case of the companion of Sirius and the other "white dwarfs." Stars of the former sort appear to be "young"—in the sense that they have most of their visible life still before them—and those of the latter class to be "old." The sun, whose mean density is 1·4 times that of water, comes not far from the middle of the sequence.

Age of a Star.—When the length of a star's life comes to be considered, the contraction theory meets with grave difficulties. The amount of gravitational energy which would have been released by the contraction of the sun, for example, from an indefinitely great size to its present dimensions is readily calculable, and is found to amount to as much as would supply the present rate of radiation from the surface for 46,000,000 years. More than half this must still be stored inside the sun and twenty million years' supply at most can be counted available for radiation. This was pointed out long ago by Lord Kelvin.

But there is now abundant evidence from radioactive data that the oldest sedimentary rocks recognized by geologists are of the order of a thousand million years old (probably somewhat more), and that, during all this interval, the temperature of the earth's surface has been closely the same as at present. The sun has therefore, during geological time, dissipated in radiation more than 50 times as much energy as it could have derived from gravitational sources, and yet has remained of about the same brightness all the time. For the giant red stars of low density the case is even stronger. The gravitational energy available for a star's past radiation is proportional to M^2/R (M being the star's mass and R its radius). For Antares, for example, for which R is 480 times as great as for the sun, and M probably only 30 or 40 times as great, the available energy is some three times as great as for the sun. Antares radiates heat at 10,000 times the sun's rate, so that its whole past history, if gravitational energy only were available, would occupy only 6,000 years.

Sub-Atomic Energy.—Such arguments have convinced practically all workers in the field that the sun, and the stars in general, must draw to maintain their radiation upon some vast supply of energy whose very existence was previously unsuspected. The problem of stellar evolution thus enters upon a new and difficult stage, for, since this "unknown source" of energy has never been tapped in our laboratories, it is hard to find out about it. Atomic theory, in its present state of development, is not able to tell us very much, but what it does tell is striking. The only storehouses in the known universe *small* enough to hold so much energy are the tiny nuclei of the atoms, or perhaps the still smaller protons and electrons of which they are composed. For particles at greater distances, such as those at the periphery of an atom, the forces are not great enough to do so much work. The main source of stellar energy appears therefore to be of "sub-atomic" nature. In this conclusion, again, all workers agree.

Loss of Mass.—A second conclusion follows from the theory of relativity. According to this all energy possesses mass, and mass and energy are, to some degree at least, interconvertible, in a definitely known ratio. To m grams of matter correspond mc^2 ergs of energy (where c is the velocity of light). Translated into more familiar units, this means that it is as legitimate to speak of a pound of heat as of a pound of iron. But a pound of heat is a very large amount, measured by ordinary standards; it would suffice to raise 20 million tons of rock to a temperature of 1,500° C. and melt it into incandescent lava. The amounts of heat involved in all ordinary thermal changes are therefore of such small mass that it is still usually permissible to treat heat as "imponderable"; but when it comes to the radiation of the stars the case is different. The sun radiates energy into space at the rate of $3{\cdot}8\times10^{33}$ ergs per second—a number too great to be directly appreciable even by the physicist. Expressed as mass, this means that the sun is getting rid of 4,200,000 *tons of heat every second.* No other mode of statement comes so near to conveying to human apprehension the tremendous activity of a star.

The sun's mass must actually be diminishing at this portentous rate, which might raise fears of its disappearance. But its present mass is so great ($1{\cdot}98\times10^{33}$ grams) that the existing radiation would use up only a millionth part of it in 15 million years, and the consumption of a moderate fraction would give a life long enough to meet the wildest demands of geology.

Process of Transformation.—What the process of transformation is by which mass disappears and energy is liberated—pound for pound—can only be conjectured. The spontaneous disintegration of heavy complex atoms, as in the case of radio-activity, liberates a great amount of energy. The formation of heavier atoms out of hydrogen would furnish still more; for such an atom weighs about 0·8 per cent. less than the corresponding number of hydrogen atoms, which contain protons and electrons enough to make it. The difference may best be attributed to liberation of energy in the reaction of formation. The conversion of a mass equal to the sun's from hydrogen to iron, for example, would liberate heat enough to maintain the present solar radiation for 120,000 million years. Finally, it may be that a proton and an electron, under certain rare conditions, may annihilate one another—the electrical charges being neutralized, the mass disappearing, and the energy escaping and being converted into heat in the surrounding gas. If the whole mass of the sun were expendable in this fashion, and should be steadily consumed at the present rate, it would shine for 15,000,000,000,000 (15×10^{12}) years before it vanished.

The existence of some transformable material, and the maintenance of radiation by loss of mass, are now generally accepted as inevitable deductions from observed facts. Whether the total change of mass during a star's history is a large or small fraction of the whole is less easy to settle. According to the answer which we give our views of the life-history of a star will be different.

Stellar Luminosity.— Though the manner in which heat is generated within a star remains obscure, the manner in which it gets out of a star is now clearly understood. Radiation in the interior is very intense. Light is streaming about in all directions, but going only a short distance before it is absorbed by the hot gas and re-emitted. On the average, this results in a flow of energy from the hotter to the cooler parts, at a rate which is greater the more rapid the fall in temperature per mile, and less the greater the opacity of the gas to radiation. Modern physics makes it possible to determine pretty closely the laws which govern the emission of radiation and its absorption by the gas, and their changes with the temperature, density, and composition of the material. A detailed theory of the luminosity of the stars has thus been developed by Eddington, which gives results in admirable accordance with the observed facts. The conclusions which concern the present problem are that the amount of heat which leaks out from the interior of a star and escapes from its surface, depends very little upon a star's diameter but very greatly upon its mass. If a star of given mass contracts, the temperature inside rises and the temperature gradient becomes steeper. The opacity remains nearly constant, but the area of the surface diminishes. The effects of these changes almost balance one another, so that the total radiation of the star is changed but little. The amount which escapes per square mile, however, increases steadily, so that, as the star contracts, its surface must become hotter and its light whiter.

Whether the total radiation increases or diminishes as the radius grows smaller depends on the finer points of the theory. Eddington, after a careful investigation, concludes that it increases slightly; but the possibility that it remains constant, or even diminishes a little, cannot be excluded from consideration.

For a star of the same size, but smaller mass, the temperature gradient is less and the opacity greater, so that much less heat escapes from the surface. These conclusions apply strictly only to stars which are built upon the same law of internal distribution of density, but it is not hard to prove—following Eddington—that for a wide range of laws of internal density, of the type that appear at all plausible, the calculated total radiation will differ but little.

If, then, the proportion of expendable matter within a star is small it will remain of nearly the same brightness all through its evolution, until it becomes so dense that calculations based on the simple laws of gases are no longer applicable. But if a considerable portion of its mass is lost by radiation it will be fainter in its old age than in its youth.

Stability.—A new difficulty now arises. If the rate at which heat escapes from a star of given mass is so nearly fixed, whatever its size, what will happen to a star in which the rate of income of heat from sub-atomic sources is out of balance with this fixed outgo? If the income is too small, it is evident that the star will have to draw on its gravitational store and will contract; if the income exceeds the outgo, the process will be reversed and the star will expand, storing up the excess energy by means of the work done against gravitation.

Whether the energy-account will remain unbalanced after these changes depends on the way in which the rate of income from sub-atomic sources changes as the star contracts, and the pressure and temperature in its interior increase. If these changes increase the rate of generation of energy, then a star of deficient income, as it contracts, will find its income gaining on its expenditure and will approach a state of equilibrium. Should it overshoot this and contract too far the income would exceed the outgo and expansion would be forced, tending again to restore the equilibrium.

In this case, and in general, when income of heat gains, relative to outgo, as the star contracts, the equilibrium will be stable. The rate at which equilibrium of this sort is approached is slow, being comparable with that of a "Kelvin contraction," so that the adjustment will require tens of thousands of years even for the most rarefied giant stars, and tens of millions for stars like the sun. In the opposite case, when the outgo gains relative to the income, equilibrium, if it existed, would be unstable, the smallest deviation tending to increase indefinitely.

If a star's expenditure of heat increases as it contracts, stability demands that the rate of sub-atomic change shall increase more rapidly; if, on the other hand, the expenditure diminishes, stability may be possible with a fixed income, such as radioactivity might furnish.

Overstability.—Too rapid an increase in income, however, leads to other dangers. Any external disturbance affecting a star may set it "pulsating"—alternately expanding and contracting, under the influence of its own gravitation. Eddington has shown that the leakage of heat from one part of the star to another should act like friction to damp out the pulsation. But, if heat is generated most rapidly when the star has contracted to its smallest size, this gives a succession of well-timed impulses, which may overcome the damping effect, and, if great enough, cause the pulsation to increase to a large amplitude. This condition, called by Eddington "overstability," will (in the case studied by him) occur if, when the star contracts, the percentage increase of the rate of heat production is more than about twice that of the temperature. There remains, however, a considerable range in which stability of both kinds is assured.

Appeal to Observation.—To find out more about the laws of release of sub-atomic energy we must go to the stars themselves, and in the present state of knowledge our answers must be tentative, showing that a certain assumed law may account for the observed phenomena rather than *proving* that such a process actually happens. The conclusions previously stated appear to be well founded; those which follow may be greatly changed by future investigation. Our guides must be the observable properties of the stars, and, in particular, their luminosities and temperatures. We might add "their masses," if it were not that observation fully supports Eddington's conclusion that the stars of a given luminosity all have nearly the same mass.

Colour-Brightness Diagrams.—These relations may best be exhibited by means of "colour-brightness" diagrams, in which the brightness of a star (its absolute magnitude) is plotted as vertical co-ordinate, and its colour (which is intimately related to its surface temperature and its spectral type) as horizontal co-ordinate. When such a diagram is made from all reliable observational data, it is found that the points representing the stars are far from being distributed at random.

The majority of points fall into a definite sequence—the "main series"—ranging from bright, hot, white stars like those in Orion's Belt, through those of moderate brightness like the sun, to faint, cool, red ones like Barnard's star of large proper motion, as is indicated by the points 1, 2, 3, 4, 5 in fig. 1. There are also many bright red and yellow "giant" stars like Antares, Arcturus or Capella (6, 7 and 8), and probably many more faint white dwarfs like the Companion of Sirius (9), which fall quite outside the main series.

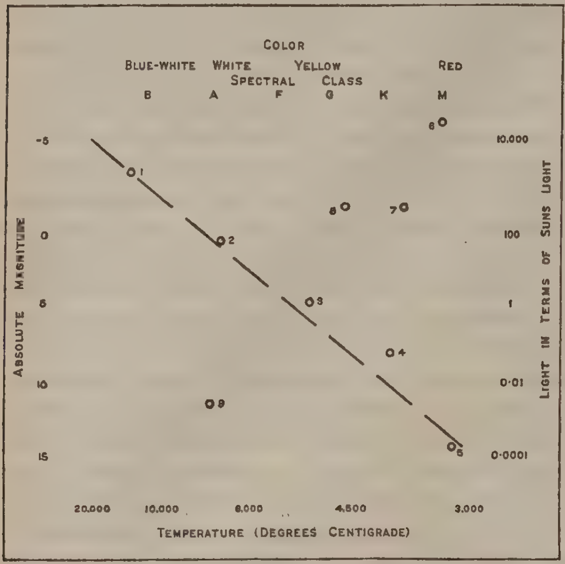


FIG. 1.—RELATIONS BETWEEN THE COLOUR AND BRIGHTNESS OF STARS (1) Stars of Orion's Belt, (2) Sirius, (3) The Sun, (4) 61 Cygni, (5) Barnard's Star, (6) Antares, (7) Arcturus, (8) Capella, (9) Companion of Sirius

The Main Series.—Since most of the known stars belong to the main series, we may begin by trying to account for this. According to Eddington's calculations the central temperatures of the stars along this series are nearly the same, and not far from 40,000,000°C. Suppose now that there is a process of liberation of sub-atomic energy within the stars, such that its rate is low at temperatures of a few millions of degrees, increases steadily, and, for a central temperature of 40,000,000°, becomes equal to the rate of loss for a star of corresponding mass. If now we have a star of great mass and low density it will be bright, red, and of large diameter, and represented by a point such as A_1 in fig. 2. Its central temperature will be low, it will contract, drawing on its gravitational energy, and the point on the diagram will move to A_2 and A_3. But as it approaches the dotted line corresponding to the central temperature 40,000,000°, heat from sub-atomic sources will be turned on—so to speak—and the star will come into a steady state at A_0 and remain at it, drawing on sub-atomic energy, for a very long time. Similarly, stars of smaller mass and low initial density will pass through the stages represented by B_1–B_2B_0 and C_1–C_0. If we imagine a star of moderate mass and very high density at the start, it would have too great an income of sub-atomic energy and expand through the stages D_1, D_2, D_0 and come to rest on the same line. If no other sub-atomic process were at work within the stars it is clear that, however they were started, they would all be found, after a few millions of years, along the main series A_0, B_0, D_0, C_0. The strong, actual concentration of stars along this series suggests that some such process of energy liberation may actually take place. The points actually lie not in a line, but along a strip of some width; but this is easily explained. If the percentage of active material in a star were lower than that at first considered the central temperature would have to be higher to cause income and outgo to balance, and we should have points along a line like $A'C'$. It is freely admitted that no theoretical reason can be given, in our present ignorance of the laws governing the structure of atomic nuclei, and still more those which determine the existence of protons and electrons, why liberation of energy should occur at this particular temperature, and be so adjusted as to be much more rapid in the more massive stars, where the central density is relatively low, than in those of small mass, where it is high. But no conclusive reasons against it can be given either, and the facts speak for themselves.

Giants and White Dwarfs.—This temperature does not account for the existence of the red giants, or the white dwarfs. They appear to demand the assumption of a second process, independent of the first, which liberates energy at a rate also increasing with the temperature, but very much greater when the density is low than when it is high, so that, for stars of different mass, it would make income equal to outgo for points along such a line as shown in fig. 3.

If this process alone were in operation, stars of various masses would follow courses represented by A_1 A_0, B_1 B_2 B_3, etc., and concentration would ensue along a sequence including the red giants and the white dwarfs. With both processes at work at once the result is shown in fig. 4. A star of large mass, as it contracts, will turn on the second process first, and settle down as a red giant, at A_0. If, however, the material thus transformable were absent, or soon exhausted, it would proceed farther to the left and become a white giant at A_0'. Less massive stars would settle down at B_0 and C_0, the latter drawing on both sub-atomic processes at once. Still smaller masses would be stabilized as yellow dwarfs at D_0 and red dwarfs at E_0, unless material of the first sort were absent, when the latter would become a white dwarf at E_0'.

Star Clusters.—Suppose now that a great quantity of matter were broken up into masses of various sizes which started independent careers as stars. After a few millions, or tens of millions, of years, the points representing them would be found along the broken line A_0, B_0, C_0, D_0, E_0 (fig. 4)—all stages from red giants to red dwarfs being represented among stars of the same age in years. With the lapse of time the bright giant stars, which expend energy very rapidly, might exhaust the material of the second kind, and move over to the line A'_0,C_0 or near it, while the relatively sluggish dwarf stars changed very little. This distribution of color and brightness would result at once if material of the second kind were absent. Now precisely these two situations are found among star clusters. (*See* R. J. Trumpler, *Publications of the Astronomical Society of the Pacific*, vol. xxxvii. pp. 307–318, 1925.) In some there is a group of bright red stars, near A_0, and others on the main series, while in others the branch A_0' C_0 is represented.

Double Stars.—Similarly, among the double stars, a pair with components of large mass would settle down at first like A_0, B_0—the brighter star being the redder one—a pair of small mass at D_0, E_0, with the fainter star the redder. The great majority of the double stars fall into one or other of these two classes. A few pairs have components of very different brightness, but the same colour (B_0, D_0), and in some, like A_0, C_0, the brighter component is a very hot star, of spectral class B. All these phenomena are immediately accounted for by the theory.

Course of Evolution.—The question of the history of an individual star is not yet answered. If the expendable fraction of the star's whole mass is small, it must remain of nearly the same brightness all through its history (fig. 5). A star of great mass will linger as a red giant A_2, A_3, till it has exhausted one store of energy, losing a little brightness as it consumes its mass, then pass rapidly to A_4 where it draws on the other store, finally exhausting it and shrinking beyond our ken. One of moderate mass will spend practically its whole life between B_2 and B_3, as a star of moderate temperature (spectral class F) and moderate brightness. One of small mass, after a long career as a red dwarf at C_3, C_3, may become a white dwarf at C_4. If, on the other hand, most of the mass is expendable, a single star may pass through almost the whole known sequence of stellar types. Beginning at A_1 (fig. 6),

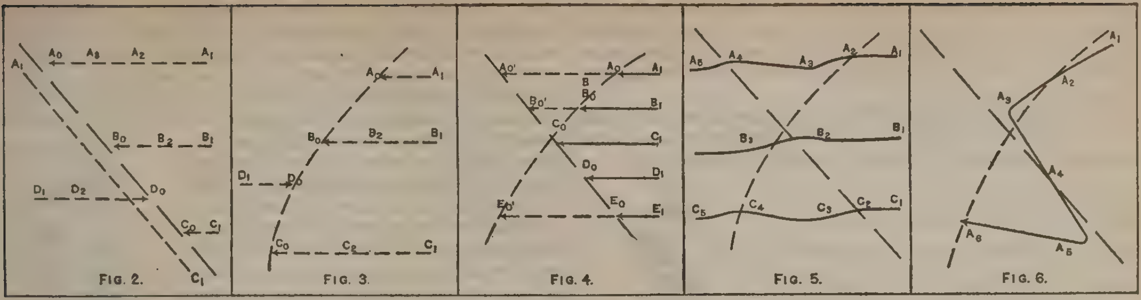


FIG. 2.—APPROACH OF STARS TO EQUILIBRIUM. PROCESS I. FIG. 3.—APPROACH OF STARS TO EQUILIBRIUM. PROCESS II. FIG. 4.—APPROACH OF STARS TO EQUILIBRIUM. BOTH PROCESSES. FIG. 5.—EVOLUTION OF STARS. SMALL LOSS OF MASS. FIG. 6.—EVOLUTION OF STARS. GREAT LOSS OF MASS

perhaps as a long period variable (the coolest and least dense of all known stars), it may become a yellow giant like Capella (A_2) and a white star like Sirius (A_3). At this point, before all the material of the second sort is exhausted, that of the first kind may begin to be consumed. Till it is gone the star must remain on the main series, passing through a stage resembling the sun (A_4), and one like 61 Cygni (A_5). Ultimately, after all the material of the first sort is exhausted, the star may become a white dwarf at A_6, fed by the unexpended store of the second kind. Many other life-histories, with a less extensive set of changes, are possible with different initial amounts of the two transformable substances.

The question cannot yet be regarded as settled. Indeed, the whole evolutionary scheme here sketched, which follows the lines laid down by Russell in 1927—is of a highly tentative nature. The two processes of energy liberation which are postulated are frankly invented *ad hoc*, and the best that can be claimed for them is that they account for most of the facts. The advance of atomic physics may replace them by something far more firmly grounded, and very different.

It may be said in conclusion that a very different evolutionary scheme has recently been put forward by Jeans, who regards the rate of liberation of energy as independent of the temperature, like radioactivity, and believes that the stars are unstable when the simple gas-laws are obeyed, and concentrated in certain regions on the diagram because, under the corresponding physical conditions of partial ionization, the behaviour of the gas departs widely from the ordinary laws, resembling that of a liquid. That such departures from the gas-laws should occur at the observed densities he has not yet shown, nor is it easy to see how they can happen. But the suggestion illustrates that there are probably many possibilities still unexplored.

BIBLIOGRAPHY.—A. S. Eddington, *The Internal Constitution of the Stars* (1926); Russell, Dugan and Stewart, *Astronomy*, vol. ii. (Boston, 1927); Sir James Jeans, *Astronomy and Cosmogony* (1928).

(H. N. R.)

STELLENBOSCH, a town 31 m. E. of Cape Town by rail, and, next to the latter, the oldest town in the province; 33° 54′ S., 18° 48′ E.; altitude 364 feet. It was founded in 1681, and named after the governor, Simon van der Stel, and his wife, whose maiden name was Bosch. The town is built in a valley, and its streets are lined with oak trees, and open channels of water. Many of the houses with heavy, thatched gables, date from the 17th century. The Dutch church in the market square is also thatched. Stellenbosch is the centre of a rich fruit and wine producing area, and the headquarters of the Cape branch of the Dutch Reformed church, with a Dutch theological seminary. There are several high schools in the town, a normal training college and a self-contained university with a strong Dutch bias. The population in 1921 included 3,695 whites, 122 natives, 33 Asiatics and 3,455 mixed and other coloured.

STEM, in popular language the stalk of a plant or trunk of a tree. In botany a stem may be defined as an axis bearing leaves. The stem with its leaves is known as the shoot. Structurally it differs from a root in having no cap (*root cap*) over the growing-point and in terminating in a bud. Under the term *caulome* (stem-structure) are included all those parts of a plant morphologically equivalent in bearing leaves. The stem generally ascends, seeking air and light, and has therefore been termed the *ascending axis*. Stems have usually considerable firmness and solidity, but sometimes they are weak, and either lie prostrate on the ground, thus becoming *procumbent*, or climb on plants and rocks by means of rootlets, like the ivy, being then called *scandent*, or twist round other plants in a spiral manner like woodbine, when they are *twining*. Twining plants turn either anti-clockwise, as the French bean, convolvulus, dodder and gourd; or clockwise, as honeysuckle, twining polygonum, hop and black bryony. In other cases climbing plants are supported by tendrils, which may be modified stems, as in vine, bryony, passion-flower, or by the tendril-like leaf-stalks, as in clematis and *Tropaeolum*. In warm climates twining plants (*lianas*) often form thick woody stems, while in temperate regions they are generally herbaceous. Some stems are developed more in diameter than in height, and present a peculiar shortened and thickened aspect, as *Testudinaria* or tortoise-plant, cyclamen, *Melocactus*, *Echinocactus* and other Cactaceae; while in many orchids the stem assumes an oval or rounded form, and is called a *pseudobulb*.

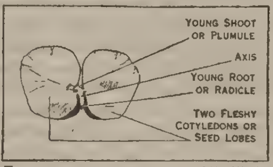
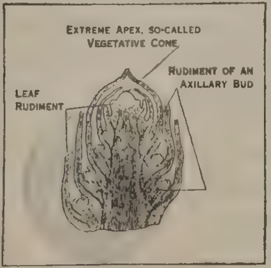


FIG. 1.—EMBRYO OF BEAN WITH COTYLEDONS SEPARATED

Names are given to plants according to the nature and duration of their stems. *Herbs*, or *herbaceous* plants, have stems which die down annually. In some of them the whole plant perishes after flowering; in others, the lower part of the stem forming the *crown of the root* remains, bearing buds from which the stem arises next season. In *biennial* herbs the whole plant perishes after two years, while in *perennial* herbs the crown is capable of producing stems for many years, or new annual products are repeatedly added many times, if not indefinitely, to the old stems. The short permanent stem of herbaceous plants is covered partially or completely by the soil, so as to protect the buds. Plants producing permanent woody stems are called *trees* and *shrubs*. The latter produce branches from or near the ground, while the former have conspicuous trunks. Shrubby plants of small stature are called *under-shrubs* or *bushes*. The limits between these different kinds of stem are not always well defined; and there are some plants occupying an intermediate position between shrubs and trees, sometimes called *arborescent shrubs*.


EXTREME APEX, SO-CALLED VEGETATIVE CONE
RUDIMENT OF AN AXILLARY BUD
LEAF RUDIMENT

FROM STRASBURGER, "LEHRBUCH DER BOTANIK" (FISCHER)

FIG. 2.—APEX OF SHOOT OF PHANEROGAMIC PLANT STEM

The stem is not always conspicuous. Plants with a distinct stem are *caulescent*; those in which it is inconspicuous are *acaulescent*, as the primrose, cowslip and dandelion. A similar term is given in ordinary language to plants whose stems are buried in the soil, such as cyclamen or sowbread. Some plants are truly stemless, and consist only of expansions of cellular tissue representing stem and leaf, called a *thallus,* and hence are denominated *Thallophytes.* (*See* ALGAE, FUNGI.)

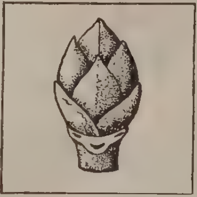


FIG. 3.—LEAF-BUD OF SYCAMORE

Development of Stem.—The first rudiment of the young shoot of the embryo appears from the seed after the radicle (young root) has protruded. It is termed the *plumule,* and differs from the radicle in the absence of a root-cap and in its tendency to ascend. The apical growing portion constitutes the terminal bud of the plant, and by its development the stem increases in height; projections appear at regular intervals, which are the rudimentary leaves, and in addition there is a provision for the production of lateral buds, which develop into lateral shoots more or less resembling the parent stem, and by these the branching of the plant is determined. These buds are found in the *axil* of previously formed leaves; or, in other words, in the angle formed between the stem and leaf. They are hence called *axillary.* They are produced like the leaves from the outer portion of the stem, and at first consist entirely of cellular tissue, but in the progress of growth vascular bundles are formed in them continuous with those of the stem, and ultimately branches are produced, which in every respect resemble the axis whence the buds first sprang. The place of origin of the leaf is called a *node;* the intervals between nodes are called *internodes.* The stem, although it has a tendency to rise upwards when first developed, in many instances becomes prostrate, and either lies along the ground partially covered by the soil, or runs completely underneath its surface, giving off roots from one side and buds from the other. Some stems are therefore subterranean, and are distinguished from roots by the provision made for regular leaf-buds.

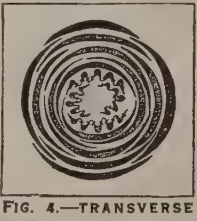


FIG. 4.—TRANSVERSE SECTION OF SYCAMORE LEAF-BUD

Growth and Bud Formation.—Growth in length of the stem is due to elongation of the internodes; the zone of most rapid growth is at some distance below the apex; below this the rate of growth gradually diminishes until the portion is reached where growth in length no longer takes place. In some cases, as in the stems of grasses, growth in length persists for a longer time in a small region at the base of the internodes; this is known as *intercalary* growth. In the dwarf or short shoots, such as those of the larch, the internodes do not elongate and the leaves remain close together. Lateral buds give rise to *branches,* from which others, called *branchlets* or *twigs,* arise. The terminal bud, after producing leaves, sometimes dies at the end of one season, and the whole plant, as in annuals, perishes; or part of the axis is persistent, and remains for two or more years, each of the leaves before its decay producing a bud in its axil. This bud continues the growth in spring. In ordinary trees, in which there is provision made for the formation of numerous lateral buds, any injury done to a few branches is easily repaired; but in palms, which only form terminal buds, and have no provision for a lateral formation of them, destruction of the terminal bud may kill the tree. In the trees of temperate and cold climates the buds which are developed during one season lie dormant during the winter, ready to open in the spring. They are generally protected by external modified leaves in the form of *scales,* which frequently exhibit a firmer and coarser texture than the leaves themselves. They serve a temporary purpose, and usually fall off sooner or later, after the leaves are expanded. The bud is often protected by a coating of resinous matter, as in the horse-chestnut and balsam poplar, or by a thick downy covering, as in the willow.

In plants of warm climates the buds are often formed by the ordinary leaves without any protecting appendages; such buds are called *naked.* A bud may be removed in a young state from one plant and grafted upon another by the process of *budding,* so as to continue to form its different parts; and it may even be made to grow in the soil, in some instances, immediately after removal. In some trees of warm climates, as papaw, palms and tree-ferns, growth by terminal buds is well seen.

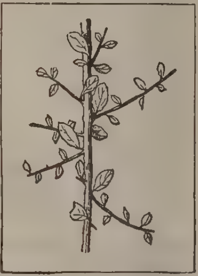


FIG. 5.—BRANCH OF SLOE

When the terminal bud is injured or arrested in its growth the elongation of the main axis stops, and the lateral branches often acquire increased activity. By continually cutting off the terminal buds or branches, a woody plant is made to assume a bushy appearance, and thus *pollard* trees are produced. The peculiar bird-nest appearance often presented by the branches of the common birch depends on an arrestment in the terminal buds, a shortening of the internodes, and a consequent clustering or fasciculation of the twigs. (*See* GALLS.)

Branching.—The mode in which branches come off from the stems gives rise to various forms of trees, as pyramidal, spreading or weeping—the angles being more or less acute or obtuse. In the Italian poplar and cypress the branches are erect, forming acute angles with the upper part of the stem; in the oak and cedar they are spreading or patent, forming nearly a right angle; in the weeping ash and elm they come off at an obtuse angle; while in the weeping willow and birch they are pendulous from their flexibility. The comparative length of the upper and under branches also gives rise to differences in the contour of trees, as seen in the conical form of spruce, and the umbrella-like form of the Italian or stone pine (*Pinus Pinea*).

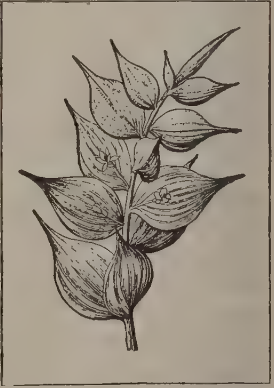


FIG. 6.—TWIG OF BUTCHER'S BROOM

Branches are sometimes long and slender, and run along the ground, producing buds with roots and leaves at their extremity. This is seen in the *runner* of the strawberry. In the houseleek (*Sempervivum*) there is a similar prostrate branch of a shorter and thicker nature, known as an *offset,* producing a bud at its extremity capable of independent existence. In many instances the branch decays, and the young plant assumes a separate existence. Gardeners propagate plants by the process of *layering,* which consists in bending a twig, fixing the central part of it into the ground, and, after the production of roots, cutting off its connection with the parent. A *stolon* differs from these in being a branch which curves towards the ground, and, on reaching a moist spot, takes root and forms an upright stem, and ultimately a separate plant. This is a sort of natural layering, and the plant producing such branches is called *stoloniferous.* In the rose and mint a subterranean branch arises from the stem, which runs horizontally to a certain extent, and ultimately sends up an aerial stem, which becomes an independent plant. Such branches are denominated *suckers,* and the gardener cuts the connection between the sucker and the parent stem, to propagate these plants.

In the case of asparagus and other plants which have a perennial stem below ground, subterranean buds are annually produced which appear above ground as shoots or branches covered with scales at first, and ultimately with true leaves. These branches are herbaceous and perish annually, while the true stem remains below ground ready to send up fresh shoots next season. In bananas and plaintains the apparent aerial stem is a shoot sent up by an underground stem, and perishes after fruiting. Branches are sometimes arrested in their development, and, in place of forming leaves, become transformed into *spines* or *thorns,* as in the hawthorn. Plants which have spines in a wild state, as the apple and pear, often lose them when cultivated, in consequence of their being changed into branches; in some cases, as in the sloe (*Prunus spinosa*), a branch bears leaves at its lower portion, and terminates in a spine. In some cases branches become flat and leaf-like, taking the place in the plant economy of the leaves, which are reduced to small scales or spines, as in butcher's broom; branches showing this modification are termed cladodes or phylloclades. In Cactaceae (e.g., *Opuntia*, prickly pear) and fleshy euphorbias, where the leaves are reduced to spines, the fleshy stems become green and perform the functions of leaves; they also serve as water reservoirs for the plants, which are natives of very dry countries.

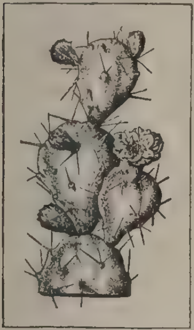

FROM STRASBURGER, "LEHRBUCH DER BOTANIK" (FISCHER)

FIG. 7.—OPUNTIA MONACANTHIA

Rhizomes, Corms and Bulbs.—The typical form of stems is rounded. They are sometimes compressed or flattened laterally, while at other times they are angular. Various terms are applied to the forms of stems, as *cylindrical* or *terete, quadrangular* or *square, jointed* or *articulated*, etc. The following are some of the more important modifications of stems: The crown of the root is a shortened stem, often partially underground, which remains in some plants after the leaves, branches and flower-stalks have withered. In this case the internodes are very short, and the nodes are crowded together, so that the plant appears to be stemless. It is seen in perennial plants, the leaves of which die down to the ground annually. A *rhizome* or *rootstock* is a horizontal stem usually sending out numerous roots and leaf-buds from its upper surface. It occurs in ferns, iris, *Hedychium, Acorus* or sweet flag, ginger, waterlily, many species of *Carex*, rushes, anemone, etc. The leaves are reduced to scales and by their presence, the absence of a root-cap and the presence of a bud at the apex, a rhizome can be distinguished from a root.

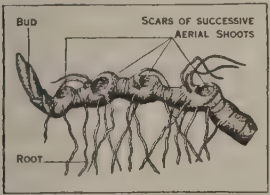


FIG. 8.—RHIZOME OF POLYGONATUM MULTIFLORUM

A rhizome such as occurs in Solomon's seal is not a single stem, *i.e.*, the product of a single bud, but is composed of portions of successive axes, the aerial parts of which have died off, leaving their scars. A rhizome sometimes assumes an erect form, as in *Scabiosa succisa*, in which the so-called *praemorse* root is in reality a rhizome, with the lower end decaying. The erect rhizome of *Cicuta virosa* (water-hemlock) shows hollow internodes, separated by partitions. In the coral-root orchid *Corallorhiza*, which grows in soil rich in humus, no roots at all are developed, the coral-like branching rhizome acting as the absorbing organ. A *tuber* is a thickened stem or branch produced by the reduction of the distance between the nodes and the swelling of the internodes, as in the potato. The eyes of the potato are leaf-buds. Tubers are sometimes aerial, occupying the place of branches. The ordinary herbaceous stem of the potato, when cut into slips and planted, sends off branches from its base, which assume the form of tubers. Tubers frequently store up a quantity of starch, as in *Maranta arundinacea*, whence West Indian arrow-root is derived.

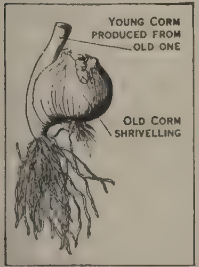
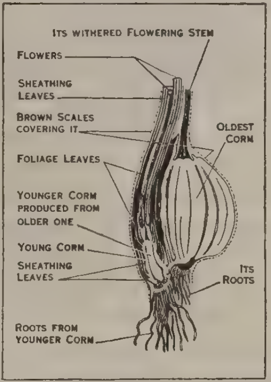


FIG. 9.—CORM OF MEADOW SAFFRON

Another form of thickened underground stem is the *corm*, as seen in the autumn crocus (*Colchicum*), gladiolus, etc. Structurally it is composed of a solid more or less rounded axis covered by a layer of thin membranous scales. A corm is only of one year's duration, giving off buds annually in the form of young corms. In autumn the young corm gives origin to leaves, the lower of which form sheaths round the corm and flower stalk, the upper remaining very small; and in the axil of the uppermost leaves the flowering-stem develops and bears the flowers. Meanwhile in the axil of one of the middle leaves on the corm, a bud—the rudiment of a new corm—appears. The flowering-stem dies down, and the young corm from which it arose enlarges greatly during the winter at the expense of its parent corm, which thus becomes shrivelled. In spring the leaves produced on it, which were merely rudiments in autumn, appear above ground as conspicuous large leaves. At the end of spring these leaves die down, the bases of the lower ones alone remaining, and constituting thin brown scales around the corm. Meanwhile, the young bud-corm in the axil of the middle leaf grows rapidly at the expense of its parent corm, but it does not attain a great size. In autumn it produces new leaves, which remain small, but from the axil of the two upper the flowering stem rises up and bears flowers; whilst in the axil of one of its middle leaves a new bud-corm appears, which will the following autumn produce young leaves, flowering stem, and a new bud-corm, and thus the cycle goes on.



FROM SACHS, "TEXT BOOK OF BOTANY" (CLARENDON PRESS)

FIG. 10.—CORMS OF COLCHICUM AUTUMNALE

The *bulb* is another form of underground stem or bud. The axis in this case is much shortened, and the internodes are hardly developed. The bases of the leaves rising from the stem are quite close together, and become succulent and enclose the axis. In the lily the thick and narrow scales are arranged separately in rows, and the bulb is called *scaly;* while in the leek, onion and tulip the scales are broad, and enclose each other in a concentric manner, the outer ones being thin and membranous, and the bulb is *tunicated.* In the axils of these fleshy scales new lateral shoots arise, forming new bulbs. The lateral buds sometimes remain attached to the axis, and produce flowering stems, so that apparently the same bulb continues to flower for many years, as in the hyacinth and tulip; at other times the young bulbs are detached, and form separate plants.

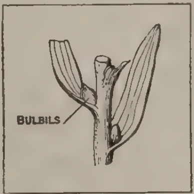


FIG. 11.—STEM OF BULBIFEROUS LILY

In the axil of the leaves of *Lilium bulbiferum, Dentaria bulbifera*, and some other plants, small conical or rounded bodies are produced, called *bulbils* or *bulblets.* They resemble bulbs in their aspect, and consist of a small number of thickened scales enclosing a growing-point. These scales are frequently united closely together, so as to form a solid mass. The scales in bulbs vary in number. In *Gagea* there is only one scale; in the tulip and *Fritillaria imperialis* they vary from two to five; while in lilies and hyacinths there are a great number of scales.

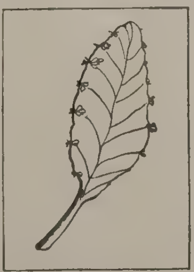


FIG. 12.—LEAF OF BRYOPHYLLUM CALYCINUM

Adventitious Shoots.—Adventitious shoots are those which arise elsewhere than in the normal predetermined place, as from old stems or roots. Such shoots are frequent on the roots of elm, poplar, plum and other fruit-trees. Occasionally adventitious buds are produced on the edges of leaves, as in *Bryophyllum calycinum, Malaxis paludosa*, and various species of *Asplenium*, and on the surface of leaves, as in *Ornithogalum thyrsoideum.* These are capable of forming independent plants. Similar buds are also made to appear on the leaves of *Begonia, Gesnera, Gloxinia* and *Achimenes*, by wounding various parts of them, and placing them in moist soil; a method pursued by gardeners in their propagation.

STENCIL, a thin plate or sheet of metal, leather, paper or other material cut or pierced with a pattern or design; this is laid upon a surface and colour or ink is brushed or rubbed over it, thus leaving the ground colour of the surface imprinted with the design or pattern cut out. In ceramics the stencil is produced by coating the biscuit with a preparation which prevents the transfer-paper or enamelling from adhering to the surface at those parts where the original colour of the biscuit is to be preserved.

STENDAL, a town in the province of Prussian Saxony, situated on the Uchte, 70 m. W. of Berlin on the main line of railway to Hanover and at the junction of lines to Bremen, Magdeburg and Wittenberge. Pop. (1925) 29,827. Stendal was founded in 1151 by Albert the Bear, on the site of a Wendish settlement, and soon afterwards acquired a municipal charter. Becoming capital of the Altmark, it rose to a considerable degree of prosperity, in part recently restored to it by its railway connections. The original Wends were gradually fused with the later Saxons.

STENDHAL (1783–1842) the pseudonym of HENRI-MARIE BEYLE, who borrowed the name from a small German town, the birthplace of Winckelmann, and who chose for his epitaph, *Quì giace, Arrigo Beyle Milanese; visse, scrisse, amò.* He was one of the most original and distinguished of French essayists and novelists. He was born at Grenoble on Jan. 23, 1783.

From Nov. 1796 to 1799, he attended the Ecole Centrale at Grenoble, where he was brilliantly successful. Here he was initiated into mathematics and accurate thinking. He arrived in Paris soon after the 18th Brumaire to study for the Ecole Polytechnique, but he soon gave up this scheme. Pierre Daru, the future *grand administrateur* of the empire, was a relation and his patron, and obtained a post for him in the War Office; later, in 1799, he sent him to Italy which became the chosen country of this cosmopolitan. He lived at Novara and Milan, in the autumn of 1800 became a sub-lieutenant, but resigned in 1802 and lived in Paris, where he frequented the *salons* and the theatres. After attempting business in Marseilles, in Aug. 1805, out of infatuation for an actress, he became a deputy to the *commissaire des guerres* (1806). He then lived for two years beyond the Rhine in Brunswick. He asked vainly for a post in Spain, was appointed auditor to the *Conseil d'Etat* in 1810, took part in the Russian campaign and became *intendant* at Sagan in 1813. He had received his baptism of fire in the Alps; he had heard the cannon at Marengo, and seen close at hand the horrors of war at the burning of Ebersberg, Smolensk and Moscow. During the tragic hours at the Beresina, he presented himself, freshly shaved, to Daru, who by this recognized in him an *homme de coeur.* After the empire fell, having lost all hope of being appointed a prefect, he went to live in Italy (1814–21); he spent six years in Milan, where he became acquainted with Byron, Madame de Staël, Silvio Pellico, Manzoni and Monti, whom he calls "the greatest living poet."

In 1814, he published in Paris *les Lettres écrites de Vienne en Autriche sur le célèbre compositeur, Joseph Haydn, suivies d'une vie de Mozart et de considérations sur Métastase et l'état présent de la musique en France et en Italie, par L. C. A. Bombet.* Herein he pillaged Carpani, Schlichtegroll, Winckler and Cramer. His plagiarisms would have brought him less reproach if he had acknowledged them more generously. *L'histoire de la peinture en Italie, par M.B.A.A.* (Beyle, *ancien auditeur*), appeared in 1817. Stendhal explains and animates the works of the abbé Lanzi and Vasari; he adds trivial or profound reflections to his borrowings from Lavater and Bossi. In *Rome, Naples et Florence* (1817), Stendhal supplemented his recollections with abundant documentary research; the work contains a wealth of fine, ingenious and vivid impressions on life, music, Italian patriotism, and on the charm of the delicious life he was enjoying. In this respect, this work seems to contain the matter of and to be a commentary on *La Chartreuse de Parme.*

In 1821 Stendhal was suspected of *carbonarisme* and espionage, and had to return to Paris. Exiled from his terrestrial paradise in Italy, he visited the houses of La Pasta, de Tracy and Delécluze, and made friends of Mérimée and Jacquemont. A brilliant and paradoxical talker, he both pleased and scandalized. He attempted to reconcile his dandyism with his poverty. He travelled in England in 1821 and 1826 and sent regular accounts and articles to the various English reviews, and to French journals.

He continued to publish literary hack-work: the amusing and anecdotal *Vie de Rossini* (1823) in which his dilettante spirit demanded from music a sentimental pleasure and poetic reverie. *Les Promenades dans Rome* (1829) was a partial success. The "cicerone of intelligence and taste" was not content with anecdotes; he described manners, customs and the art of the *"chasse au bonheur"* in Italy; and the guide may again be seen in the account of the landscapes and monuments which enchanted the author. In 1838 appeared *Les Mémoires d'un Touriste.* Stendhal had travelled extensively through France, either alone or in company with Mérimée, who instructed him in the Gothic. In addition to *choses vues,* the description of his native province, the Dauphiné, and the fair of Beaucaire, the work contains many stories clipped from journals or taken from the impressions of others. But it is saved by its vivid and feeling style, and by its "precious nothings." Stendhal also wrote some more original works. *De l'amour* (1822) constitutes under the guise of a psychological and documented analysis, a study and a preface for his novels; physiology is mingled with psychology. In it is also found a curious and original theory of "crystallization," a symbolic picture of the birth and growth of love.

Stendhal's first novel was an interesting study of this "crystallization," *Armance ou quelques scènes d'un salon de Paris en 1827* (1827). This was followed by a novel dealing with love and ambition—*Le Rouge et le Noir* (1830). In reading the *Gazette des Tribunaux,* which he cynically called "the golden book of French energy in the 19th century," Stendhal had noticed a tragic incident. The son of a farrier of the Dauphiné, a former seminarist, had been guillotined at Grenoble on Feb. 23, 1828, for having shot and wounded a lady whom he loved. On this scandalous material the novelist constructed his story and even wove in some personal confessions, for his Julien Sorel sometimes resembles the author. The interest of this novel is found in the energetic spirit of his characters, full of intense and unscrupulous life, in the dramatic adventures, traits of character and passion noted with precision and clearness, and in its psychological analysis.

Stendhal had already shown himself to be a pamphleteer. It was by a real pamphlet that he took his position in the Romantic battle, when he published in 1823 *Racine et Shakespeare,* which was re-published in 1825 with more vigour and more mordancy than ever. This work was impregnated with the Italian Romanticism of Manzoni, Visconti and Berchet. Stendhal attempted to free the theatre from the "unities" of place and time. He condemned Alexandrine verse and recommended a national tragedy which would be modern, even topical, and by preference liberal. These ideas were not all new, but the tone and the accent were completely personal. Stendhal had protested against the industrialism of Saint Simon in his witty work *D'un nouveau complot contre les industriels* (1825).

Shortly after the revolution of July 1830 Stendhal was appointed consul at Trieste, but since Metternich refused him his *exequatur,* he was sent in April 1831 to Civita-Vecchia. There he longed for Paris, the city of conversation. He wandered about Naples, made excavations in the papal territory, continually visited Rome and took holidays in Paris between 1836 and 1839. He had not yet had any true success when he was hailed as a great novelist by Balzac in an article published on Sept. 25, 1840, in the *Revue Parisienne,* on the *Chartreuse de Parme.* He had just completed an advantageous contract with the *Revue des deux Mondes* for "nouvelles" when he was overcome on the boulevard by an attack of apoplexy on March 22, 1842. Three friends, including Mérimée, followed his funeral to the cemetery of Montmartre. He counted on obtaining a little glory about 1880 or even later: "I take a ticket in the lottery, the grand prize of which may be summed up as—to be read in 1935."

He was read long before this, and *La Chartreuse de Parme* is one of the great romances of the 19th century. The hypothesis which saw in it only an ingenious reproduction of ancient Italian chronicles which Stendhal had dug out of the libraries has been exploded. The value of the novel lies in the analysis of the *grandes* *passions* and in his pictures of contemporary manners. It differs widely from the rude and simple stories which he liked to take as his inspiration. Stendhal has put in this book his experiences and intimate feelings, his impressions of Italy revived by nostalgia. This book was seven years in contemplation and it was finally written in Paris in seven weeks, appearing in April 1839. The first part of the book consists of memories rearranged by the author—of Milan on the morrow of Lodi, of the adventures of Fabrice, present at a great battle without seeing much of it, of France after Waterloo, of the intrigues of a little Italian court in 1820. The book is full of Stendhal's reading on Italy of former days which gives rise to certain discrepancies. The actors are original characters, even if one sees the prototype of Count Mosca in Metternich or in Count Sauron, the governor of Lombardy. The Duchess of Sanseverina differs greatly from la Vannoza, the mistress of the future Pope Alexander VI., and Fabrice del Dongo, the Napoleonic marquis who became a priest after taking part in a conspiracy, has more resemblance to Julien Sorel than to Alexander Farnese. Stendhal excels in the delineation of souls and of exceptional and complex characters, scheming and energetic. Portraits, landscapes and Italian life play a large part in this crowded and disconcerting romance. The style is always natural, clear and limpid. The "little precise phrases, worthy of a code or of algebra" raised the enthusiasm of Taine who regarded Stendhal as a "superior spirit."

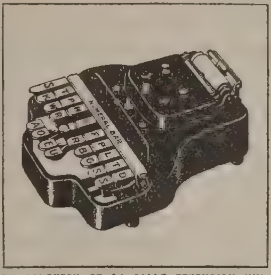
From his "Italian chronicles" he repeatedly drew dark and bloody stories and horrible and romantic novels. He was amused by these stories which he published between 1829 and 1838 in the *Revue de Paris: Vanina Vanini, Le coffre et le revenant, Le Philtre. Vittoria Accoramboni, Les Cenci, La duchesse de Palliano, L'Abbesse de Castro, San Francesco a Ripa,* appeared in the *Revue des deux Mondes* (1837–53).

Stendhal's admirers have published his unpublished works and even some illegible fragments preserved in the library at Grenoble. With audacious disquieting sincerity, sometimes bordering on cynicism, Stendhal wrote autobiographies entitled *La Vie d'Henri Brulard* (1890), *Souvenirs d'Egotisme* (1892), *Lucien Leuwen* (1894), *Journal d'Italie* (1911), in order to enjoy his past and to rescue from oblivion his "so different" personality. *Lamiel* (1889) is a romance in the style of Balzac and Sue of a foundling child of a seduced peasant woman. In his correspondence, vivid, primitive, amusing, passing from irony to tenderness, he paints himself with somewhat crude freedom. It is a feast for lovers of human documents. A place apart must be given to the *Lettres à Pauline*, his younger sister, whom Stendhal adored and whom he made his confidante. *La Vie de Napoléon* (1876) is less original than might have been expected. History is mingled with legend and gossip.

Stendhal, the "hussar of romanticism," independent of all schools, was at once behind the times and a pioneer. Disciple of the ideologues and even of the philosophers of the 18th century, he nevertheless seems to have been in advance of our own generation. Almost unknown during his lifetime, Stendhal the psychologist, an expert in unravelling and analyzing the sentiments of the human heart, curious about the "little true facts," careful to "write philosophically" for a fastidious *élite*, for the "happy few," was one of the introducers of romanticism and of the psychological novel. It was all very well for him to write that "a novel is a mirror taking a walk along the high road"; his mirrors possessed a strange magic. Of him more than anyone else it may be said that he was original. There are "Stendhaliens" and "anti-Stendhaliens." Henri Beyle lives to-day more than 100 years ago.

BIBLIOGRAPHY.—Stendhal's works have been published in 17 vols. by Michel Levy (1853–55). They were republished from 1913 under the direction of Paul Arbelet and Edouard Champion (35 vols.). His correspondence has been collected and re-arranged by A. Paupe and P. Cheramy (1908) The following works are important: *Notice sur M. Beyle,* by his friend Romain Colomb (1845); Mérimée, *Henri Beyle* (1850); the articles by Sainte-Beuve, in tome IX. of the *Causeries du lundi,* and by Taine in *Nouveaux essais de critique et d'histoire;* the books of E. Rod (1892), A. Chuquet (1902), P. Martino (1914) and P. Arbelet, *La jeunesse de Stendhal* (1914). H. Cordier, *Bibliographie Stendhalienne,* gives á list of articles before 1914. *See* also Paul Hazard, *La vie de Stendhal* (1927); Lytton Strachey in *Books and Characters* (1922). (J. GIR.)

STENOTYPY is the substitution of a printed character for the usual shorthand phonogram. This is accomplished by means of a machine called the stenotype. The machine is equipped with 23 keys and a numeral bar and prints 16 letters of the alphabet, the numerals from zero to nine and an asterisk. The mechanism is such that any one or any combination of the 16 letters or numbers can be printed at one time on one line of a strip of paper which is fed automatically through the back of the machine. This permits the printing of several short words, a complete word or the contraction of a word at a single stroke. The keys are so arranged that the initial consonants are under the fingers of the left hand, the vowels under the thumbs, and the final consonants under the fingers of the right hand. Duplication of consonants accounts for the five additional keys. The machine weighs only about 4½lb. and is correspondingly small. The reading of the notes requires no training.



BY COURTESY OF LA SALLE EXTENSION UNIVERSITY

MASTER MODEL FOUR OF A STENOTYPE MACHINE

STENTOR, one of the Greeks before Troy (*Iliad* v. 783), whose "stentorian" voice was as loud as that of 50 men.

STEPHAN, HEINRICH VON (1831–1897), German statesman, was born at Stolp, Pomerania, on Jan. 7, 1831. He entered the Prussian postal service, in which he rose rapidly. He was the first postmaster-general of the German Empire and was the chief promoter of the International Postal Union, presiding at the first conference, at Bern, in 1874. He died on April 8, 1897.

See E. Knickeberg, *H. v. Stephan* (1897).

STEPHANITE, a mineral consisting of silver sulphantimonite, Ag_5SbS_4; containing 68·5% of silver, and sometimes of importance as an ore of this metal. Under the name *Schwarzerz* (black ore) it was mentioned by G. Agricola in 1546. The stephanite mineral has a hardness of 2·5 and is very brittle; the specific gravity is 6·3. It occurs with other ores of silver in metalliferous veins, as in the Comstock lode in Nevada.

STEPHANUS BYZANTINUS (STEPHEN OF BYZANTIUM), the author of a geographical dictionary entitled *'Εθνιάκ*, of which, apart from some fragments, we possess only the meagre epitome of one Hermolaus, dedicated to Justinian; whether to the first or second emperor of that name is disputed. Stephanus probably flourished in the earlier part of the 6th century, under Justinian I. The chief fragments remaining of the original work (which contained quotations from classical authors and topographical and historical details) are preserved by Constantine Porphyrogennetos, *De administrando imperio*, ch. 23 (the article *'Ιβηρίαι δύο*) and *De thematibus*, ii. 10 (an account of Sicily); the latter includes a passage from the comic poet Alexis on the Seven Largest Islands. Another fragment, from the article *Δύμη* to the end of Δ, exists in a ms. of the Seguerian library.

See E. H. Bunbury *History of Ancient Geography*, i. 102, 135, 169; ii. 669–671 (1883); Riese, *De Stephani Byzant. auctoribus* (Kiel, 1873); J. Geffcken, *De Stephano Byzantio* (Göttingen, 1886).

STEPHEN, in some senses the greatest figure in primitive Christianity prior to Paul's conversion, was one of "the Seven" (Acts xxi. 8, nowhere called "deacons") set over the "daily ministration" towards the needy members of the Jerusalem community. Like Philip and perhaps others of his colleagues (vi. 3), he had higher gifts than his office would suggest. He was "full of faith and of holy Spirit"; and as his spiritual power showed itself in mighty deeds as well as words (vi. 5, 8), he became a marked man in Jerusalem. Himself a Jew of Greek culture, he naturally tried to win over his fellow Hellenists (vi. 9).

It is here that Stephen's advance upon prior Apostolic teaching becomes apparent. His special "wisdom" lay in greater insight into the merely relative nature and value of the externals of Israel's religion, particularly those connected with the Temple. His fellow Hellenists, as a body, were eager to disprove the feeling of the native "Hebrews" that they were only half Jews. Hence teaching which minimized the value of the sacred "customs which Moses had delivered" (vi. 14), by making "salvation" depend simply on faith in Jesus as Messiah, would cause deep resentment in such circles, in spite of their more liberal attitude to things non-Jewish. For in Jerusalem the Temple overshadowed men's thoughts touching the Divine presence. To this he would reply in the spirit of the prophets, that the heart is the true seat of the Shekinah; and that if they refused God manifest in His Messiah, no holy "customs"—no, not the Temple itself—could save from the displeasure of the living God. Nay, he argued, quoting words of Jesus (Matt. xxvi. 61, Mk. xiv. 58, Jo. ii. 10) which were easy to misquote (Acts vi. 14), that the Temple might even be destroyed, as it had been in the past, without loss to true religion. But they could not rise to this conception and treated his words as "blasphemous," and roused "the people and the elders and the scribes" against him.

He was seized and brought before the Sanhedrin on the charge of speaking "against the Temple and the Law" (vi. 11–14). His defence took the form of a survey of Israel's religious past, with a view to show: (1) that "the God of Glory" had covenant relations with their forefathers before they had either Holy Place (Land or Temple) or Law (vii. 1–17); (2) that the first visible meeting place between God and His people was far other than that for which absolute sanctity was now claimed. Indeed, the form of "the tabernacle of testimony in the wilderness" (no Holy Land) had more divine sanction than any later Temple (44–47); (3) that, after all, the presence of "the Most High" was not bound up with any structure of human hands, as Isaiah witnessed (48–50). The moral of all this was plain: Israel's *forms* of fellowship with the Most High had all along been relative and subject to change. Hence there was no "blasphemy" in suggesting that in the Messianic age yet another change might come about, and that observance of Temple services could prove little as to acceptance with God. But there is another and more urgent line of pleading. This is found in the elaborate section dealing with the person and work of Moses, the great lawgiver (17–38)—a section full of extra-biblical touches—followed by one on Israel's hardness of heart towards him, together with its result, the Exile (39–43). Pure and original Mosaism is represented as something which in its full spiritual intention had been frustrated by Israel's stiffneckedness (39, 42 *seq.*). The figure of Moses is made to stand forth in ideal outlines, the thinly-veiled Christian application shining through. "This is that Moses who said unto the children of Israel, 'A prophet shall God raise up unto you . . . like unto me:' who received living oracles to give unto us: to whom our fathers would not be obedient, but thrust him from them, and turned back in their hearts. . . ." (38 *seq.*). Here we have the very situation as between Stephen and his hearers; and it is made unmistakable by the speaker's closing words (51–53). Had they kept the Law dutifully, they would have believed on Him in whom true Mosaism was fulfilled and transcended. The author of Acts probably owed his report of Stephen's speech (as of his whole story) to Philip the "evangelist," who had been one of the Seven (xxi. 8). Possibly also Paul had spoken in Luke's hearing of Stephen's death and his own part in it (vii. 58, 60, *cf.* vi. 9).

Stephen's martyrdom is described as tumultuary in character, though the legal forms of stoning for blasphemy were observed (vii. 58); nor is it inconceivable that an act exceeding Jewish rights under the Romans should have taken place at the sudden impulse of religious fanaticism.

See articles in the *Ency. Bib.* vol. iv., and Hauck's *Realencykl. f. protestant. Theol. u. Kirche*, vol. xix. (J. V. B.)

STEPHEN, the name of nine popes.

Stephen I., bishop of Rome from about 254 to 257, followed Lucius I. He withdrew from church fellowship with Cyprian and certain Asiatic bishops on account of their views as to the necessity of rebaptizing heretics (Euseb. *H. E.* vii. 5; Cypr. *Epp.* 75). He is also mentioned as having insisted on the restoration of the bishops of Merida and Astorga, who had been deposed for unfaithfulness during persecution but afterwards had repented. He is commemorated on August 2. His successor was Sixtus II.

Stephen II., pope from March 752 to April 757, was in deacon's orders when chosen to the vacant see within twelve days after the death of Zacharias.[1] The main difficulty of his pontificate was in connection with the aggressive attitude of Aistulf, king of the Lombards. The death of Stephen took place not long after that of Aistulf. He was succeeded by Paul I.

Stephen III., pope from Aug. 7, 768 to Feb. 3, 772, was a native of Sicily, and, having come to Rome during the pontificate of Gregory III., gradually rose to high office in the service of successive popes. On the deposition of Constantine II. Stephen was chosen to succeed him. He was succeeded by Adrian I.

Stephen IV., pope from June 816 to Jan. 817, succeeded Leo III. He did not continue Leo's policy, which was more favourable to the clergy than to the lay aristocracy. Immediately after his consecration he ordered the Roman people to swear fidelity to Louis the Pious, to whom he found it prudent to betake himself personally in the following August. After the coronation of Louis at Reims in October he returned to Rome, where he died in the beginning of the following year. His successor was Paschal I.

Stephen V., pope from 885 to 891, succeeded Adrian III., and was in turn succeeded by Formosus. In his dealings with Constantinople in the matter of Photius, as also in his relations with the young Slavonic Church, he pursued the policy of Nicholas I.

Stephen VI., pope from May 896 to July–August 897, succeeded Boniface VI., and was in turn followed by Romanus. His conduct towards the remains of Formosus, his last predecessor but one (*see* Formosus) excited a tumult, which ended in his imprisonment and death by strangling.

Stephen VII. (January 929 to February 931) and Stephen VIII. (July 939 to October 949) were virtually nonentities, who held the pontificate while the real direction of the pontifical state was in the hands of Marozia and, afterwards, of her son Alberic, senator of the Romans.

Stephen IX., pope from August 1057 to March 1058, succeeded Victor II. (Gebhard of Eichstädt). His baptismal name was Frederick, and he was a younger brother of Godfrey, duke of Upper Lorraine, marquis of Tuscany (by his marriage with Beatrice, widow of Boniface, marquis of Tuscany). Frederick, who had been raised to the cardinalate by Leo IX., acted for some time as papal legate at Constantinople, and was with Leo in his unlucky expedition against the Normans. He shared his brother's fortunes, and at one time had to take refuge from Henry III. in Monte Cassino. Five days after the death of Victor II. he was chosen to succeed him. He showed great zeal in enforcing the Hildebrandine policy as to clerical celibacy. He died at Florence on March 29, 1058.

STEPHEN (1097?–1154), king of England, was the third son of Stephen Henry, count of Blois and Chartres, and, through his mother Adela, a grandson of William the Conqueror. Born some time before 1101, he was still a boy when he was taken into favour by his uncle, Henry I. of England, and received the honour of knighthood and the county of Mortain. In 1118 he severed his connection with Blois and Chartres, renouncing his hereditary claims in favour of his elder brother Theobald. But he acquired the county of Boulogne by marrying Matilda (*c.* 1103–1152), the heiress of Count Eustace III. and a niece of Henry's first wife. The old king arranged this match after the untimely loss of his son, William Atheling, in the tragedy of the White Ship; until 1125 Stephen was regarded as the probable heir to the English throne. But on the return of the widowed empress Matilda (*q.v.*) to her father's court, Henry compelled Stephen and the rest of his barons to acknowledge her as their future ruler (1126). Seven years later these oaths were renewed; and in addition the ultimate claims of Matilda's infant son, Henry of Anjou, were recognized (1133). But the death of Henry I. found the empress absent from England. Stephen hurried across the Channel and began to canvass for supporters, arguing that his oaths to Matilda were taken under coercion, and that she, as the daughter of a professed nun, was illegitimate.

He was raised to the throne by the Londoners, the official baronage and the clergy; his most influential supporters were the old justiciar, Robert, bishop of Salisbury, and his own brother Henry, bishop of Winchester. Innocent II. was induced by Bishop Henry to ratify the election, and Stephen thus cleared himself from the stain of perjury. Two charters of liberties, issued in rapid succession, confirmed the King's alliance with the Church and earned the good will of the nation. But his supporters traded upon his notorious facility and the unstable nature of his power. Extortionate concessions were demanded by the great barons, and particularly by Earl Robert of Gloucester, the half-brother of the empress. The clergy insisted that neither their goods nor their persons should be subject to secular jurisdiction. Stephen's attempt to create a mercenary army and a royalist party led at once to a rupture between himself and Earl Robert (1138), which was the signal for sporadic rebellions. Soon afterwards the king attacked the bishops of Salisbury, Ely and Lincoln—a powerful family clique who stood at the head of the official baronage—and, not content with seizing their castles, subjected them to personal outrage and detention. The result was that the clergy, headed by his brother, the bishop of Winchester, declared against him (1139).

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[1] A priest named Stephen, elected before him, died three days after, without having received the episcopal consecration.

Stephen was thoroughly discredited when the empress at length appeared in England (Sept. 30, 1139). Through a misplaced sense of chivalry he declined to take an opportunity of seizing her person. She was therefore able to join her half-brother at Gloucester, to obtain recognition in the western and south-western shires, and to contest the royal title for eight years. Stephen's initial errors were aggravated by bad generalship. He showed remarkable energy in hurrying from one centre of rebellion to another, but he never ventured to attack the headquarters of the empress. In 1141 he was surprised and captured while besieging Lincoln castle. The empress in consequence reigned for six months as "Lady (*Domina*) of the English"; save for her faults of temper, the cause of Stephen would never have been retrieved. But, later in the year, his supporters were able to procure his release in exchange for the earl of Gloucester. After an obstinate siege he expelled Matilda from Oxford (Dec. 1142) and compelled her to fall back upon the west.

The next five years witnessed anarchy such as England had never before experienced. England north of the Ribble and the Tyne had passed into the hands of David of Scotland and his son, Prince Henry; Ranulf earl of Chester was constructing an independent principality; on the west the raids of the Angevin party, in the east and midlands the excesses of such rebels as Geoffrey de Mandeville, earl of Essex, turned considerable districts into wildernesses. Meanwhile Geoffrey of Anjou, the husband of the empress, completed the conquest of Normandy (1144). In 1147 the situation improved for Stephen; Robert of Gloucester, the ablest of the Angevin partisans, died, and the empress left England in despair. But her son soon appeared in England to renew the struggle (1149) and conciliate new supporters. Soon after his return to Normandy Henry was invested by his father with the duchy (1150). He succeeded to Anjou in 1151; next year he acquired Aquitaine by marriage.

Stephen struggled hard to secure the succession for Eustace, his elder son. But he had quarrelled with Rome respecting a vacancy in the see of York; the pope forbade the English bishops to consecrate Eustace (1151); and there was a general unwillingness to prolong the civil war. Worn out by incessant conflicts, the king bowed to the inevitable when Henry next appeared in England (1153). Negotiations were opened; and Stephen's last hesitations disappeared when Eustace was carried off by a sudden illness. Late in 1153 the king acknowledged Henry as his heir, only stipulating that the earldom of Surrey and his private estates should be guaranteed to his surviving son, William. The king and the duke agreed to co-operate for the repression of anarchy; but Stephen died soon thereafter (Oct. 1154).

On his great seal Stephen is represented as tall and robust, bearded, and of an open countenance. He was frank and generous; his occasional acts of duplicity were planned reluctantly and never carried to their logical conclusion. In warfare he showed courage, but little generalship; as a statesman he failed in his dealings with the Church, which he alternately humoured and thwarted. He was a generous patron of religious foundations; and some pleasing anecdotes suggest that his personal character deserves more commendation than his record as a king.

See the *Gesta Stephani*, Richard of Hexham, Aelred of Rievaux' *Relatio de Standardo*, and the chronicle of Robert de Torigni, all in R. Howlett's *Chronicles of the Reigns of Stephen*, etc. (4 vols., London, 1884–89); Orderic Vitalis's *Historia ecclesiastica*, ed. Le Prévost (5 vols., Paris, 1838–55); William of Malmesbury's *Historia novella*, ed. W. Stubbs (London, 1889); John of Worcester's *Continuation of Florence*, ed. J. H. Weaver (Oxford, 1908). *See* also Miss K. Norgate's *England under the Angevin Kings*, vol. i. (London, 1887); O. Rössler's *Kaiserin Mathilde* (Berlin, 1897); J. H. Round's *Geoffrey de Mandeville* (London, 1892); H. W. C. Davis's "The Anarchy of Stephen's Reign" in *Eng. Hist. Review* for 1903. (H. W. C. D.)

STEPHEN I. [St. Stephen] (977–1038), king of Hungary, was the son of Geza, duke of Hungary, and of Sarolta, one of the few Magyar Christian ladies. His tutors included the German priest Bruno, the Czech priest Radla, and an Italian knight, Theodate of San Severino, who taught him arms and letters. In 996 Stephen married Gisela, the daughter of Duke Henry II. of Bavaria. In the following year his father died and the young prince was confronted by a formidable pagan reaction between the Drave and Lake Balaton. Stephen hastened against the rebels, bearing before him the banner of St. Martin of Tours, whom he now chose to be his patron saint, and routed the rebels at Veszprem (998), assuming the royal title immediately afterwards.

The rest of Stephen's life was spent largely in a struggle against the pagan nobles, which engrossed his energies, and compelled him to adopt a pacific policy towards the emperors of the East and West; but when attacked by the emperor Conrad in 1030 Stephen repelled the invasion successfully. He died at Esztergom in 1038 and was canonized in 1083. For an account of his reforms *see* Hungary: *History*.

See Antal Pór, *Life of St. Stephen* (Hung.; Pest, 1871); Lajos Balics, *History of the Roman Catholic Church in Hungary*, vol. i. (Hung.; Pest, 1885); János Karácsonyi, *Documents issued by Stephen I.* (Hung.; Pest, 1892), idem, *Life of St. Gellert* (Hung.; Pest, 1887); W. J. Winkler de Kétrszynski, *Vita sancti Stephani* (Cracow, 1897); E. Horn, *St. Etienne, roi apostolique de Hongrie* (1899).

STEPHEN V. (1239–1272), king of Hungary, was the eldest son of Béla IV., whom he succeeded in 1270. In 1262, as crown prince, he had compelled his father, whom he had assisted in the Bohemian War, to surrender 29 counties to him, virtually dividing Hungary into two kingdoms; while afterwards he seized the southern banate of Macso, which led to a fresh war between father and son in which the latter triumphed. In 1268 he invaded Bulgaria and assumed the title of king of Bulgaria. During his father's lifetime Stephen had a double matrimonial alliance with the Neapolitan princes of the House of Anjou, the chief partisans of the pope. He certainly needed exterior support; for on his accession to the Hungarian throne he encountered almost universal hostility owing to his alleged pagan leanings, due largely to the influence of his Cuman wife Elizabeth, to whom his father had married him for political reasons in 1255. The malcontents combined with Ottakar II. of Bohemia, and invaded western Hungary; but Stephen routed Ottakar at Mosony (1271) and was preparing to recover his infant son Ladislaus whom the rebels had kidnapped, when he died suddenly on Aug. 6, 1272.

STEPHEN, SIR JAMES FITZJAMES, Bart. (1829–1894), English lawyer, judge and publicist, was born in London on March 3, 1829, the third child and second son of Sir James Stephen. He was educated at Eton, London university, and Trinity, Cambridge. He was already acquainted with Sir Henry Maine (*q.v.*), six years his senior, and then newly appointed to the chair of civil law. This acquaintance now ripened into a perfect friendship, which ended only with Maine's death in 1888.

Stephen was called to the bar in 1854, and in 1859 he was appointed recorder of Newark. In 1863 he published his *General View of the Criminal Law of England* (2nd recast ed. 1890). This was the first attempt that had been made since Blackstone to explain the principles of English law and justice in a literary form, and it had a thoroughly deserved success. All this time Stephen kept up a great deal of miscellaneous writing, and the foundation of the *Pall Mall Gazette* in 1865 gave him a new field. The decisive point of his work was in the summer of 1869, when he accepted the post of legal member of council in India. Fitzjames Stephen's friend Maine was his immediate predecessor in this office. Guided by Maine's comprehensive genius, the government of India had entered on a period of systematic legislation which was to last about twenty years. The materials for considerable parts of this plan had been left by Maine.

Stephen had the task of working them into their definite shape and conducting the bills through the Legislative Council. This he did with wonderful energy, with efficiency and workmanship adequate to the purpose, if sometimes rough according to English notions, and so as to leave his own individual mark in many places. The Native Marriages Act of 1872 was the result of deep consideration on both Maine's and Stephen's part. The draft of the Contract Act was materially altered in Stephen's hands before, also in 1872, it became law. The Evidence Act of the same year was entirely Stephen's own. He came home in 1872.

Indian experience had supplied Stephen with the motive for his next piece of work, which historians of the common law may well regard as his greatest title to remembrance. The materials which Stephen had long been collecting took permanent shape in the *History of the Criminal Law of England* (1883), which, though not free from inequalities and traces of haste, must long remain the standard work on the subject. The Bills of Exchange Act (1882), the Partnership Act (1890), the Sale of Goods Act (1893) and the Marine Insurance Act (passed 1906) are indirectly due to his efforts. In 1879 Stephen became judge of the queen's bench division. He resigned that office in April 1891, after a breakdown, and died on March 11, 1894, having filled a not very long life with a surprising amount of work, of which a large proportion was of permanent value. He married Mary Cunningham in 1855.

See Sir Leslie Stephen, *Life of Sir James Fitzjames Stephen* (London, 1895), with bibliographical appendix, a model biography; same author's article in the *Dict. Nat. Biog.*; *Letters with biographical Notes*, by his daughter, Caroline Emelia Stephen (1907). *See* also Sir C. P. Ilbert, "Sir James Stephen as a Legislator," *Law Quart. Rev.* x. 222.

STEPHEN, SIR LESLIE (1832–1904), English philosopher and man of letters, son of Sir James Stephen, was born in London on Nov. 28, 1832. He was educated at Eton, at King's college, London, and Trinity Hall, Cambridge. In 1854 Stephen obtained a Goodbehere fellowship, and was ordained deacon on Dec. 21, 1855, becoming a priest in 1859. In 1856 he was admitted to a junior tutorship at Trinity Hall. He was a good athlete and a mountaineer. His first ascent was in 1857 (Col du Géant), and he made many others in the following years, until his first marriage in 1867. He was president of the Alpine club from 1865 to 1868, and editor of the *Alpine Journal* from 1868 to 1871. His accounts of his mountaineering feats were published in various journals, and collected in *The Playground of Europe* (1871). In the meantime, during his residence at Trinity Hall, his philosophical studies led him to abandon the orthodox theological position, and in 1875 he relinquished his orders. He interested himself in university politics, and advocated the need for examination reforms. During the American Civil War he was greatly in sympathy with the North, and in 1863 visited America to investigate the situation. On his return he published *The Times and the American War by L. S.* (1865), in answer to English arguments in support of the South. Stephen came to London in 1864, with useful recommendations from his brother Sir J. Fitzjames Stephen. He contributed for many years to the *Saturday Review*, and from 1865 co-operated with George Smith in the foundation of the *Pall Mall Gazette*. From Oct. 1866 to Aug. 1873 he contributed political articles to the *Nation*. His literary criticisms for the *Cornhill Magazine* (from 1866) were collected from time to time in separate volumes, as *Hours in a Library* (1874, 1876 and 1879). In 1871 he became editor of the *Cornhill*, and during the 11 years of his editorship the magazine made a reputation by its literary excellence. R. L. Stevenson, Thomas Hardy, Henry James and Edmund Gosse were among his contributors. In his *Essays on Free Thinking and Plain Speaking* (1873) Stephen challenged the dogmas of popular religion. His *History of English Thought in the Eighteenth Century* (2 vols., 1876), later extended into *The English Utilitarians* (1900), remains a standard work on the subject. He married in 1867 the younger daughter of W. M. Thackeray, and in 1868 visited America with her, where he met Emerson and Oliver Wendell Holmes the younger.

In Nov. 1882 George Smith made Stephen editor of the *Dictionary of National Biography*, which he conducted until April 1891, continuing to contribute until 1901. His first wife died in 1875, and in 1878 he married again. In his later years he was greatly affected by the death first of his brother James (1894), and shortly afterwards (1895) of his wife. One of his daughters, Mrs. Virginia Woolf, is separately noticed in this book. Stephen received many marks of distinction, and in 1902 was made K.C.B. He continued his literary work almost to the end of his life, and his last books were a monograph on Hobbes (1904), and his Ford lectures, *English Literature and Society in the Eighteenth Century*, published on the day of his death, Feb. 22, 1904. His work, both philosophical and literary, is remarkable for the sincerity of the author's outlook, and for his unprejudiced judgments. He wrote also *Social Rights and Duties* (1896); *Science and Ethics* (1882); *An Agnostic's Apology* (1893); *Studies of a Biographer* (2 vols., two series, 1899 and 1902), and monographs for the "English Men of Letters" series.

See F. W. Maitland, *Life and Letters of Leslie Stephen* (1906); Sir Sidney Lee, *Principles of Biography* (the Leslie Stephen lecture, 1911).

STEPHEN (ISTVÁN) BÁTHORY (1533–1586), king of Poland and prince of Transylvania. Báthory spent his early years at the court of the emperor Ferdinand, subsequently attached himself to Janos Zapolya, and won equal renown as a soldier and diplomatist. Zapolya rewarded him with the voivodeship of Transylvania, where his defence of the rights of his patron's son, John Sigismund, incurred the animosity of the emperor Maximilian, who kept him in prison for two years. On May 25, 1571, on the death of John Sigismund, Báthory was elected prince of Transylvania by the Hungarian estates, in spite of the opposition of Vienna. He expelled the rival candidate, Gaspar Békesy, from Transylvania (1572). In 1579 the Polish nobility, at the instigation of Zamoyski (*q.v.*) elected Báthory king of Poland, in opposition to the emperor Maximilian, the candidate of the senate. Báthory persuaded the Transylvanian estates to elect his brother Christopher in his stead, hurried to Cracow, espoused the princess Anne, the sister of the last Jagiello, and was crowned on May 1.

The leading events of Stephen Báthory's reign can here only be briefly indicated. All armed opposition collapsed with the surrender of Danzig, after a six months' siege, on Dec. 16, 1577. Stephen was now able to devote himself to foreign affairs. The difficulties with the sultan were temporarily adjusted by a truce signed on Nov. 5, 1577; and the Diet of Warsaw having voted supplies, Stephen embarked on war with Muscovy. Penetrating to the heart of the country, he besieged Pskov (Aug.–Dec. 1581), and forced Ivan the Terrible to cede him Polotsk and Livonia (peace of Zapoli, Jan. 15, 1582). The chief domestic event of Stephen's reign was the establishment in Poland of the Jesuits, in furtherance of his designs of uniting Poland, Muscovy and Transylvania into one great state. The project was dissipated by his sudden death, of apoplexy, Dec. 12, 1586.

See I. Polkowski, *The Martial Exploits of Stephen Báthory* (Pol.; Cracow, 1887); Paul Pierling, *Un Arbitrage pontifical au xvi^{me} siècle* (Brussels, 1890); Lajos Szadeczky, *Stephen Báthory's Election to the Crown of Poland* (Hung.; Budapest, 1887).

STEPHENS, ALEXANDER HAMILTON (1812–1883), American statesman, vice president of the Confederate States during the Civil War, was born in Wilkes (now Taliaferro) county, Georgia, on Feb. 11, 1812. He was a weak and sickly child of poor parents, and from his sixth to his 15th year, when he was left an orphan, he worked on a farm. After his father's death he went to live with an uncle in Warren county. The superintendent of the local Sunday school sent him to an academy at Washington, Wilkes county, for one year and in the following year (1828) he was sent by the Georgia Educational society to Franklin college (University of Georgia), where he graduated in 1832. Deciding not to enter the ministry, he paid back the money advanced by the society. He was a schoolmaster for about two years, and then was admitted to the bar in 1834.

In 1836 he was elected to the Georgia house of representatives after a campaign in which he was vigorously opposed because he had attacked the doctrine of nullification, and because he had opposed all extra-legal steps against the abolitionists. He was annually re-elected until 1841; in 1842 he was elected to the State senate, and in the following year, on the Whig ticket, to the national House of Representatives. In this last body he urged the annexation of Texas, chiefly as a means of achieving more power for the South in Congress. He was denounced as a traitor to his party because of his support of annexation, but he later became the leader of the Whig opposition to the war with Mexico. He vigorously supported the Compromise Measures in 1850, and continued to act with the Whigs of the North until they, in 1852, nominated Gen. Winfield Scott for the presidency without Scott's endorsement of the Compromise. Stephens and other Whigs of the South then chose Daniel Webster, but a little later they joined the Democrats. In 1854 Stephens helped to secure the passage of the Kansas-Nebraska Bill. Before the Georgia legislature in Nov. 1860, and again in that State's secession convention in Jan. 1861, he strongly opposed secession, but when Georgia seceded he "followed his state," assisted in forming the new government, and was elected vice president of the Confederacy. Throughout the war, he was so concerned about States' rights and civil liberty that he opposed the exercise of extra-constitutional war powers by President Jefferson Davis lest the freedom for which the South was fighting should be destroyed. His policy was to preserve constitutional government in the South and strengthen the anti-war party in the North by convincing it that the Lincoln administration had abandoned such government; to the same end he urged, in 1864, the unconditional discharge of Federal prisoners in the South. Stephens headed the Confederate commission to the peace conference at Hampton Roads in Feb. 1865. In the following May, after the fall of the Confederacy, he was arrested at his home and taken to Fort Warren, in Boston harbour, where he was confined until Oct. 12. In 1866 he was elected to the United States Senate, but was not permitted to take his seat. He was a representative in Congress, however, from 1873 to 1882, and was governor of Georgia in 1882–83, dying in office, at Atlanta, on March 4, 1883.

From 1871 to 1873 he edited the *Atlanta Daily Sun,* and he published *A Constitutional View of the Late War between the States* (1868–70), perhaps the best statement of the Southern position with reference to state sovereignty and secession; *The Reviewers Reviewed* (1872), a supplement to the preceding work; and *A Compendium of the History of the United States* (1875; new ed., 1883).

See Louis Pendleton, *Alexander H. Stephens* (Philadelphia, 1908); R. M. Johnston and W. H. Browne, *Life of Alexander H. Stephens* (Philadelphia, 1878; new ed., 1883); Henry Cleveland, *Alexander H. Stephens in Public and Private, with Letters and Speeches* (Philadelphia, 1866); M. L. Avary (ed.), *Recollections of A. H. Stephens,* with a biographical study (1910); U. B. Phillips (ed.), "The Correspondence of Robert Toombs, Alexander H. Stephens and Howell Cobb," in *American History Association, Annual Report,* vol. ii. (1911); and Gamaliel Bradford, *Confederate Portraits* (1914).

STEPHENS, JAMES (1882–), Irish poet, was born in Dublin. He was earning his living as a clerk in Dublin when he made his name by the exquisite prose of the delightful fairy stories published as *The Crock of Gold* (1912). He shows a sense of fantasy and a delicate poetic talent in all his works. The later ones include *Reincarnation* (1918); *Deirdre* (1923); *In the Land of Youth* (1924); *Collected Poems* (1926) and *Etched in Moonlight* (1928). Stephens was an ardent Nationalist, and worked hard for the creation of the Irish Free State.

STEPHENS, JOHN LLOYD (1805–1852), American traveller, was born Nov. 28, 1805, at Shrewsbury, N.J. Having been admitted to the bar, he practised for about eight years in New York city. In 1834–36 he made extensive travels in Europe, Egypt and Syria. In 1839 Stephens arranged with Frederick Catherwood to make an exploration in central America, with a view to discovering and examining the antiquities said to exist there. Stephens, meantime, was appointed to a mission to central America. Stephens published in 1841 *Incidents of Travels in Central America, Chiapas and Yucatan.* A second visit (1841) to Yucatan is described in *Incidents of Travel in Yucatan* (1843). Stephens died at New York on Oct. 10, 1852.

STEPHENSON, GEORGE (1781–1848), English engineer, was the second son of Robert Stephenson, fireman of a colliery engine at Wylam, near Newcastle, where he was born on June 9, 1781. In boyhood he was employed as a cowherd, and afterwards he drove the "gin-horse" at a colliery. At 14 he became assistant fireman to his father at a shilling a day, and at 17 he was appointed plugman, his duty being to attend to the pumping-engine. As yet he was unable to read, but stimulated by a desire to study the inventions of Boulton and Watt, he attended a night school and made rapid progress. In 1801 he became brakesman, in 1802 engineman at Willington Quay, where he took up watch and clock cleaning in his spare time. In 1804 he moved to Killingworth, where in 1812 he was appointed engine-wright of the High Pit at a salary of £100 a year. It was here in 1815 that he devised his miner's safety lamp, at the time when Sir Humphry Davy was also producing his lamp, a coincidence which led to much controversy.

In 1813 Stephenson was authorised to build a "travelling engine" for the tramroads between the Killingworth colliery and the port 9 mi. away on the plan of one already running at Wylam. The engine, which was named "Blucher," ran a successful trial on July 25, 1814, and in 1822 he persuaded the directors of the Stockton and Darlington railway (then in construction) to use steam instead of animal traction. At the opening of this railway on Sept. 27, 1825, therefore, the first public passenger train in the world was drawn by Stephenson's locomotive "Active," which was subsequently renamed "Locomotion." His connection with the Stockton and Darlington led to his employment on the Liverpool and Manchester railway, whose track he carried successfully over Chat Moss. When the line was nearing completion he persuaded the directors, who favoured haulage by fixed engines, to give the locomotive a trial. They offered a prize of £500 for a suitable machine, and in the Rainhill trials in October, 1829, Stephenson's engine, "The Rocket," was chosen. (For a description see *Steam Engine.*) On September 15, 1830, the railway was formally opened, the eight engines employed having been built at the works started at Newcastle in 1823 by Stephenson, his cousin Thomas Richardson, and Edward Pease. Stephenson was engineer of the Grand Junction, London & Birmingham (with his son Robert), Manchester to Leeds, Derby to Leeds, Derby to Birmingham, and Birmingham to York railways; but he strongly disapproved of the "railway mania" of 1844. He was also consulted about the construction of railways in Belgium and Spain. The last years of his life were spent in retirement at Tapton House, Chesterfield, in farming and horticulture, and there he died on Aug. 12, 1848.

See *Life of George Stephenson,* by Samuel Smiles (1857, new ed., 1881); and Smiles's *Lives of the Engineers,* vol. v. (1873).

STEPHENSON, GEORGE ROBERT (1819–1905), British civil engineer, was born at Newcastle-on-Tyne on Oct. 20, 1819, and was the nephew of George Stephenson (1781–1848) (*q.v.*). After working in colliery workshops near Manchester, he was sent to King William's School, Isle of Man. After his father's death in 1837, he worked for his uncle in the drawing-office of the Manchester and Leeds railway. In 1860, when he was consulting engineer to the provincial government of Canterbury, New Zealand, the Lyttelton-Christchurch line was built under his direction. He returned to England, and with Sir John Hawkshaw in 1864 built the East London railway. He was partly responsible for the construction of the Victoria tubular bridge across the St. Lawrence, and designed many bridges in England and abroad. In 1859 he succeeded his cousin Robert Stephenson (*q.v.*) at the locomotive works at Newcastle-on-Tyne, and at the Snibston and Tapton collieries. He died at Cheltenham on Oct. 26, 1905.

STEPHENSON, ROBERT (1803–1859), English engineer, only son of George Stephenson (*q.v.*), was born at Willington Quay on Oct. 16, 1803. He spent four years at school in Newcastle, and was then (1819) apprenticed to Nicholas Wood, a coal-viewer at Killingworth, after which he was sent in 1822 to attend science classes at the university of Edinburgh. He assisted his father in surveying the Stockton and Darlington and Liverpool and Manchester railways, and in 1824 he took charge of the engineering operations in South America of the Colombian Mining Association of London. He resigned in 1827, and returned to England via New York in company with Richard Trevithick, whom he had met in a penniless condition at Cartagena. Stephenson then undertook the management of his father's factory in Newcastle, and assisted in the improvement of the locomotive. His work extended to Sweden, Denmark, Belgium, Switzerland and Egypt. He specialised in the construction of railway bridges, especially those of the tubular girder type, and among his more notable examples are the Royal Border bridge at Berwick-on-Tweed, the High Level bridge at Newcastle-on-Tyne, the Britannia tubular bridge over the Menai Straits, the Conway tubular bridge, and the Victoria tubular bridge over the St. Lawrence at Montreal. In 1847 he entered the House of Commons as member for Whitby, retaining the seat till his death in London on Oct. 12, 1859. He was buried in Westminster Abbey.

See *The Story of the Life of George Stephenson, including a Memoir of his Son Robert Stephenson*, by Samuel Smiles (1857; new ed. 1881); Jeaffreson, *Life of Robert Stephenson* (2 vols., 1864); and Smiles's *Lives of the Engineers*, vol. v. (1873).

STEPNEY, an eastern metropolitan borough of London, England, bounded north by Bethnal Green, east by Poplar, south by the river Thames, and west by the City of London and Shoreditch. Pop. (1921) 249,657; area, 1,767 acres. The thoroughfares of Mile End Road and Whitechapel Road and that of Commercial Road East traverse the borough from the east and converge near the City boundary, where stood the ancient Aldgate. In the north Stepney includes the districts of Spitalfields, Whitechapel and Mile End; and in the south Wapping, Shadwell, Ratcliff and Limehouse. The name appears in Domesday and later as *Stevenhethe*. The suffix is thus the common form *hythe*, a haven; but for the prefix no certain derivation is offered. At Mile End, so called from its distance from the City (Aldgate), Wat Tyler and Richard II. met in 1381. Pepys records the village as a favourite place of resort. The district of Spitalfields has an old association with the silk-weaving industry; a trade in singing birds is also characteristic of this district. Wharves and factories line the river bank. In the extreme west the borough includes within its bounds the historic Tower of London (*q.v.*), the Royal Mint and the Tower Bridge over the Thames. Stepney is a suffragan bishopric in the diocese of London. The metropolitan borough of Stepney returns three members to Parliament, one each for the Limehouse, Mile End and Whitechapel and St. George's divisions.

STEPNIAK, SERGIUS (1852–1895), Russian revolutionist, whose real name was Sergius Michaelovich Kravchinski, was born in South Russia, of noble parents. He became an officer in the artillery; but his sympathy with the peasants, among whom he had lived during his boyhood in the country, developed in him at first democratic and, later, revolutionary opinions. He began secretly to sow the sentiments of democracy among the peasants. His teaching did not long remain a secret, and in 1874 he was arrested. He succeeded in making his escape—possibly he was permitted to escape on account of his youth—and immediately began a more vigorous campaign against autocracy. His sympathetic nature was revolted by the brutal methods adopted towards prisoners, especially political prisoners, and by the stern measures of repression of revolutionary sentiment. For a time he supported a terrorist policy, and in 1880 he was obliged to leave the country. He settled for a short time in Switzerland, and after a few years came to London. He was already known in England by his book *Underground Russia*, which had been published in London in 1882. He followed it up with other works on the condition of the Russian peasantry, on Nihilism, and on the conditions of life in Russia. Stepniak was killed by a railway engine at a level crossing at Bedford Park, Chiswick, on Dec. 23, 1895.

STEPPE, the level treeless Russian plains and thence sometimes extended as a type-name for similar plains elsewhere; specifically it is usually applied to the plains in the south and south-east of European Russia and in the south-west of Asiatic Russia, and in this connection the term connotes level grassy areas on which the slight summer rainfall with a winter deficiency produces patches with semi-desert conditions.

STERCORARIIDAE: *see* SKUA.

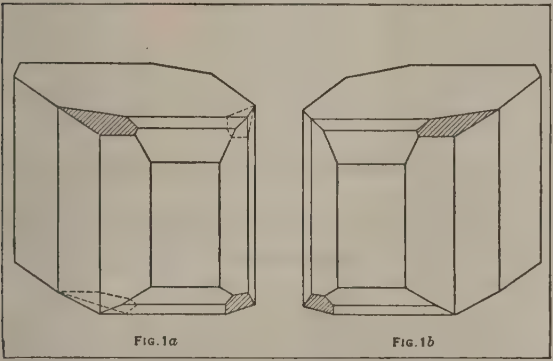
STEREOBATE, in architecture, the rough masonry substructure, or foundation, of a Greek temple.

STEREOCHEMISTRY is a branch of chemistry which is concerned with the arrangement in space of the atoms in the molecules of which substances are composed. (Gr. *στερεός*, solid). Knowledge regarding the spatial configuration of molecules has been acquired chiefly through the investigation of examples of *stereoisomerism*, a type of isomerism in which the isomers exhibit the same chemical reactions (and therefore possess the same chemical structure) and yet differ in certain physical properties; for differences between compounds of the same structure can only be due to differences in the arrangement of the atoms in their molecules in space.

The fundamental principles of stereochemistry were established by Louis Pasteur in a series of investigations on tartaric acid, carried out chiefly during the years 1849–53. Tartaric acid is obtained as a by-product in the manufacture of wine, being deposited from the fermented must in the form of potassium hydrogen tartrate. The crude salt contains, however, a small proportion of the potassium hydrogen salt of another acid of the same composition named racemic acid. Now tartaric and racemic acid not only have identical chemical compositions but they also possess the same chemical structure. Yet they show certain marked differences in properties. For example, racemic acid is much less soluble in water than tartaric acid and crystallizes with water of crystallization, whereas tartaric acid separates in anhydrous crystals; but the most remarkable difference between the two substances is in their effect on plane-polarized light. Many naturally occurring substances of organic origin, such as sugar, camphor and oil of turpentine, possess, even in the liquid or dissolved state, the curious property of rotating the plane of polarization of a beam of plane-polarized light through an angle proportional to the thickness traversed. Tartaric acid and the tartrates have this property, being *dextrorotatory* (*i.e.*, they rotate the plane of polarization to the right, or in the sense which is clockwise when regarded in the direction contrary to that in which the light is travelling), while racemic acid and the racemates are optically inactive.

Pasteur's discoveries arose out of a crystallographic investigation of tartaric acid. He observed that there was a certain lack of symmetry in the crystalline form of this substance of such a kind that the crystal was non-superposable on its mirror-image. The crystal and its image thus differ in the same kind of way as the right hand from the left hand. He prepared and examined 19 different salts of tartaric acid and found that each of these showed a similar lack of symmetry in its crystalline form. Thus fig. 1*a* represents the crystalline form of one of these salts, sodium ammonium tartrate. If the crystal possessed the full symmetry of the system to which it belongs, two faces, corresponding with the two shaded, should be found in the positions indicated by dotted lines. These faces, instead of occurring 8 times in the crystal, occur only 4 times (there are of course two corresponding faces on the back of the crystal not shown in the figures) and such faces, occurring only half as frequently as the full symmetry of the crystal demands, are termed *hemihedral faces*. The sodium ammonium tartrate crystal, on account of the presence of these hemihedral faces, is evidently non-superposable on its mirror-image represented in fig. 1*b*. In contrast to tartaric acid and the tartrates, racemic acid and such of its salts as Pasteur examined (with one exception, which will be considered below) crystallize in symmetrical forms superposable on their mirror-images. The optically active tartrates thus crystallize in dissymmetric forms, whilst the optically inactive racemates yield symmetrical crystals.

Pasteur's chief discovery was made through investigating the exceptional racemate referred to above, which was sodium ammonium racemate. Crystallized under certain conditions this salt yielded crystals which unlike those of the other racemates exhibited hemihedral faces, but the crystals were of two kinds. Some were identical in form with dextrorotatory sodium ammonium tartrate (fig. 1*a*) and were in fact crystals of that salt. The other crystals differed from these only in that their hemihedrism was in the opposite sense; they were the realization of the mirror-image of sodium ammonium tartrate: they had thus the form represented in fig. 1*b*. When picked out from the mixture and dissolved in water they gave a laevorotatory solution; and the acid extracted from them had a crystalline form which was the mirror-image of that of tartaric acid, and its solutions were laevorotatory.



FROM STEWART, "STEREO-CHEMISTRY" (LONGMANS GREEN & CO.)

FIG. 1.—(A & B) ENANTIOMORPHOUS CRYSTALS OF SODIUM AMMONIUM TARTRATE

This new acid has exactly the same solubility, melting point, specific gravity, etc., as tartaric acid; in all such properties the two acids are identical. They differ in that, (1) solutions of the new *laevorotatory* acid rotate the plane of polarization exactly as much to the left as equivalent solutions of tartaric acid rotate it to the right, and (2) their crystals cannot be superposed; their hemihedrism is in opposite senses. In the two compounds, therefore, all properties are identical except those which have direction, and these are equal and opposite. The only relationship between their molecules that can give this relationship in properties is evident; the molecules must be related as object to mirror-image. The reason why tartaric acid exists in two forms is thus that its molecule has a lack of symmetry that renders it non-superposable on its mirror-image, so that right- and left-handed forms of the molecule are possible. The dextrorotatory tartaric acid obtained directly from grape-juice is termed *dextro*-tartaric (or *d*-tartaric) acid, and the laevorotatory modification extracted from sodium ammonium racemate is known as *laevo*-tartaric (or *l*-tartaric) acid.

When concentrated solutions of *d*-tartaric and *l*-tartaric acids are mixed, the less soluble racemic acid crystallizes at once from the mixture. Racemic acid is evidently composed of molecules of *d*- and *l*-tartaric acids in equal proportions, and its optical inactivity is the result of the summation of the equal and opposite activities of its components. In the crystal of racemic acid the *d*- and *l*-molecules are packed together in pairs; such a crystal may therefore be compared with a large package of pairs of gloves. The salts of racemic acid similarly crystallize almost invariably in uniform crystals composed of pairs of the *d*- and *l*-molecules. Under exceedingly special conditions, however—in the case of a particular salt, the sodium ammonium double salt, and provided that crystallization takes place below 27° C—the constituent *d*- and *l*-tartrates crystallize in separate crystals, just as under exceptional circumstances gloves might be packed with right-hand and left-hand gloves in separate packages.

The discovery of *l*-tartaric acid thus revealed the significance of optical activity in liquid and dissolved substances. All natural objects can be divided into two classes: (i.) those which are superposable, and (ii.) those which are non-superposable on their mirror-images. It is evident that a substance of which the molecules belong to the first class can only exist in one form and cannot be optically active in the liquid or dissolved state, for in view of the symmetry of its molecules there can be nothing in them to cause the rotation of the plane of polarization in one direction rather than in the other. The molecules of substances that are optically active in the liquid or dissolved state must therefore belong to the second class, and such molecules are necessarily capable of existence in enantiomorphous (opposite-shaped) forms, and the optical activities of these forms must be equal and opposite; these complementary forms are termed *enantiomorphs antimers* or *optical antipodes.* Optically active substances must therefore occur in pairs. To every naturally occurring optically active compound there should be an optical antipode. Many of these are known as, for example, the laevorotatory antipodes of glucose and camphor, whilst others still await discovery.

To express the fact that a substance is composed of molecules which are non-superposable on their mirror-images, Pasteur introduced a new term. He described such substances as possessing *molecular dissymmetry*. The fundamental principle established by his investigations may thus be stated as follows: *If any substance exhibits optical activity in the liquid or dissolved state it possesses molecular dissymmetry.* The converse principle is also to be regarded as well established (for it now rests on a very broad experimental basis), namely, *Every molecularly dissymmetric substance is capable of showing optical activity in the liquid or dissolved state.* It would appear also that the *d*- and *l*-modifications of a molecularly dissymmetric substance crystallize in enantiomorphous forms, though the enantiomorphism may be difficult to detect.

Separation of the Antimeric Forms.—When a molecularly dissymmetric substance is prepared in the laboratory from inactive materials, an optically inactive mixture composed of equal parts of its dextro- and laevo-modifications must be formed, since there will be no asymmetric influence to favour the formation of one antimer rather than the other. The experimental demonstration of the molecular dissymmetry of a synthetic compound therefore always involves the resolution of the initially formed inactive mixture into its active antimeric components. The separation of antimeric substances requires, however, the use of special methods, since the processes of fractional crystallization and distillation usually employed for the isolation of individual substances are inapplicable, for antimers have equal solubilities in all solvents and equal vapour pressures at all temperatures. The special processes by which the resolution of molecularly dissymmetric substances can be effected are of three types which may be entitled: (i.) The method of manual separation of the enantiomorphous crystals of the antimers, (ii.) the method of conversion of the mirror-image isomers into diastereoisomers, (iii.) the biochemical method.

(i.) The first method is illustrated by Pasteur's separation of the antimeric sodium ammonium tartrates. Whilst it is thus of great historical interest, it has been of comparatively little practical value in the subsequent development of stereochemistry on account of its exceedingly limited applicability, for when an equimolecular mixture of the *d*- and *l*-forms of a molecularly dissymmetric substance crystallizes, it almost always happens that uniform crystals, built up of pairs of enantiomorphous molecules, are formed. Such crystals, being analogously constituted to those of racemic acid, are termed *racemic crystals,* and the association of *d*- and *l*-molecules of which they are formed is termed a *racemic compound,* though there is no evidence that the molecules constituting each pair are linked by forces different from the cohesive forces binding together the molecules in a crystal.

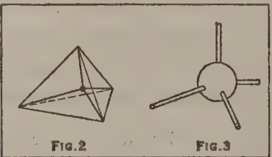
(ii.) The second method of resolution may be illustrated by considering the salt of an inactive molecularly dissymmetric acid with an active base. If the symbols + and − are used to denote enantiomorphous configurations, the antimeric forms of the acid may be represented as (+A) and (−A), and the base, *e.g.,* a laevorotatory alkaloid, as (−B). Combination of the acid and the base will then yield the two salts (+A) (−B) and (−A) (−B). It is clear then that two compounds which can be thus represented are not antimeric; they are said to be *diastereoisomeric.* Similarly an inactive dissymmetric base (+B), (−B) will give rise with a dextrorotatory acid (+A) to the diastereoisomeric salts (+A) (+B), (+A) (−B). Diastereoisomeric compounds, being different and not antimeric, must differ to a greater or less degree in all their properties, and a pair of diastereoisomeric salts may in fact differ very considerably in solubility so that they can be easily separated by fractional crystallization. Each then yields on decomposition one of the pure antimeric forms of the acid or base as the case may be. This is the most important of the methods of resolution, and most of the very large number of optically active substances that have been prepared artificially have been obtained by its means.

(iii.) The biochemical method depends on the different effects of living organisms on antimeric compounds. Thus moulds grown in a solution of ammonium racemate destroy the *d*-tartrate and leave the *l*-tartrate; yeasts added to solutions of inactive glucose ferment the naturally occurring *d*-glucose and leave the *l*-antimer; similarly, rabbits fed with the inactive forms of common α-amino-acids assimilate or destroy the active modification occurring in nature and excrete the other. Since digestive chemical changes are mainly effected through enzymes, the biochemical method of resolution evidently depends on the well-known high specificity of enzyme action. Enzymes act very unequally on antimers, and must therefore themselves be dissymmetric; Emil Fischer used the simile that the enzyme fits the substrate as the key fits the lock.

THE STEREOCHEMISTRY OF CARBON

The most symmetrical arrangement possible for the valencies of a quadrivalent element is that in which their relative directions correspond with those of the four axes of a regular tetrahedron (fig. 2).

This view of the spatial distribution of the carbon valencies was adopted by F. A. Kekulé as early as 1867, and he had models constructed to represent the carbon atom, somewhat of the form shown in fig. 3, consisting of a sphere with four rods attached in the directions of the axes of a circumscribed regular tetrahedron. It was, however, a few years later (1873) that the attention of chemists was first directed seriously to the need for considering the spatial configuration of molecules. In that year J. Wislicenus showed that the lactic acid of sour milk and the sarcolactic acid of muscle juice (which differed in the hydration and solubility of their salts and in their optical properties, the latter being optically active) had the same chemical structure, and hence concluded that their difference could only be due to the different position of their atoms in space. In the following year J. H. van't Hoff published a pamphlet entitled "A Proposal respecting the Extension of Chemical Structural Formulae into Space," in which he showed that the "tetrahedral" theory of the arrangement of the carbon valencies supplied an interpretation of the molecular dissymmetry of organic compounds which was in accordance with the experimental facts. Similar views were put forward almost simultaneously by Le Bel.



FIGS. 2, 3.—TETRAHEDRAL DISTRIBUTION OF VALENCIES IN A SINGLE CARBON ATOM

On van't Hoff's theory the molecule of a carbon compound of the type C *a b c c* has the configuration I., as shown in fig. 4, and this has a plane of symmetry, namely, the plane passing through the edge *a b* and the middle point of *c c* cutting the tetrahedron in half as indicated by the dotted line; the molecule is therefore superposable upon its mirror-image, and a compound of this type should exist in one modification only. Replacement in this compound of one of the two radicals *c* by a fourth radical *d* will give, however, two enantiomorphous configurations, II. and III., according as the one or the other of these two radicals is replaced, for this substitution destroys the plane of symmetry and leaves a completely asymmetric molecule. A compound of the type C *a b c d* containing a carbon atom linked to four different radicals should therefore be molecularly dissymmetric and should exist, according to the principles established by Pasteur, in two antimeric optically active forms. A carbon atom thus linked is termed an *asymmetric carbon atom.*

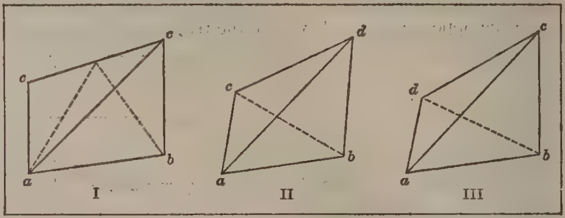
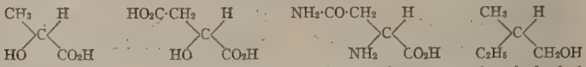
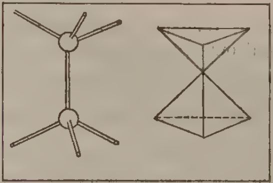


FIG. 4.—CONFIGURATION OF CARBON COMPOUNDS ACCORDING TO VAN'T HOFF'S THEORY

This conclusion accorded well with the observed distribution of optical activity in organic compounds. All optically active compounds of which the constitution was known contained a carbon atom linked in this manner. This is illustrated by the following formulae of optically active compounds:



Lactic acid Malic acid Asparagine Amyl alcohol



FIGS. 5, 6.—TETRAHEDRAL DISTRIBUTION OF VALENCIES OF TWO CARBON ATOMS

When we come to consider the configuration of compounds containing more than one carbon atom, a further question arises. In addition to knowing the relative positions of the valency bonds of the individual atoms we should have some idea of the orientation of the different atoms relatively to one another in the molecule. Evidently the valencies linking two carbon atoms together will lie in a straight line as illustrated by the models shown in fig. 5 (tetrahedral axes) and fig. 6 (solid tetrahedra), and the experimental facts indicate that the two atoms can rotate freely about this line as an axis, for compounds like CH_2Br–CH_2Br, ethylene bromide, or $HO_2C\cdot CH_2$–$CH_2\cdot CO_2H$, succinic acid, exist in one modification only. The two halves of such molecules must therefore be capable of rotating about the linking by which they are united so as to assume the relative position of maximum stability. These two simple assumptions of the *tetrahedral distribution of the carbon valencies* and *free rotation about a single linking* provide so complete an explanation of practically the whole of the stereochemistry of carbon that there can be little doubt of their essential correctness.

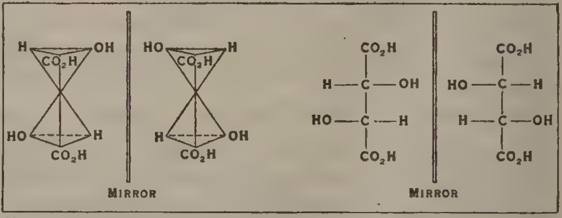


FIG. 7.—ENANTIOMORPHOUS CONFIGURATIONS AND PROJECTION FORMULAE OF THE TRANS-D- AND L-TARTARIC ACIDS

THE STEREOCHEMISTRY OF OPEN-CHAIN COMPOUNDS

Mirror-image Isomerism.—As regards their mirror-image isomerism, open-chain compounds may be considered according to the number of carbon atoms that their molecules contain. Dissymmetric compounds with *one* or *two carbon atoms* in the molecule suitable for resolution are not easy to obtain, and it was not until 1913 that a one-carbon compound—bromoiodomethanesulphonic acid, $CHBrI\cdot SO_3H$—was satisfactorily resolved (Pope and Read). It proved to be optically stable. Among the compounds with *three carbon atoms* in the molecule are the biochemically important substances, lactic acid and the α-amino-acids, alanine, serine and cystine. The configuration of the group $-H_2C-HCX-CO_2H(X=OH$ or $NH_2)$ seems to be the same in the naturally occurring optically active forms of these substances. The compounds containing *four carbon atoms* in the molecule include the tartaric acids which played so important a part in the establishment of the fundamental principles of stereochemistry. Their structure having been fixed as dihydroxy-succinic acids, the tetrahedral theory enabled a precise form to be given to their molecular dissymmetry envisaged by Pasteur; *d*- and *l*-tartaric acids will have the enantiomorphous configurations shown in fig. 7 which can also be conveniently indicated by the projection formulae shown on the right. It will probably only be possible to determine which of these configurations corresponds with which antimer when a method has been discovered of calculating the optical rotation of a dissymmetric compound from some measurable property, such as the refractivity, of the radicals *a, b, c, d,* associated with the asymmetric carbon atom.

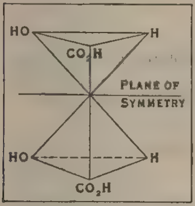
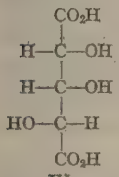


FIG. 8.—THIRD POSSIBLE, OR CIS-, CONFIGURATION OF TARTARIC ACID MOLECULE PLANE OF SYMMETRY

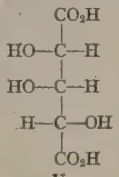
Besides the two configurations of the tartaric acid molecule shown above, a third, represented in fig. 8, is also possible. This configuration has a *plane of symmetry,* as indicated, and is therefore superposable upon its mirror-image and is incapable of optical activity. This inactive, non-resolvable form of tartaric acid was discovered by Pasteur, who obtained it by the action of heat on salts of tartaric acid, and is known as *mesotartaric acid.* The existence of this form is determined by the structural identity of the two halves of the tartaric acid molecule. The acid contains two equivalent asymmetric carbon atoms, and the relation between its *d*-, *l*-, and *meso*-modification can be represented by the symbols +A+A, −A−A, and +A−A. Every compound containing two equivalent asymmetric carbon atoms must be capable of existence in three such forms and generally in a racemic form.

In the *five-carbon series* a new stereochemical feature is exhibited in trihydroxyglutaric acid (IV.–VII.).



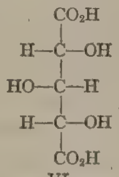
$$\begin{array}{c} CO_2H \\ | \\ H-C-OH \\ | \\ H-C-OH \\ | \\ HO-C-H \\ | \\ CO_2H \end{array}$$

IV.



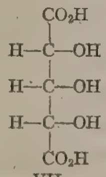
$$\begin{array}{c} CO_2H \\ | \\ HO-C-H \\ | \\ HO-C-H \\ | \\ H-C-OH \\ | \\ CO_2H \end{array}$$

V.



$$\begin{array}{c} CO_2H \\ | \\ H-C-OH \\ | \\ HO-C-H \\ | \\ H-C-OH \\ | \\ CO_2H \end{array}$$

VI.



$$\begin{array}{c} CO_2H \\ | \\ H-C-OH \\ | \\ H-C-OH \\ | \\ H-C-OH \\ | \\ CO_2H \end{array}$$

VII.

This compound contains two equivalent asymmetric carbon atoms and thus occurs in two optically active antimeric forms, IV. and V., but instead of having only one meso-form like tartaric, it possesses two such inactive non-resolvable modifications as shown by the projection formulae VI. and VII. If the enantiomorphous configurations of the group $CH(OH)\cdot CO_2H$ are indicated by +R and −R, the relation between these two non-resolvable forms of the acid can also be represented as in fig. 9.

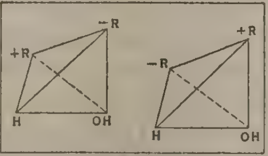
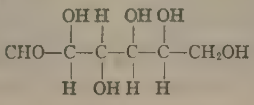


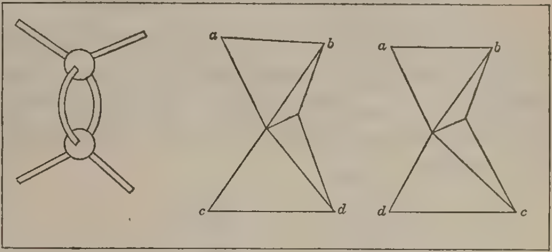
FIG. 9.—NON-RESOLVABLE MODIFICATIONS OF TRIHYDROXYGLUTARIC ACID

The *six-carbon series* contains the sugars glucose and fructose and their stereoisomers, and it is in this group of compounds that the usefulness of the conception of the asymmetric carbon atoms has been most strikingly demonstrated. The hydroxy-aldehydic formula for glucose



$$\begin{array}{ccccccccc} & & OH & & H & & OH & & OH \\ & & | & & | & & | & & | \\ CHO & - & C & - & C & - & C & - & C-CH_2OH \\ & & | & & | & & | & & | \\ & & H & & OH & & H & & H \end{array}$$

contains four non-equivalent asymmetric carbon atoms. Since the introduction of a new asymmetric carbon atom into a compound doubles the number of stereoisomerides previously possible, a compound containing *n* non-equivalent asymmetric carbon atoms should exist in 2^n forms. The number of possible stereoisomers of the same structure as glucose is therefore sixteen; in other words, there should be eight stereoisomeric aldohexoses, each existing in two antimeric forms. All the eight are known, many of them in both antimeric forms, and their configurations have all been determined. (*See* CARBOHYDRATES.) It is unnecessary to proceed further with the consideration of open-chain compounds as the study of the more complex series has not brought new principles to light.

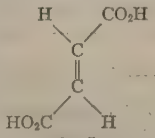


FIGS. 10, 11, 12.—TETRAHEDRAL DISTRIBUTION OF VALENCIES OF TWO DOUBLY LINKED CARBON ATOMS

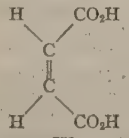
Geometrical Isomerism.—On the tetrahedral hypothesis two doubly linked carbon atoms will be represented by models such as those shown in fig. 10 or figs. 11 and 12.

Van't Hoff pointed out in his original brochure that this view of the ethylenic linking leads to two conclusions: (1) That there should be no free rotation about an ethylenic linking; the molecule should possess two equilibrium configurations as indicated by figs. 11 and 12. Ethylenic compounds should therefore exist in stereoisomeric forms, except when the radicals *a* and *b* (or *c* and *d*) are identical; (2) That the doubly linked carbon atoms and the four radicals *a, b, c, d* all lie in one plane. This plane is then a plane of symmetry, and thus ethylenic compounds, even when of the type ${}^{a}_{b}\!\!>\!C{:}C\!<\!{}^{c}_{d}$, should be incapable of exhibiting optical activity.

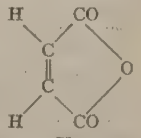
These conclusions are fully confirmed by experiment. A large number of ethylenic compounds of the requisite structural type have been found to exist in two isomeric forms, and no adequate explanation has been found for this isomerism except the *cis-trans isomerism* determined by this conception of the ethylenic linking; also no case of optical activity determined by the non-planar configuration of the complex ${}^{a}_{b}\!\!>\!C{:}C\!<\!{}^{c}_{d}$ has been established. The best known example of cis-trans isomerism is that presented by fumaric and maleic acids. These acids are structurally identical; each of them is an ethylenedicarboxylic acid of the structure $HO_2C\cdot CH{:}CH\cdot CO_2H$. The great difference in properties which they exhibit can only be due to difference in configuration. Maleic acid, which readily forms a cyclic anhydride X., and is regenerated from it by addition of water, must have the cis-configuration IX. Fumaric acid consequently has the trans-configuration VIII. Other examples of cis-trans isomers are cinnamic, XI., and allocinnamic acids, XII., oleic and elaidic acids, XIII., and stilbene and isostilbene, XIV.



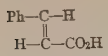
VIII.
Fumaric acid

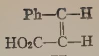


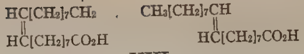
IX.
Maleic acid

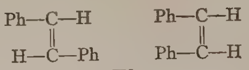


X.
Maleic anhydride


XI.

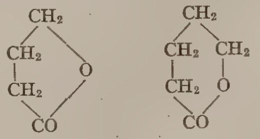

XII.


XIII.


XIV.

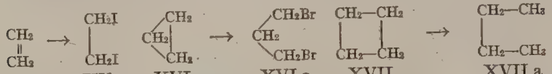
STEREOCHEMISTRY OF CYCLIC COMPOUNDS

Ring Formation.—An overwhelming proportion of the known cyclic compounds contain five- or six-numbered rings. The special tendency to the formation of such rings, thus indicated, is well illustrated by the hydroxy-acids of the general formula $HO{\cdot}(CH_2)_n{\cdot}CO_2H$. When $n=3$ or 4, but only then, these acids lose water spontaneously, forming cyclic internal esters (lactones) of the structure



Such ring formation can thus only occur when a 5- or 6-membered compound will be formed.

It is possible to form three- and four-membered rings, but they tend to spring open under the influence of reagents, the tendency being more marked in the 3- than in the 4-rings. Thus ethylene, XV., which we can regard as a 2-ring, cyclopropane, XVI., and cyclobutane, XVII., form a series of diminishing unsaturation.


XV. XV.a XVI. XVI.a XVII. XVII.a

For ethylene combines with all the halogens, even with iodine, when ethylene di-iodide XV.a is formed; cyclopropane, XVI., is stable towards iodine but reacts with bromine in the cold, forming trimethylene dibromide; cyclobutane, XVII., is not opened by bromine, but is converted by catalytic reduction with hydrogen (under conditions under which cyclopentane and cyclohexane are perfectly stable) into *n*-butane, XVII.a.

These facts constitute a striking confirmation of the tetrahedral theory, for the angle at which the axes of a regular tetrahedron are inclined to one another is 109° 28′, and this is very nearly the same as the angle between adjacent sides of the regular pentagon (108°). Thus we have an immediate explanation of the ready formation of 5-membered carbon rings; in them the valencies linking each carbon atom to its neighbour on either side are inclined at an angle which hardly differs from the natural angle between carbon valencies. In cyclobutane, however, the angle of deflection of the valencies from their natural inclination, $\frac{1}{2}(109^\circ\,28'-90^\circ)=9^\circ\,44'$, is considerable; in cyclopropane it is larger, $\frac{1}{2}(109^\circ\,28'-60^\circ)=24^\circ\,44'$; whilst in ethylene it amounts to $54^\circ\,44'$.

This theory correlating the relative instability of 3- and 4-rings with the strain due to deflection of the valencies from their natural directions is known as *Baeyer's Strain Theory* (1885). In six- and higher-membered rings there is apparently no strain; the strain is relieved by buckling of the ring. Thus cyclohexane may have either of the strain free arrangements.

Such non-planar configurations, if sufficiently permanent, should cause molecular dissymmetry in appropriate derivatives. It has been impossible to demonstrate this dissymmetry; hence the molecules of these buckled rings are probably in a state of flux between their various possible configurations on account of their thermal agitation. Convincing evidence of the non-planar configuration of the cyclohexane ring is however supplied by the discovery (Hückel, *Annalen*, 1925, 441, 1) that decahydronaphthalene, XVIII., can exist in a trans- as well as in a cis-modification, for if the two cyclohexane rings in this compound were plane the cis-form would alone be possible.

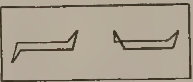
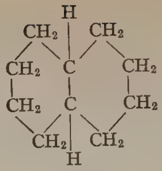
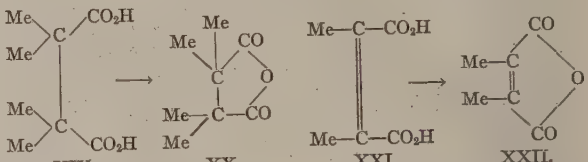


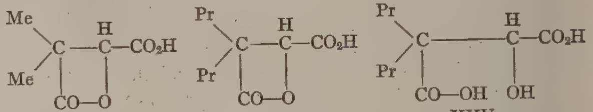
FIG. 13.—BUCKLING OF SIX-MEMBER RINGS TO RELIEVE STRAIN


XVIII.

Substitution has a remarkable effect in promoting ring closure. Thus tetramethylsuccinic acid, XIX., passes into its cyclic anhydride, XX., with far greater readiness than succinic acid itself,


XIX. XX. XXI. XXII.

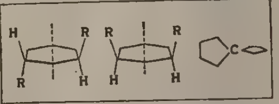
and dimethylmaleic acid, XXI., shows so great a tendency to ring-closure that when liberated from its salts it passes spontaneously into its anhydride, XXII. The larger the substituent the greater seems to be its effect. Thus the dimethyl-lactone, XXIII., can only be produced indirectly, and once opened it cannot be re-formed, but the analogous dipropyl-lactone, XXIV., is formed spontaneously from the corresponding hydroxy-acid, XXV.:—


XXIII. XXIV. XXV.

It has long been held probable that the regular tetrahedral configuration obtains only in a carbon atom attached to four like radicals, as in methane or carbon tetrachloride, and that when the radicals are not all alike the angles between the valencies may be rendered unequal. Further, if the angle between one pair of valencies is increased by the space demands or the mutual repulsion of the two attached radicals, the angle between the other pair may suffer a correlated decrease. Many facts have been accumulated by Thorpe and Ingold which can be interpreted as supporting the view that enhanced tendency to ring closure may arise from such modifications of the natural valency angle.

Geometrical Isomerism.—Since freedom of rotation about single linkings is abolished by ring-closure, geometrical isomerism is of frequent occurrence among cyclic compounds. Thus any disubstituted polymethylene (in which the substituents are on different carbon atoms) may exist in a *cis*- and a *trans*-form as the accompanying diagrams of a *cis*- and *trans*-1-3-disubstituted cyclohexane show.

Where, as in the compound represented, the two substituents are alike, the molecule of the *cis*-form has a plane of symmetry (the perpendicular plane through the dotted line in fig. 15) and this modification is therefore non-resolvable into optical antipodes; the molecule of the *trans*-form has, however, only an axis of symmetry (the dotted line in fig. 14); it is therefore dissymmetric, and this modification can thus exist in optically active forms. This difference between cis- and trans-modifications provides a very reliable method for determining configuration in those cases (as in many cyclo-paraffin carboxylic acids) where it is applicable.



FIGS. 14 & 15.—CIS- AND TRANS-1-3 DISUBSTITUTED CYCLOHEXANE: FIG. 16.—DOUBLE FIVE MEMBERED RINGS

The phenomena presented by cyclic compounds have a most important bearing on the spatial distribution of the carbon valencies. For whilst *any* non-planar configuration would account for the observed relationship between molecular dissymmetry and structure, and for the isomerism due to the combinations of centres of asymmetry, the relative stability and readiness of formation of 5-membered rings proves that the natural angle between two of the carbon valencies must be close to 108° (the angle of the regular pentagon). Since, further, spirocyclic compounds of the double 5-ring type are formed with great readiness it would appear that the angle between the other two valencies also approximates to 108°. The chemistry of cyclic carbon compounds thus strongly indicates the regular tetrahedral arrangement in which the intervalency angle is 109·5°.

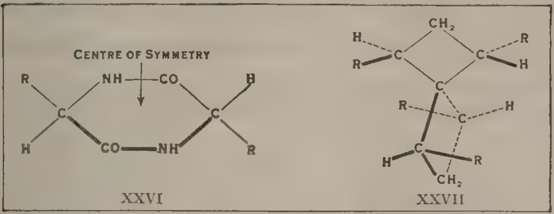
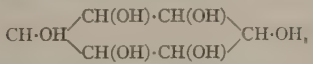


FIG. 17.—EXAMPLES OF MOLECULES WITH A CENTER OF SYMMETRY AND WITH AN ALTERNATING AXIS OF SYMMETRY

Mirror-image Isomerism.—The conception of the asymmetric carbon atom, which in the open-chain series provides such a ready means of recognising molecular dissymmetry, is much less useful when applied to cyclic compounds. In cyclic compounds molecular dissymmetry is most easily recognised by noting the absence of centre, alternating axis and planes of symmetry from the tridimensional formula, for a molecule must possess at least one such element of symmetry to have the property of superposability upon the mirror-image. Examples of molecules with a *plane of symmetry* have already been given. Well known examples of molecules with a *centre of symmetry* are those of the trans-forms of the cyclic anhydrides of the α-amino-acids, XXVI. (fig. 17). The *alternating axis of symmetry* has not yet acquired practical importance in stereochemistry, since no compounds with a molecule having an alternating axis but no plane or centre of symmetry are known; one of the simplest examples would be a compound of the type XXVII.

Among the cyclic compounds possessing special stereochemical interest are methylcyclohexylideneacetic acid, XXVIII. (fig. 18), resolved by Perkin, Pope and Wallach (*J. Chem. Soc.*, 1909, *95*, 1789) and the naturally occurring *d*- and *l*-inositols. The latter are cyclic hexahydric alcohols of the structure



$$\mathrm{CH{\cdot}OH}\begin{cases}\mathrm{CH(OH){\cdot}CH(OH)}\\ \mathrm{CH(OH){\cdot}CH(OH)}\end{cases}\mathrm{CH{\cdot}OH},$$

and although there are 7 geometrical isomers of this formula, the configuration of the active forms can be deduced because only one of the isomers (that of which XXIX. represents one of the antimeric components) is molecularly dissymmetric.

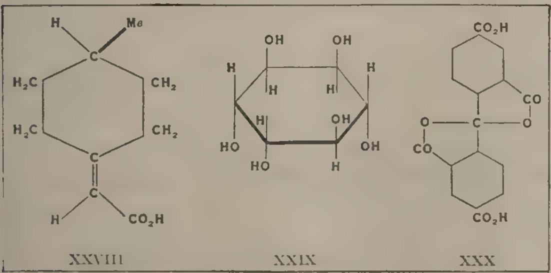
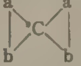


FIG. 18.—CONFIGURATIONS OF CYCLIC COMPOUNDS

The ketodilactone of benzophenonetetracarboxylic acid, XXX., resolved by Mills and Nodder (1921) is of the type



Its optical activity demonstrates the molecular dissymmetry that on the tetrahedral theory such spirocyclic compounds, in spite of the symmetry of their structural formulae, should possess. They have an axis of symmetry and the two forms correspond with the right- and left-handed forms of a two-bladed screw-propeller.

STEREOCHEMISTRY OF ELEMENTS OTHER THAN CARBON

4-Covalent Elements.—In all optically active compounds known up to 1899 the molecular dissymmetry was dependent upon the spatial arrangement of the valencies of carbon. In that year a great advance was made through the discovery by Pope and Peachey that quaternary ammonium salts of the type $N(R_1R_2R_3R_4)X$ could be resolved into optical antipodes, for this indicated that the valency configurations of other elements besides carbon could have sufficient permanence to make their stereochemical investigation possible, and thus a wide field of research was opened. Further work on quaternary ammonium salts showed, (1) that molecular dissymmetry could no longer be demonstrated when two of the hydrocarbon radicals were identical, proving that the ion $(NR_1R_2R_3R_3)$ has a plane of symmetry; (2) that different methods of formation of a given salt, such as

$$NR_1R_2R_3+R_4X \rightarrow NR_1R_2R_3R_4X \leftarrow NR_2R_3R_4+R_1X$$

never yielded isomeric modifications, indicating that the valencies linking the four hydrocarbon radicals to the nitrogen atom are inter-equivalent. Only two configurations of the ammonium ion satisfy these conditions, namely, the pyramidal configuration XXXI. (fig. 19) and the tetrahedral configuration XXXII., and of these the first has been definitely disproved by showing that a spirocyclic ammonium salt of the type XXXIII. (fig. 20) can be resolved into optically active components; for it can easily be seen that, if the two rings in this compound were attached to the base of a square pyramid, the molecule would have a plane of symmetry and the compound would be non-resolvable. In the ammonium ion the nitrogen atom must accordingly have the tetrahedral configuration XXXII. corresponding with the asymmetric configuration XXXIV. of its spirocyclic derivative XXXIII.

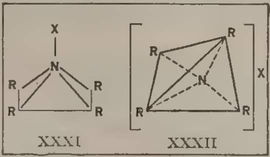
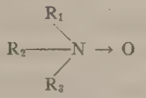


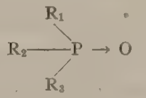
FIG. 19.—PYRAMIDAL AND TETRAHEDRAL CONFIGURATIONS FOR AMINE SALTS

The amine-oxides are another class of compounds of 4-covalent nitrogen (*see* VALENCY), and in these also the radicals are tetrahedrally disposed about the nitrogen atom, for amine-oxides of the type XXXV. have been obtained in optically active forms by Meisenheimer (1908).



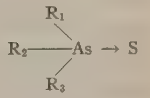
$$R_2{-}\overset{R_1}{\underset{R_3}{N}}\rightarrow O$$

XXXV.



$$R_2{-}\overset{R_1}{\underset{R_3}{P}}\rightarrow O$$

XXXVI.



$$R_2{-}\overset{R_1}{\underset{R_3}{As}}\rightarrow S$$

XXXVII.

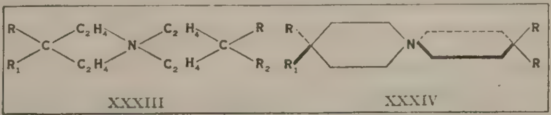
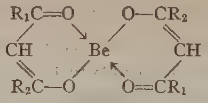


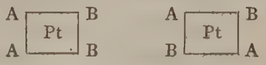
FIG. 20.—SPIROCYCLIC AMMONIUM DERIVATIVE AND ITS ASYMMETRIC CONFIGURATION

Phosphorus and arsenic have also been shown to have the tetrahedral configuration when in the 4-covalent state—phosphorus through the optical activity of a phosphine-oxide, XXXVI. (Meisenheimer and Lichtenstadt, 1911), and arsenic through that of an arsine-sulphide, XXXVII. (Mills and Raper, 1925). In the first short period (*see* PERIODIC LAW), besides carbon and nitrogen, the elements beryllium, boron and oxygen can assume the 4-covalent state, and there is evidence that the atoms of each of these elements then have the four radicals tetrahedrally disposed about them. This was proved for beryllium by the production of an optically active compound of the type



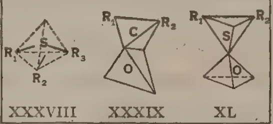
(Mills and Gotts, 1926), and for boron in a similar way by Böeseken and Meulenhoff (1924), and the tetrahedral symmetry of 4-covalent oxygen is indicated by the work of Morgan and Bragg on basic beryllium acetate (1923). The molecular dissymmetry of silicon compounds of the type $SiR_1R_2R_3R_4$ has been established by Kipping, and the investigation of the configuration of 4-covalent copper and zinc by the method used for 4-covalent beryllium has shown that their valencies are also tetrahedrally distributed.

It thus appears to be the rule that when an atom is linked directly to four other atoms these are arranged around it tetrahedrally. This rule is however not universal: thus, many compounds of 4-covalent platinum containing a complex of the type $[PtA_2B_2]$ occur in two, evidently stereoisomeric, modifications. A and B may be chemically similar, as ammonia and ethylamine, the complex then being a bivalent ion, or chemically diverse, as pyridine and chlorine, when the complex is electrically neutral. This isomerism is clearly incompatible with a tetrahedral arrangement of the radicals about the platinum atom and is to be explained most simply by supposing that 4-covalent platinum has a plane configuration and that the isomers are cis- and trans-modifications of the type



3-Covalent Elements.—The stereochemical relationships of 3-co-ordinated elements are clearest in the case of sulphur. Sulphonium salts $[SR_1R_2R_3]X$, in which three groups are covalently linked to the sulphur atom, were shown to be molecularly dissymmetric by Pope and by Smiles (1900); the sulphonium ion therefore has a non-planar configuration (fig. 21).

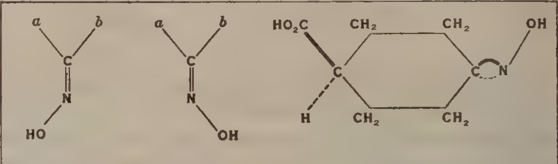
Other compounds of 3-covalent sulphur are the sulphinic esters, $R{\cdot}S{<}^{O}_{OEt}$, the sulphoxides, ${}^{R}_{R}{>}S{\rightarrow}O$, and the sulphilimines, ${}^{R}_{R}{>}S{\rightarrow}NR$, and these have each been shown to have a similar non-planar configuration, since optically active representatives of the three classes have been obtained, principally by Phillips and Kenyon (1925–27). The sulphoxides therefore differ from the ketones in configuration, probably as shown in diagrams which are given in fig. 21; the difference assumed in the oxygen linking is indicated by the electronic theory of valency and is confirmed by the parachor (*q.v.*). Optically active selenonium salts were obtained by Pope and Neville (1902); hence 3-covalent selenium also has a non-planar configuration.



XXXVIII XXXIX XL

FIG. 21.—NON-PLANAR CONFIGURATIONS FOR 3-COVALENT ELEMENTS

The configuration of the trivalent nitrogen atom is of special interest on account of the number and importance of the compounds in which the element is present in this state. The numerous attempts made to obtain optically active compounds of the type $NR_1R_2R_3$ have all given negative results, but it is scarcely safe to conclude from this that these compounds have a planar configuration, for it is possible that they are non-planar but racemize rapidly, and the configuration of this important type is still an open question. However, in compounds of trivalent nitrogen of the type $-X{:}N{\cdot}Y-$, where the nitrogen atom is directly linked to two other atoms only, and therefore to one of them by a double bond, the evidence for the non-planar disposition of its valencies is quite definite. Thus, oximes of the type ${}^{a}_{b}{>}C{:}NOH$ can generally be prepared in two isomeric modifications, and as the isomerism is repeated in the *O*-methyl ethers, for which only one structure ${}^{a}_{b}{>}C{:}NOMe$ is possible, it must be determined by a difference of configuration. The form of the group ${}^{a}_{b}{>}C{:}N$ being fixed by the well-established tetrahedral arrangement of the carbon valencies, a configurational difference can only be produced by a lateral displacement of the hydroxyl group to bring it nearer to one of the groups *a* or *b*, as indicated by the diagrams (fig. 22), and this requires a non-planar disposition of the nitrogen valencies.



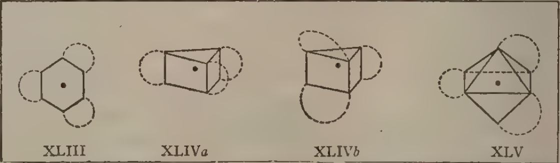
XLIa XLIb XLII

FIG. 22.—POSSIBLE DISPOSITIONS OF CYANIDE RADICALS

This view, due to Hantzsch and Werner (1890), is confirmed, (1) by the course in the two isomerides of an intra-molecular transformation brought about by acids (*Beckmann transformation*) in which one of the two groups *a* or *b* changes places with the hydroxyl group, for if *a* is thus transposed in the one modification then *b* is transposed in the other; and (2) by the optical activity of the cyclic oxime, demonstrated by Mills and Bain (1910), since the molecule of this compound can only be dissymmetric if the nitrogen valencies do not lie in one plane.

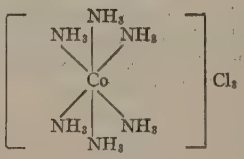
6-Covalent Elements.—Werner's proof that substances like the compounds of metallic salts with ammonia, formerly regarded as "molecular compounds," are co-ordination compounds in which a certain number of atoms or groups, most frequently six, are directly attached to the metallic atom ($CoCl_3{\cdot}6NH_3$, for example, having the constitution XLVI.) brought with it the problem of determining how these six groups are disposed about the central atom. If it is assumed that the valencies by which they are attached are inter-equivalent (and this is supported by the absence of the isomerism which should otherwise occur), three arrangements are possible: the plane hexagonal, the prismatic, and the octahedral (fig. 23).

A decision between these was obtained by investigating the compounds formed by linking the co-ordination positions together in pairs through 4-membered chains, as can be done, for example,

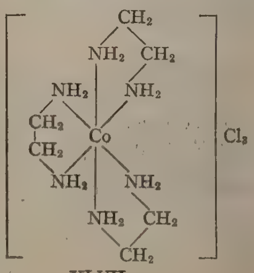


XLIII XLIVa XLIVb XLV

FIG. 23.—FOUR POSSIBLE CONFIGURATIONS OF 6-COVALENT ELEMENTS



XLVI



XLVII

by the three-fold replacement of two co-ordinated ammonia molecules by one of ethylenediamine (or of two nitrito-groups by an oxalato-group), so as to produce a complex in which the metallic atom forms a common member of three symmetrical 5-membered rings, XLVII. Since it is evident that only adjacent co-ordination positions can be bridged in this way, the possible configurations for the tricyclic complex are those indicated by the dotted lines in the four different diagrams which are given in fig. 23, and of these the three first are evidently symmetrical and only the last is dissymmetrical, for it possesses only a (trigonal) axis of symmetry. Experimental investigation of the salts of these tricyclic ions has shown that they can be produced in optically active forms. The ions are thus dissymmetric and must consequently have the last configuration. It is therefore to be concluded that in such compounds the six covalencies of the central metallic atom are octahedrally disposed.

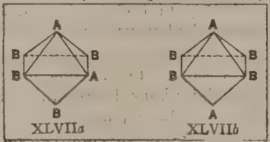
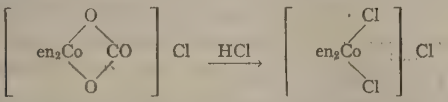


FIG. 24.—OCTAHEDRAL ISOMERS (A) CIS- AND (B) TRANS-

This conclusion is confirmed by the phenomena of geometrical isomerism shown by complexes of the type [MA_2B_4], such as are contained in the diacidotetrammine salts of cobalt and chromium. These compounds should exist in three isomeric forms if their configuration is hexagonal or prismatic, but in two only if it is octahedral, the alternative arrangements then being those in which the two groups A lie at the ends, (1) of an edge (*cis*-compound), and (2) of a diagonal (*trans*-compound) of the octahedron, and the number of isomers actually found is two. Moreover, in dicyclic derivatives of this type like [en_2CoCl_2]Cl ($en = NH_2{\cdot}CH_2{\cdot}CH_2{\cdot}NH_2$), that isomer for which the *cis*-configuration is indicated by its formation from a tricyclic compound



can be obtained optically active, whilst the other, the *trans*-isomer, cannot be resolved in accordance with the following tridimensional formulae, fig. 25, which show the symmetry, on the octahedral representation, of the *trans*- and the dissymmetry of the *cis*-form.

The general result of the stereochemical investigation of the elements has thus been to show that as a rule the valencies of an atom are disposed in space as symmetrically as possible, so that, for example, a 4-covalent atom has the four directly attached atoms arranged tetrahedrally about it, and the six atoms linked to a 6-covalent atom are grouped round it octahedrally; but it has also shown that there are well-marked exceptions to this rule, the most notable being the probable square arrangement of the four groups about 4-covalent platinum and the non-planar disposition of the valencies of 3-covalent sulphur. (W. H. Mi.)

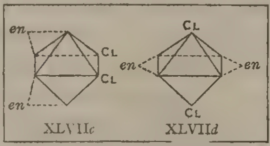


FIG. 25.—CIS- AND TRANS- CONFIGURATIONS OF DICYCLIC DERIVATIVES

Bibliography.—F. A. Kekulé, *Lehrbuch der organischen Chemie*, 4 vols. (1861–87); J. H. van't Hoff, *La Chimie dans l'Espace* (1875), trans. A. Eiloart, *Arrangement of Atoms in Space* (1877); A. Werner, *Lehrbuch der Stereochemie* (1904); A. Hantzsch, *Grundriss der Stereochemie* (1904); A. W. Stewart, *Stereochemistry* (1907); F. M. Jaeger, *Lectures on the Principle of Symmetry* (1917).

STEREOCOMPARATOR, an instrument for comparing two astronomical photographs of the same star-field, commonly combined with a Blink-microscope (*q.v.*).

STEREOPHOTOGRAMMETRY. In the earliest applications of photography to surveying, use was made of various simple graphical constructions or calculations in order to determine bearings and angles of elevation or depression from the camera station. In order to simplify these constructions or calculations, the photograph was usually exposed in a vertical plane. Two photographs, taken from the ends of a known base and treated in this manner, thus enabled a complete survey to be made of all visible ground in the area common to the pair. The necessity for avoiding acute graphical intersections in the fixing of points usually meant a long base, with a resulting difficulty in the identification of corresponding features in the two widely dissimilar views. The next step was consequently to return to a comparatively short base and at the same time to eliminate the indetermination of acute graphical intersection by the parallactic measurement of distances.

The Stereocomparator.—The first practical application of this method appears to have been in the stereocomparator of Tourcade in 1900. The two photographs were taken in the same vertical plane, although not necessarily at the same height, and were of course placed in the same plane in the comparator. Bearings and elevations were still calculated from the photo-co-ordinates of points on one of the pictures, while the distances from the base were calculated from a stereoscopic measure of parallax. The latter was effected by a lateral shift of one plate relative to the other, until the stereoscopically reconstructed image of the setting feature appeared to lie at the same distance from the observer as the fused image of a pair of floating marks contained in the eye-pieces of a binocular microscope used for the examination of the plates.

The stereocomparator has had an extensive application in the past, and is even now directly applied in one modern method of survey from vertical air photographs. From the practical point of view, however, its initial use suffered from two serious drawbacks, in that it required the computation of space co-ordinates from independent measurements, and that it implied a system of point by point plotting. (See also Binocular Instrument: *The Stereoscope*.)

The Thompson Stereoplotter.—The first of these disadvantages was overcome in the 1908 model of the Thompson stereoplotter, which may consequently be considered as the first example of the true plotting machine. It employed the stereocomparator principle without modification, but by the addition of a lever system.

The Stereoautograph.—The disadvantage of point by point plotting remained in the Thompson machine and was overcome by the von Orel stereoautograph of 1909–11. It is interesting to note, however, that Thompson in 1908 had in view the construction of an automatic machine called the "stereoplanigraph." This would no doubt have been on the same general lines as the stereoautograph had it reached maturity. The stereocomparator is again used in the von Orel machine, but the plotting system is based on intersections from the ends of the base rather than on an explicit measure of distances. Reduced to its lowest terms, it consists of two azimuth levers which are coupled to the lateral shift of the two plates. This simple arrangement would, however, introduce mechanical difficulties in the carriage of a drawing pencil at the variable intersection of the two levers, and in the necessity for shifting the pivots of these levers in accordance with variations in base length.

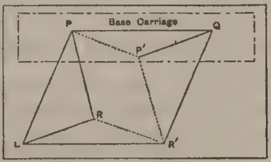


FIG. 1

Suppose, in the first alternative, that LP, RP (fig. 1) were the azimuth levers; P being the plotted point and LR the base. Then if any two parallelograms LPQR′, RPP′R′ are drawn on the rays LP, RP with a common corner at R′, it is clear that P′Q will be equal in magnitude and direction to the base LR, and that LP, R′P′ will still represent the true directions of the azimuth levers. Consequently L, R′ may represent two *fixed* pivots of the azimuth levers, if the base QP′ is set inwards in magnitude and direction from a length PQ equal and parallel to LR′. Moreover the base carriage PP′Q may be moved anywhere parallel to itself by alteration in the lengths and directions of the azimuth levers LP, R′P′. The point P will always represent the position of the plotted point relative to L as left hand camera station. Similarly, P′ will always represent the position of the plotted point relative to R′ as right-hand camera station. Lastly, the actual drawing pencil will trace a similar plot if it is placed in any fixed position relative to P or P′. It may consequently be rigidly attached anywhere to the base carriage. This simple principle, due originally to von Orel, is sometimes known as the *zeiss parallelogram,* and has been elaborated into several different types. These different types, which find an application in the later plotting machines, are all comprised in the fact that any or all of the three co-ordinates of one end of the base relative to the other end may be set at any of the corners of the initial parallelogram LPQR′—a statement which is evident from the simplest geometrical considerations.

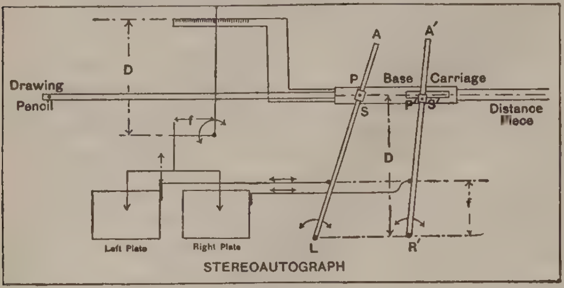


FIG. 2

A diagram of the action of the stereoautograph is given in fig. 2. The azimuth control shifts the carriage of *both* plates, and consequently rotates the two azimuth levers AA′ by an equivalent amount. These levers slide in sleeves SS′ attached to pivots on the base carriage, which is thus moved freely along the distance piece. The sleeve pivots, PP′ correspond to the points PP′ of fig. 1, the base setting being effected on the pivot P′. The distance control moves the distance piece bodily, and parallel to itself, towards or away from the line of pivots LR′ of the azimuth levers. In consequence, the base carriage slides down the left azimuth arm, rotating the right azimuth arm in the process and thus shifting the right-hand plate relative to the left on an upper slide. The parallactic separation of corresponding points is thus altered, so that the floating marks appear successively in stereoscopic coincidence with points whose distance from the base corresponds to the setting of the distance piece. This is of course the unmodified principle of the stereocomparator. The height system is essentially the same as in the Thompson machine, the height scale being carried on an extension of the distance piece.

By combining the movements of the three controls, the apparent movements of the floating mark can be made to follow along the detail of the reconstructed stereoscopic image, the plan of which is thus drawn automatically by a pencil attached to the base carriage. By clamping the height lever to the distance piece, the machine loses a degree of freedom. If then the distance and azimuth controls are moved so that the floating mark still appears to travel along the surface of the ground, the pencil will trace the contour corresponding to the height at which the height lever is clamped.

The stereoautograph is capable of fast automatic plotting, provided that the plates are exposed in the *same vertical plane.* The whole principle of the stereocomparator as a means of determining horizontal distances from a measure of simple parallax otherwise breaks down. Moreover, if the plates are inclined, vertical lines in nature will no longer appear parallel on the photograph, but will converge to the plumb point as vanishing point. The system of plotting azimuths in these early machines, however, obviously requires the image of vertical lines to be parallel, in order that the horizontal distances between points on the plate may be independent of the heights of such points.

Before long, it became essential on the score of accuracy, convenience and economy to expose inclined plates on converging orientations. Even in mountainous country, where photographic survey had hitherto found its exclusive application, it was often desirable to site the cameras on high ground in order to minimize the extent of dead ground not covered stereoscopically. The camera axes had consequently to be depressed in order to include as wide a field as possible. With the World War period of improvements in photography from the air, it became economically possible to survey *flat* country photographically, with the corresponding necessity for exposing horizontal rather than vertical plates. Further, in the case of air photographs, it is as yet impossible so to stabilize the camera or the aeroplane as to ensure that the two plates are exposed in the same plane at all, at any rate to the degree of precision attainable by deliberate exposure on the ground.

It may in fact be assumed that any type of country can be surveyed photographically provided that, in order to secure the best results, it can be photographed on a plate parallel to its mean slope. Precipitous mountain slopes require vertical, and dead flat plains horizontal plates. Between these two extremes there will be a particular tilt for the most efficient survey of a particular type of country, and a corresponding height of station in order to secure the necessary photographic field. The development of air photography has allowed this ideal to be approached, with the consequent demand for a plotting machine with a "universal" range in permissible orientations in space of the camera axes.

The stereoautograph can, as a geometrical proposition, be adapted by certain variations in its plotting mechanism to deal with inclined or converging photographs. *See* O. von Gruber, "Der von Orel-Zeiss'sche Stereoautograph mit Zusatzeinrichtung zur Ausarbeitung von Luftaufnahmen," in *Internationales Archiv für Photogrammetrie* (Vienna, 1923); but a different base setting is in general necessary for each contour. Moreover, corresponding points on the two photographs will, generally speaking, no longer lie at the same distance from the eye base when the photographs are placed in the same plane in the comparator, by reason of the perspective distortion due to tilt. A restricted range in tilt can in these circumstances be tolerated by the eyes without a breakdown of stereoscopic fusion, but the process cannot be continued indefinitely, even if a complicated transverse shift of the plates were introduced.

The Photogoniometer.—Attempts were accordingly next made to extend the range of plotting machines by the incorporation of the Porro-Koppe photogoniometer, which uses a theodolite to measure horizontal and vertical angles from a photograph. The photograph is mounted in the plate carrier in relation to a photographic objective, which is in all respects similar to the camera objective, so that the internal perspective conditions are reproduced correctly. This implies two transverse adjustments in the plane of the photograph and a fine focussing rack as the first essentials in design. The external perspective conditions are then re-established by tilting the whole camera body similarly to the field camera at exposure. This implies the possibility of tilting about a horizontal axis in order to set for the magnitude of tilt, and of rotating the photograph in its own plane about the plate perpendicular in order to set for the direction of tilt. Horizontal and vertical angles as from the camera station may then be measured by means of a theodolite whose horizontal and vertical axes are arranged to intersect in or near the centre of the exit pupil of the objective.

Where the photogoniometer is employed as an auxiliary in a plotting machine, rotation in azimuth is usually given to the camera body, while rotation in altitude only is furnished by the telescope of the theodolite. In this form the photogoniometer is mechanically unsuitable for photographs whose axes are vertical or tilted less than about 45° from the vertical; *i.e.,* for the majority of air photographs. Where the instrument is used independently, however, there is no need to accept this limitation. Both altitude and azimuth rotations may, for instance, be imparted to the telescope, leaving the camera body adjustable for tilt only; or, in order to avoid moving the eye into impossible positions where the camera axis approaches the vertical, the altitude movement may be furnished by the rotation of a prism in front of the telescope objective.

Intersection Photogoniometric Machines.—The first plotting machine to employ the photogoniometer principle was the

Hugershoff *autocartograph*, the photographs being observed through the goniometer lenses by a binocular telescope. The autocartograph is designed for high obliques, and there is difficulty in dealing with vertical (axis) air photographs, or indeed with any photographs where the camera axis is tilted less than about 45° from the vertical. This is a direct consequence of the design of the photogoniometers, as mentioned above. Moreover the azimuth levers would need to be capable of all round rotation, and the von Orel plotting system is clearly unsuited to this possibility. It is true that the height and distance controls of the auxiliary drum plot can be interchanged, with the result that an elevation instead of a plan can be drawn on the drum. Consequently, if a pair of vertical (axis) photographs are placed in the position of horizontal (axis) photographs in the goniometers, it is possible to draw a direct plan from them on the drum.

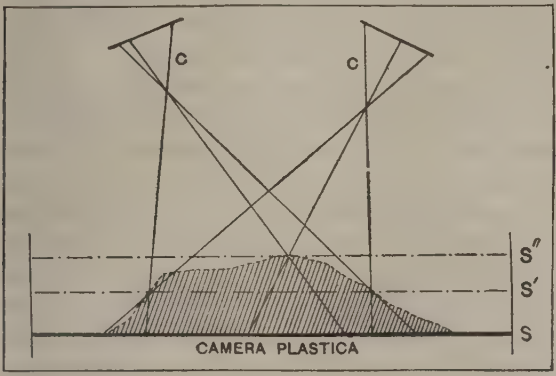


FIG. 3

The Camera Plastica.—Concurrently with the intersection photogoniometric type, various efforts have been made to develop machines to deal primarily with air photographs on the principle of the *camera plastica*. The latter, usually attributed to Scheimpflug, is shown diagrammatically in fig. 3. Two projection cameras CC are set in the same relation to one another in the scale of the plot as the two positions of the air camera at exposure, and throw real images on a movable screen S representing the ground plane of reference. It is clear that if the screen is moved bodily towards the projection cameras (to S′ or S″) until the coincidence of corresponding images is obtained, this coincident image will represent the true plan position of the point considered, the position of the screen at the same time affording a measure of heights. Coincidence may be estimated by a flicker system which enables the two images to be thrown on the screen alternately in rapid succession, or a stereoscopic image in anaglyphic relief may be obtained by projecting in two colours and viewing through filters of the same colours. In the latter case plotting may be effected according to the movements of a real floating mark in the plane of the screen, the depth movement being effected by bodily translation of the screen towards the projection cameras.

Many applications of this principle have appeared on the market, the best known being perhaps the Nistri *photocartograph*. In this case the two projection cameras are set by trial on control point screens. In order to preserve true perspective conditions the projection lenses are set at the principal distance of the air camera from the photographs, and must consequently be of shorter focus in order to form sharp images on the screen. Coincidence plotting is effected on the flicker system, the movements of a steel pointer over the screen being copied by a pantograph.

The inception of this type of machine was no doubt due to the fact that the whole photograph is seen at once, and that in consequence the systematic trial setting of air photographs on control points is much easier. Up to the present no fully economic method of determining independently the plate constants of the air photograph has been discovered, and the computed or trial setting of photogoniometric machines is apt to be protracted. On the other hand the camera plastica type depends on depth of focus on the plotting screen, and the introduction of considerable tilts and variations in relief is apt to strain this factor beyond its limits of endurance, particularly as the use of a small stop is for various reasons undesirable. With automatic focussing devices and the use of rectified photographs, the range of the camera plastica might possibly be extended.

The Zeiss Stereoplanigraph.—This difficulty of preserving focus during movements of the plotting plane has been successfully overcome in the Zeiss stereoplanigraph which works on the same general principle as the camera plastica, by the introduction of an auxiliary tele-objective of variable focus. In this machine two projection cameras are fixed on a cross slide, the internal and external perspective conditions at exposure being reproduced by setting in exactly the same way as for the photogoniometers of the autocartograph. The rear nodes of the projection camera objectives form a Zeiss parallelogram with the two floating marks, any of the corners of which are thus available for setting the magnitude and direction of the base. Actually the projected length of the base is set inwards on the floating marks, while the remaining two co-ordinates defining the orientation of the base in space are set one on each of the camera units. The object of this arrangement is to provide room for the two camera units without an excessive increase in their distance from the floating marks (this being one of the disadvantages of the simple camera plastica), and at the same time to avoid superimposing the two images on a single floating mark, with the consequent necessity for visual separation by colour filters.

The distance and height plotting movements are operative on the cross slide carrying the two camera units, while the direction movement is effected by a lateral shift of the two floating marks together in the direction of the line joining them. The distance and direction, or alternatively height and direction, plotting movements are coupled through gearing to a drawing pencil. This possibility of interchanging the distance and height controls enables direct plotting to be carried out either in plan or in elevation, so that it is possible to deal equally well with horizontal, vertical, or intermediately tilted photographs. In order to preserve focus on the plane of the floating marks, an auxiliary lens system, consisting of bi-convex and bi-concave lenses of equal power, is supported in front of the camera objective, the rear node of the combination coinciding approximately with the rear node of the camera objective. The combination is universally jointed on its rear node and is oriented so that its axis always passes through the floating mark, by means of the taper guide rods.

The visual system is a complicated form of stereoscopic comparator, the object of which is to observe the stereoscopic coincidence of the floating marks with various objects in the landscape during plotting. It thus corresponds essentially to the anaglyph filters of a simple camera plastica. If the original negatives are placed in the projection cameras, a reconstructed space image as in nature is formed near the plane of the floating marks, since the auxiliary lens system introduces no inversion. Since this is viewed in reverse it is necessary to cross the eyepieces of the visual system in order to avoid pseudoscopy. (*See* BINOCULAR INSTRUMENTS; MICROSCOPE.) The eyepieces must for the sake of convenience remain immovable, while the floating marks travel on the direction plotting movement. This is effected by the introduction of scissor-jointed link prisms, which also serve to facilitate the crossing of the eyepieces. Lastly the line of collimation of the instrument must be universally jointed at the floating marks, in order that the movable part between the floating mark and the rear node of the auxiliary lens system may be deflected in a constant direction into the visual system. This is done by means of an optical Cardan link actuated by the taper guide rods. "Leaning" of the image introduced by rotation about the two Cardan axes is, as usual, corrected by the differential rotation of a Dove prism.

The Wild Autograph.—The latest complete example of stereophotogrammetric plotting machinery is the Wild "autograph," in which will be recognized the autocartograph and stereoplanigraph characteristics. The projection cameras are rotatable about horizontal and vertical axes. They are connected to guide rods, which can slide in sleeves attached to universal joints at the ends of the base slide. The centres of these latter joints form a Zeiss parallelogram with the centres of rotation of the projection cameras; the base setting being effected entirely on the two former corners of the parallelogram.

All the three plotting movements act on the base slide B, and are geared to a drawing pencil in exactly the same way as in the stereoplanigraph. Sympathetic movements of the projection cameras follow by reason of their connection to the base slide through the guide rods. In addition the direction plotting movement is shared by two prisms of the visual system rigidly mounted on the vertical axis of the projection cameras. Any tilts may be dealt with by an appropriate initial setting of these prisms or by tilting the whole visual system, and by an interchange of axes as in the stereoplanigraph.

Owing mainly to the absence of heavy moving parts the result is a light, compact machine. This very considerable advantage is however offset by further complication, since, in order to correct the effect of the above plotting movements, it is necessary to introduce a variable rotation of the plates in their own plane; *i.e.,* a rotation which must be varied for each particular tilt of the camera axes at exposure. This variable rotation, which is effected by a system of variable cams, is however entirely automatic, and requires no attention from the observer after the initial setting. There is little in it to go wrong or to require re-adjustment. A practical disadvantage of the machine for air work might lie in the necessity for computing the *relative* orientations of the camera axes in space before the machine can be set. In the case of ground surveys with the Wild phototheodolite, only a few combinations are necessary or possible, and the calculations can be done once and for all.

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STEREOSCOPE. An optical instrument used for obtaining from two slightly different pictures (*i.e.,* pictures or photographs of the same object but from a slightly different point of view), the impression of a single picture in relief. *See* Binocular Instrument.

STEREOSCOPIC VISION: *see* Vision.

STEREOTYPING. A process of producing duplicate printing plates from a form of type or blocks by pouring molten metal on a matrix made in plaster of paris or papier-mâché. (*See* Printing.)

STERILITY, the inability to beget living offspring, may be the result of any of the following causes.

Absence of sexual intercourse due to the lack of appropriate psychological stimuli leading to coition. This is one factor in the mutual sterility of different species. (*See* Hybridism.)

Absence or incompleteness of coition due to gross abnormality of the external or internal organs of reproduction. Hermaphroditism (*see* article, Sex); occlusion of the ducts which convey the gametes from the sex-gland to the site of fertilisation, either congenital or acquired through disease; imperforate hymen and other structural abnormalities fall into this group. The chemical condition of the female passages may be such as to kill the entering spermatozoa.

Infecundity.—The inability to produce functional gametes is found in many hybrids (*see* Hybridism) and in certain intersexual forms. In such mammals in which the testes lie normally within a scrotum, the testis if retained within the abdominal cavity does not produce functional spermatozoa. Infecundity may follow upon exposure to X-rays, for these destroy that tissue of the sex-gland which is concerned with the elaboration of the gametes.

Mutual repugnance on the part of the gametes resulting in non-fertilisation. Though as yet nothing very definite is known of the physico-chemical requirements of fertilisation there is a considerable body of evidence to show that an attraction between the male and female gametes must exist if fertilisation is to occur.

Abnormalities in the fertilised egg which embarrass or prevent cleavage and development bringing these processes to a stop at some stage, death of the individual thereupon resulting. This is the fate of many hybrid embryos. (*See* Hybridism.) Lethal factors (*see* Genetics and Sex) also operate in this fashion.

Abnormalities in the medium in which the fertilised eggs find themselves which prevent or embarrass development. The exact constitution of the sea-water in terms of alkalinity, for example, determines whether or not the fertilised ova of marine organisms shall begin and continue their development. Pathological conditions within the uterus of the mammalian female can prevent proper implantation of the descending egg.

Disharmonies between the developing offspring and the maternal environment can lead to difficult labour and death of either or of both mother and young. For example the male cattle×bison hybrid has a prominent crest and this cannot be accommodated by the maternal passages of the cow. Such male hybrids therefore usually are still-born. Contracted pelvis and similar abnormalities of the female birth-canal are common causes of death of both infant and mother. The general well-being of the mother is necessary for the normal development of the infant she bears.

In the case of the human subject there are certain conditions which are essential to fertility. Healthy spermatozoa must be received into a healthy vagina with a normal cervix, uterus, tubes and ovaries. An examination of any case of sterility must therefore begin with an examination of the male. It is estimated that in 25 per cent of childless marriages the man is at fault.

Experimentation with laboratory animals has shown that infecundity may result from deficiency of the reproductive vitamin *E* (Mason, 1925).

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STERLING, JOHN (1806–1844), British author, was born at Kames Castle in Bute on July 20, 1806. He belonged to a family of Scottish origin which had settled in Ireland during the Cromwellian period. He was the son of Edward Sterling (1773–1847), who was for many years a leader-writer on *The Times.* John Sterling was educated at Glasgow university and at Trinity college and Trinity Hall, Cambridge. At Cambridge he was a member of the famous "Apostles'" Club. With F. D. Maurice he purchased the *Athenaeum* in 1828 from J. Silk Buckingham, which was not a success. In 1834 he was ordained and became curate at Hurstmonceaux, where his old tutor Julius Hare was vicar. Acting on the advice of his physician he resigned his curacy in 1835, but, according to Carlyle, the primary cause was a divergence from the opinions of the Church. He died at Ventnor on Sept. 18, 1844. Sterling owes his fame to the vivid *Life* by Carlyle, to whom, with Hare, his papers were entrusted.

STERLING, a term used to denote money of standard weight or quality, especially applied to the English gold sovereign, and hence with the general meaning of recognized worth or authority, genuine, of approved excellence. The word has been generally derived from the name of "Easterlings" given to the North German merchants who came to England in the reign of Edward I. and formed a *hansa* or gild in London, modelled on the earlier one of the merchants of Cologne. Their coins were of uniform weight and excellence (*cf.* Matthew Paris, ann. 1247, *moneta esterlingorum, propter sui materiem desiderabilem,* etc., "money of the *esterlingi,* for its desirable materiel," etc.), and thus it is supposed gave the name of the moneyers to a coinage of recognized fineness. This theory is based on the statement of Walter de Pinchbeck, a monk of the time of Edward I. (quoted in Wedgwood, *Dict. of Eng. Etym.*). The word, however, occurs much earlier. The *Roman de Rou* (1180) has "Pour ses estellins recevoir," and "in Anglia unus Sterlingus per solvetur" occurs in an ordinance of Philip of France and Henry II. of England of 1184, both quoted in Du Cange (*Gloss.*, *s.v.* Esterlingus). The "sterling" was a coin, the silver penny, 240 of which went to the "pound sterling" of silver of 5,760 grains, 925 fine, and described in a statute of Edward I., quoted in Du Cange, as "denarius Angliae qui vocatur sterlingus (the English penny, which is called Sterling)." The word was borrowed by most European languages and is there applied to English money.

STERLING, a city of Colorado, U.S.A., 140 m. N.E. of Denver, on the South Platte river and Federal highways 38 and 138, served by the Burlington Route and the Union Pacific railway systems; the county-seat of Logan county. The population was 6,415 in 1920 (87% native white) and was estimated locally at 9,000 in 1928. The city was founded in 1878 and incorporated in 1883. In 1900 the population was 998.

STERLING, a city of Whiteside county, Illinois, U.S.A., on the north bank of Rock river, 110 m. W. of Chicago. It is on the Lincoln highway and the Hennepin canal feeder, and is served by the Burlington Route and the Chicago and North-western railways, and by motor bus lines in all directions. Pop. 8,182 in 1920 (91% native white) and was estimated locally at over 10,000 in 1928. Rock Falls (pop. 2,927 in 1920) is just across the river. The cities have abundant water-power and large manufacturing industries, making agricultural implements. Sterling was chartered as a city in 1857.

STERN, DANIEL: *see* AGOULT, MARIE CATHERINE SOPHIE DE FLAVIGNY.

STERNE, LAURENCE (1713–1768), English humorist, was the son of Roger Sterne, an English officer, and great-grandson of an archbishop of York. He was born at Clonmel, Ireland, on Nov. 24, 1713, a few days after the arrival of his father's regiment from Dunkirk. For ten years the boy and his mother moved from place to place after the regiment, from England to Ireland, and from one part of Ireland to another. Sterne's early knowledge of garrison life enabled him to draw the portraits of Uncle Toby and Corporal Trim. He was fixed for eight or nine years at a school at Halifax in Yorkshire. His father died when he was in his eighteenth year. He was sent to Jesus College, Cambridge, where he took his degree in 1736. Through the influence of his uncle, precentor and canon of York, he obtained (1738) the living of Sutton-in-the-Forest, near York. Two years after his marriage in 1741 to Elizabeth Lumley he was presented to the neighbouring living of Stillington, and did duty at both places. He was also a prebendary of York Cathedral.

Sutton was Sterne's residence for twenty uneventful years. He kept up an intimacy which had begun at Cambridge with John Hall-Stevenson (1718–1785), a witty and accomplished epicurean, owner of Skelton Hall ("Crazy Castle") in the Cleveland district of Yorkshire. Stevenson's various occasional sallies in verse and prose—his *Fables for Grown Gentlemen* (1761–1770), and his *Crazy Tales* (1762), bear a resemblance in spirit and turn of thought to Sterne's work, inferior as they are in literary genius. In 1759 Sterne wrote a skit on a quarrel between Dean Fountayne and Dr. Topham, a York lawyer, over the bestowal of an office in the gift of the archbishop. This sketch, in which Topham figures as Trim the sexton, and the author as Lorry Slim, gives an earnest of Sterne's powers as a humorist. It was not published until after his death, when it appeared in 1769 under the title of *A Political Romance*, and afterwards the *History of a Warm Watch-Coat*. The first two volumes of *Tristram Shandy* were issued at York in 1759 and advertised in London on Jan. 1, 1760, and at once made a sensation.

For the last eight years of his life after this sudden leap out of obscurity we have a faithful record of Sterne's feelings and movements in letters to various persons, published in 1775 by his only child, Lydia Sterne de Medalle, and in the *Letters from Yorick to Eliza* (1766–1767), also published in 1775. At the end of the sermon in *Tristram* he had intimated that, if this sample of Yorick's pulpit eloquence was liked, "there are now in the possession of the Shandy family as many as will make a handsome volume, at the world's service, and much good may they do it." Accordingly, when a second edition of the first instalment of *Tristram* was called for in three months, two volumes of *Sermons* by Yorick were announced. Although they had little or none of the eccentricity of the history, they proved almost as popular.

Sterne's clerical character was far from being universally injured by his indecorous freaks as a humorist: Lord Fauconberg presented the author of *Tristram Shandy* with the perpetual curacy of Coxwold. To this new residence he went in high spirits with his success, "fully determined to write as hard as could be," seeing no reason why he should not give the public two volumes of Shandyism every year and why this should not go on for forty years. Vols. iii. and iv. appeared in 1761; vols. v. and vi. in January 1762. But he was ordered to the south of France; and he came back after two and a half years very little stronger. He was overjoyed with his reception in Paris. He continued to build up his history of the Shandy family, but the work did not progress as rapidly as it had done. The digressions became extensive. In vol. vii. the work is allowed to stand still while the writer is being transported from Shandy Hall to Languedoc. Vol. viii. begins the long-promised story of Uncle Toby's amours with the Widow Wadman. After seeing to the publication of this instalment of *Tristram* and of another set of sermons—more pronouncedly Shandean in their eccentricity—he quitted England again in the summer of 1765, and travelled in Italy as far as Naples. The ninth and last and shortest volume of *Tristram*, concluding Toby Shandy's amours, appeared in 1767.

This despatched, Sterne turned to a new project, *The Sentimental Journey through France and Italy*. Its plan admitted of any length that the author chose, but, after seeing the first two volumes through the press in the early months of 1768, Sterne's strength failed, and he died in his lodgings, 41 Old Bond Street, London, March 18, three weeks after the publication.

An excellent edition of Sterne's works, edited by Professor George Saintsbury, was issued in six volumes in 1894. *See* also J. J. Texte, *Rousseau et les origines du cosmopolitisme littéraire* (1895); Thayer, *Laurence Sterne in Germany* (1905); W. L. Cross, *The Life and Times of Laurence Sterne* (2 vols. 1909, new ed. New Haven, 1925); Walter Sichel, *Sterne: a Study* (1910); L. Melville, *Life and Letters of Laurence Sterne* (2 vols. 1911); G. Rabizzani, *Sterne in Italia* (1920).

STESICHORUS (*c.* 640–555 B.C.), Greek lyric poet, a native of Himera in Sicily, or of Mataurus a Locrian colony in the south of Italy. The story of his being struck blind for slandering Helen and recovering his sight when he recanted is told by Plato among others. We possess about thirty fragments of his poems, none of them longer than six lines. They are written in the Doric dialect, with epic licences; the metre is dactylico-trochaic. Brief as they are, they show us what Longinus meant by calling Stesichorus "most like Homer"; they are full of epic grandeur, and have a stately sublimity that reminds us of Pindar. This use of lyric for heroic subjects is what Quintilian (*Instit.* x. 1, 62) means by saying that he "sustained the burden of epic poetry with the lyre." Several of his poems sung of the adventures of Heracles; one dealt with the siege of Thebes, another with the sack of Troy. The last is interesting as being the first poem containing that form of the story of Aeneas's flight to which Virgil afterwards gave currency in his *Aeneid*. The popular legends of Sicily also inspired his muse; he was the first to introduce the shepherd Daphnis who came to a miserable end after he had proved faithless to the nymph who loved him. Stesichorus completed the form of the ode by adding the epode to the strophe and antistrophe.

Fragments in T. Bergk, *Poetae lyrici graeci*, iii.

STETHOSCOPE, a medical instrument used in auscultation (*q.v.*). The single stethoscope is a straight wooden or metal tube with a small flattened bell, the surface of which is usually covered with ivory or bone at the end, which is placed against the body of the patient, and a large flat disc at the other end, for application to the ear of the observer. In the "binaural" stethoscope, which has the advantage of flexibility, the tube is divided above the bell into two flexible tubes which lead to both ears.

STETTIN, a seaport, capital of the Prussian province of Pomerania, on the Oder, 17 m. above its entrance into the Stettiner Haff, 30 m. from the Baltic, 84 m. N.E. of Berlin by rail, and at the junction of lines to Stargard-Danzig and Küstrin-

Breslau. Pop. (1925) 253,740. Stettin is said to have existed as a Wendish settlement in the 9th century, but its first authentic appearance in history was in the 12th century, when it was known as Stedyn. From the beginning of the 12th century to 1637 it was the residence of the dukes of Pomerania, one of whom gave it municipal rights in 1243. Already a leading centre of trade it entered the Hanseatic League in 1360. The Pomeranian dynasty became extinct in 1637, and in 1648 Stettin was ceded to Sweden. In 1678 it was taken from Sweden by Frederick William, elector of Brandenburg, but it was restored in 1679, only, however, to be ceded to Prussia in 1720 by the Peace of Stockholm. It was fortified more strongly by Frederick the Great. Stettin was the birthplace of the empress Catherine II. of Russia.

The main part of the town occupies a hilly site on the left bank of the river, and is connected with the suburbs of Lastadie ("lading place" from *lastadium*, "burden,") and Silberwiese, on an island formed by the Parnitz and the Danzig. Until 1874 Stettin was closely girdled by extensive and strong fortifications. The church of St. Peter, founded in 1124 and restored in 1816–17, has the distinction of being the oldest Christian church in Pomerania. Both this and the church of St. James, dating from the 14th century, are remarkable for their size. The old palace, now used as public offices, is a large but unattractive edifice. Two gateways, the Königstor and the Berliner Tor, remains of the old fortifications, are still standing.

Stettin, regarded as the port of Berlin, is one of the principal ship-building centres of Germany and a place of much commercial and industrial activity. There are six floating docks, and four ice breakers keep the port open in winter. A great impulse to its trade was given in 1898 by the opening of a free harbour adjoining the suburb of Lastadie on the east bank of the Oder; this embraces a total area of 137 acres. It has two basins, with the necessary accompaniment of cranes, storehouses, etc., and the Oder from Stettin to the Haff is 23 ft. deep.

STEUBEN, BARON VON, FREDERICK WILLIAM AUGUSTUS HENRY FERDINAND (1730–1794), German soldier, born at Magdeburg, Prussia, Nov. 15, 1730, was a descendant of a noble family, which for generations had produced soldiers. From his 14th year, Steuben led a soldier's life. Reared in the rigorous military school of Frederick the Great, he took part in many battles of the Seven Years' War, where he so distinguished himself as to attract the attention of King Frederick, who appointed him as his aide-de-camp (1762). After the close of the Seven Years' War, he resigned from the army and became grand-marshal at the court of the Prince of Hohenzollern-Hechingen, and, after a service of ten years, accepted a similar position at the court of the margrave of Baden. In 1777, his old friend the count of St. Germain, then the French minister of war, persuaded him to go to the assistance of the American colonists.

Steuben arrived at Portsmouth (N.H.), on Dec. 1, 1777, and offered his services to Congress as a volunteer. In March 1778 he began drilling the inexperienced soldiers at Valley Forge; and by May he was made inspector-general or drill-master. He trained the soldiers admirably, adapting Prussian military ideas to the needs of his pupils. Results of his work were shown in the next campaign, particularly at Monmouth, where he rallied the disordered, retreating troops of Gen. Charles Lee. His *Regulations for the Order and Discipline of the Troops of the United States* (1779) was of great value to the army. He was a member of the court-martial which tried Maj. John André in 1780, and after Gen. Horatio Gates's defeat at Camden was placed in command of the district of Virginia, with instructions "to collect, organize, discipline and expedite the recruits for the Southern Army."

In April 1781 he was superseded in command of Virginia by La Fayette, and later took part in the siege of Yorktown. Retiring from the service after the war, he passed the last years of his life at Steubenville (N.Y.), where he died on Nov. 28, 1794. New York, Virginia, Pennsylvania and New Jersey gave him grants of land for his services, and Congress passed a vote of thanks and gave him a gold-hilted sword in 1784, and later granted him a pension of $2,400.

See Frederick Kapp, *The Life of Frederick William von Steuben* (1859); and George W. Greene, *The German Element in the War of American Independence* (Cambridge, Mass., 1876); Francis Bowen, "Life of Baron Steuben" in J. Sparks's *Library of American Biography*, vol. viii., pp. 119–202 (1902); Rudolf Cronan, "The Army of the American Revolution and its Organizer," *American Historical Review* vol. xxxi. pp. 455–458 (1923).

STEUBENVILLE, a city of eastern Ohio, U.S.A., on the Ohio river, 40 m. W. of Pittsburgh; the county seat of Jefferson county. It is served by the Pennsylvania, the Wheeling and Lake Erie, and electric railways, motor-bus and truck lines, and river packets and barges. Two highway bridges span the Ohio. Pop. (1920), 28,508 (20% foreign-born white); 1928 local estimate, 37,500. The city lies on a plain 700 ft. above sea-level, surrounded by hills rising 300–500 ft. higher, in a beautiful and fertile region containing rich deposits of coal, oil, gas, clay and building-stone. The coal-mines of the county had an output of 5,154,753 tons in 1926. There are two power plants generating 600,000 h.p. of electrical energy at the mines. The manufacturing industries are large and varied, including iron, steel, paper, glass and clay works, and the aggregate output in 1927 was valued at $61,500,000. Bank clearings in 1927 amounted to $135,845,732. Steubenville was planned in 1797, immediately after the erection of the county, on the site of Ft. Steuben (built 1786 and named after Baron von Steuben). It was chartered as a city in 1851.

STEVENAGE, an urban district of Hertfordshire, England, 28½ m. N. of London by the L.N.E. railway. Pop. (1921) 5,038. The church of St. Nicholas, with a graceful tower and spire, is mainly Early English, but has Norman and later portions. There is a grammar school, founded in 1558.

STEVENS, ALFRED (1818–1875), British sculptor, was born at Blandford in Dorset on Jan. 28, 1818. He was the son of a house painter. In 1833 the rector of his parish sent him to Italy, where he spent nine years in study at Naples, Rome, Florence, Milan and Venice. He had never been at an English school. In 1841 Thorwaldsen employed him for a year in Rome. After this he left Italy for England, and in 1845 he obtained a tutorial position in the School of Design, London, which he held until 1847. In 1850 he became chief artist to a Sheffield firm of workers in bronze and metal. In 1852 he returned to London. To this period belongs his design for the vases on the railings in front of the British Museum, and also the lions on the dwarf posts which were subsequently transferred to the inside of the museum. In 1856 Stevens agreed to execute the Wellington monument for St. Paul's Cathedral for the sum of £20,000.

Stevens died in London on May 1, 1875.

See SCULPTURE: *British;* Sir William Armstrong, *Alfred Stevens* (1881); H. Stannus, *Alfred Stevens* (1891).

STEVENS, ALFRED (1828–1906), Belgian painter, was born in Brussels on May 11, 1828. His father, an officer in the service of William I., king of the Netherlands, encouraged his son's talent and sent him to draw in the studio of François Navez, director of the Brussels Academy. In 1844 Stevens went to Paris and worked under Camille Roqueplan, a friend of his father's; he also attended the classes at the École des Beaux Arts, where Ingres was then professor. In 1849 he settled in Paris, where he exhibited in the Salons. In 1855 he exhibited at the Antwerp Salon a little picture called "At Home," which showed his genius for depicting ladies of fashion. Henceforth he concentrated on graceful female subjects. At the Historical Exhibition of Belgian Art, Brussels, 1880, he exhibited "The Four Seasons" (in the Palace at Brussels), "The Parisian Sphinx," "The Japanese Mask," "The Japanese Robe," and "The Lady-bird" (Brussels Gallery). He died on Aug. 24, 1906.

See J. du Jardin, *L'Art flamand* (6 vols., 1896–1900); Camille Lemonnier, *Histoire des beaux arts en Belgique* (1882; 2nd ed., 1887).

STEVENS, HENRY (1819–1886), American bibliographer, was born in Barnet, Vt., on Aug. 24, 1819. He studied at Middlebury college, Vermont, and graduated at Yale in 1843, teaching to pay his way and for a time acting as a Government clerk. In this capacity he won the friendship of Col. Peter Force, who employed him to collect books, pamphlets and manuscripts for the American archives on his return to Yale and during his year at the Cambridge, Mass., law school. His commissions from Force and other collectors took him abroad, where he ransacked the European capitals for rare Americana for the Smithsonian Institution, the library of Congress, and such private buyers as John Carter Brown and James Lenox. At the suggestion of Sir Anthony Panizzi, the librarian of the British Museum, he also supplied that institution with many American books. He died at Hampstead, London, England, on Feb. 28, 1886.

Perhaps his most notable achievement was his redemption of the Franklin manuscripts, which were finally disposed of to the U.S. Government. He wrote: *Catalogue of the American Books in the Library of the British Museum* (1856); *Historical Nuggets, Bibliotheca Americana* (1862); *Historical and Geographical Notes on the Earliest Discoveries in America* (1869); *Benjamin Franklin's Life and Writings* (1881); *Recollections of Mr. James Lenox . . . and the Formation of His Library* (1886); and *Thomas Hariot* (1900); edited by his son, H. N. Stevens.

STEVENS, JOHN (1749–1838), American inventor, was born in New York City in 1749, graduated at Columbia university in 1768, subsequently studied law and was admitted to the New York bar in 1771. In 1776 he became a captain in the Revolutionary army, and later colonel of his own regiment. From 1777 to 1782 he served as treasurer of the State of New Jersey. In 1784 he built a home on what was then the Island of Hoboken, subsequently, when connected with the mainland, known as Stevens Point, where he resided for over half a century until his death March 6, 1838. He purchased the ferry to New York and much of the main New Jersey shore. Along the road leading to the ferry landing he began the development of the city of Hoboken.

The problem of safe and speedy transportation across the Hudson drew his interest early to the possibilities of steam navigation. In 1788 he built the first multitubular boiler on record for use in his marine engines. In a desire to protect this invention he petitioned Congress for a patent law, which he outlined, and which was passed as the Patent Law of 1790 the foundation of the present patent system. He was the first to apply the principle of screw propulsion to navigation, building in 1802 a steamboat with two underwater propellers of screw type in the stern which successfully crossed the Hudson several times and only failed because the inefficient boilers of that day could not generate enough power to make the screw device practical. He turned then toward the development of high pressure steam engines and boilers in which field he was a pioneer. But a few days after Fulton's successful trial of the "Clermont" Stevens launched the "Phoenix," the engine of which was built by Stevens himself, whereas that of the "Clermont" was imported from England. Fulton having received a monopoly grant of navigation rights on the Hudson, Stevens sent the "Phoenix" by sea to Philadelphia, the first voyage of a steamship on ocean waters. Stevens was also interested in railways, writing in 1812 a pamphlet entitled *Documents tending to prove the Superior Advantages of Railways and Steam Carriages over Canal Navigation.* On February 6, 1815, he obtained the first railway charter granted in America for a railway between the Delaware and Raritan rivers, but it was not until 1830 that he formed the Camden and Amboy Railway company, and 1832 that he completed the first railway across New Jersey, operated by his sons Robert L. Stevens (*q.v.*) and Edward A. Stevens.

See A. D. Turnbull, *John Stevens: An American Record* (1928).

STEVENS, ROBERT LIVINGSTON (1787–1856), American mechanical engineer, was born at New York City on Oct. 18, 1787, the son of John Stevens (*q.v.*) whose mechanical ability he inherited. Whereas the father spent most of his thought on the improvement of motive-power and machinery of steamboats, the son made many advances in construction, strengthening hulls, reducing weight, distributing strain and improving the lines to gain speed. He designed the false bow, which, when first introduced on the "New Philadelphia," enabled that steamer to break previous records and be the first of Hudson river steamers to go from Albany to New York during daylight. With this steamer and the "North America," the Stevens family inaugurated a day line on the Hudson. In 1822 he built the ferryboat "Hoboken" on modern lines and introduced the piled slip which directed the boat's entrance to the landing-place.

In 1830 he was made first president of the Camden and Amboy railway and went to England to inspect equipment already in use there. On the outward voyage he designed the "T" rail with a broad base, long known as the Stevens, or American rail, and now universally used. He contracted in England for 500 tons of such rails, the first made, and also placed an order with the Stephensons for a locomotive made according to his specifications. This was the famous "John Bull" which he brought to America on his return, and which is now in the Smithsonian Institution. He made many improvements on railway locomotives, introducing the pilot truck in 1832, the bogie truck shortly afterwards, and, finally, using eight instead of four or six wheels in order to promote adhesion to the rails and drawing power. When stone blocks could not be furnished fast enough for his road-bed he resorted to logs laid crosswise with broken stone and gravel between and discovered that he had found a bed more serviceable and comfortable than any known previously. He devised spikes "six inches long with heads" to hold the rails in place on the logs. As a recreation Stevens took up yachting, and in 1844 he designed the "Maria," for twenty years the swiftest yacht afloat. Later he designed the "America" for his brother, John Cox Stevens, who with it defeated all English challengers, and founded the America's Cup races. He died at Hoboken, New Jersey, April 20, 1856.

STEVENS, THADDEUS (1792–1868), American political leader, was born in Danville, Vt., on April 4, 1792. He graduated at Dartmouth college in 1814, removed to York, Pa., was admitted to the bar (in Maryland), and for 15 years practised at Gettysburg, Pa. He frequently appeared in behalf of fugitive slaves before the Pennsylvania courts. In 1840 he did much to bring about the election of W. H. Harrison, and in the campaign of 1844 Stevens again rendered marked services to the Whig ticket. He was a Whig representative in Congress in 1849–53, and was leader of the radical Whigs and Free-Soilers, strongly opposing the Compromise Measures of 1850, and being especially bitter in his denunciations of the Fugitive Slave law. In 1855 he took a prominent part in organizing the Republican party in Pennsylvania, and in 1856 was a delegate to the Republican national convention. He became chairman of the ways and means committee on July 4, 1861, and until his death was, as James G. Blaine said, "the natural leader who assumed his place by common consent." During the Civil War he was instrumental in having necessary revenue measures passed in behalf of the administration. He was not, however, in perfect harmony with Lincoln, who was far more conservative than Stevens. He introduced from the joint committee what became the Fourteenth Amendment, and also the Reconstruction Act of Feb. 6, 1867. He also advocated the Freedmen's Bureau bills and the Tenure of Office Act, and went beyond Congress in favouring the confiscation of the property of the Confederate States. He led Congress in the struggle with the President, and after the President's removal of Secretary of War Stanton he reported the impeachment resolution to the house and was chairman of the committee appointed to draft the articles of impeachment. He died at Washington, D.C., on Aug. 11, 1868, and was buried at Lancaster, Pa.

See S. W. McCall's *Thaddeus Stevens* (1899), in the American Statesmen Series, a sympathetic, but judicious biography; J. F. Rhodes, *History of the United States from the Compromise of 1850* (1904); W. U. Hensel, "Thaddeus Stevens as a Country Lawyer," *Green Bag*, vol. xviii. p. 641–656 (1906); James Albert Woodburn, "The Attitude of Thaddeus Stevens Toward the Conduct of the War," *American History Review*, vol. xii. p. 567–583 (1907); and James Albert Woodburn, *The Life of Thaddeus Stevens.*

STEVENSON, ROBERT (1772–1850), Scottish engineer, was the only son of Alan Stevenson, partner in a West Indian house in Glasgow, and was born in that city on June 8, 1772. He was educated at Anderson's College, Glasgow, and at Edinburgh University. He assisted his stepfather, Thomas Smith, in lighthouse schemes, and at nineteen was sent to superintend the erection of a lighthouse on the island of Little Cumbrae. Subsequently he succeeded Smith as engineer to the Commissioners of Northern Lighthouses, and from 1797 to 1843, he designed and built a large number of lighthouses, the most important being that on the Bell

Rock, begun in 1807. On his advice an admiralty survey was established, from which the admiralty sailing directions for the coasts of Great Britain and Ireland were prepared. Stevenson published an *Account of the Bell Rock Lighthouse* in 1824, contributed to the *Encyclopædia Britannica,* and wrote various papers read before learned societies. He died at Edinburgh on July 12, 1850.

STEVENSON, ROBERT LOUIS BALFOUR (1850–1894), British essayist, novelist and poet, was the only child of Thomas Stevenson, civil engineer, and his wife, Margaret Isabella Balfour. He was born at 8 Howard Place, Edinburgh, on Nov. 13, 1850. He suffered from infancy from great fragility of health, and nearly died in 1858 of gastric fever, which left much constitutional weakness behind it. He went to school, mainly in Edinburgh, from 1858 to 1867. As his health improved it was hoped that he would be able to adopt the family profession of civil engineering, and in 1868 he went to Anstruther and then to Wick as a pupil engineer. In 1871 he had so far advanced as to receive the silver medal of the Edinburgh Society of Arts for a paper suggesting improvements in lighthouse apparatus. His earliest publication, the anonymous pamphlet of *The Pentland Rising,* had appeared in 1866, and *The Charity Bazaar,* a trifle in which his future manner is happily displayed, in 1868. Though he greatly enjoyed the outdoor business of the engineer's life it strained his physical endurance too much, and in 1871 it was reluctantly exchanged for study at the Edinburgh bar, to which he was called in 1875. In 1873 he first met Sidney Colvin, who was to prove the closest of his friends and at last the loyal and admirable editor of his works and his correspondence.

He was now labouring, with extreme assiduity, to ground himself in the forms and habits of literary style. In 1875 appeared, anonymously, his *Appeal to the Clergy of the Church of Scotland,* and in that year he made the first of many visits to the forest of Fontainebleau. Meanwhile at Mentone in the winter of 1873–1874 he had grown in mind under the shadow of extreme physical weakness, and in the following spring began to contribute essays of high originality to one or two periodicals, of which the *Cornhill,* then edited by Leslie Stephen, was at first the most important. Stevenson made no attempt to practise at the bar, and the next years were spent in wanderings in France, Germany and Scotland. Records of these journeys were published as *An Inland Voyage* (1878), and as *Travels with a Donkey in the Cevennes* (1879). During these four years Stevenson's health, which was always bettered by life out of doors, gave him little trouble. At Fontainebleau in 1876 Stevenson had met Mrs. Osbourne, the lady who afterwards became his wife; she returned to her home in California in 1878, and in August of the following year, alarmed at news of her illness, Stevenson hurriedly crossed the Atlantic. He travelled, from lack of means, as a steerage passenger and then as an emigrant, and in December, after hardships which seriously affected his health, he arrived in San Francisco. In May 1880 he married, and moved to the desolate mining-camp which he has described in *The Silverado Squatters.* Some of his most poignant and most enchanting letters were written during this romantic period of his life. In the autumn of 1880 he returned to Scotland, with his wife and stepson, who were received at once into the Edinburgh household of his parents. But the condition of his health continued to be very alarming, and they went almost immediately to Davos, where he remained until the spring of 1881. In this year was published *Virginibus puerisque,* the earliest collection of Stevenson's essays. He spent the summer months in Scotland, writing articles, poems, and above all his first romance, *The Sea-Cook,* afterwards known as *Treasure Island;* but he was driven back to Davos in October. In 1882 appeared *Familiar Studies of Men and Books* and *New Arabian Nights.* His two winters at Davos had done him some good, but his summers in Scotland invariably undid the benefit. He therefore determined to reside wholly in the south of Europe, and in the autumn of 1882 he settled near Marseilles. This did not suit him, but from March 1883 to July 1884 he was at home at a charming house called La Solitude, above Hyères; this was in many ways to be the happiest station in the painful and hurrying pilgrimage of Stevenson's life. *The Silverado Squatters* was published in 1883, and also the more important *Treasure Island,* which made Stevenson for the first time a popular writer. He planned a vast amount of work, but his schemes were all frustrated in January 1884 by the most serious illness from which he had yet suffered. The attack was followed by long prostration and incapacity for work, and by continued relapses. In July he was brought back to England, and from this time until August 1887 Stevenson's home was at Bournemouth. In 1885 he published, after long indecision, his volume of poems, *A Child's Garden of Verses,* an inferior story, *The Body Snatcher,* and that admirable romance, *Prince Otto,* in which the peculiar quality of Stevenson's style was displayed at its highest. He also collaborated with W. E. Henley in some plays, *Beau Austin, Admiral Guinea* and *Robert Macaire.* Early in 1886 he struck the public taste with precision in his wild symbolic tale of *The Strange Case of Dr. Jekyll and Mr. Hyde.* In the summer of the same year he published *Kidnapped,* which had been written at Bournemouth.

Stevenson printed privately as a pamphlet, in June 1887, a brief and touching sketch of his father. In July he published his volume of lyrical poems called *Underwoods.* The ties which bound him to England were now severed, and he determined to remove to another hemisphere. He sailed from London, with his wife, mother and stepson, for New York on Aug. 17, 1887. He never set foot in Europe again. His memoir of his friend Professor Fleeming Jenkin was published soon after his departure. After resting at Newport, he went for the winter to be under the care of a physician at Saranac Lake in the Adirondacks. In this retreat he was very quiet, and steadily active with his pen, writing both the greater part of the *Master of Ballantrae* and many of his finest later essays. He had undertaken to contribute a monthly essay to *Scribner's Magazine,* and these essays, twelve in number, were published continuously throughout the year 1888. Early in that year was begun *The Wrong Box,* a farcical romance in which Mr. Lloyd Osbourne participated; Stevenson also began a romance about the Indian Mutiny, which he abandoned. His attitude about this time to life and experience is reflected in *Pulvis et umbra,* one of the noblest of all his essays. In April 1888 he was at the coast of New Jersey for some weeks, and in June started for San Francisco, where he had ordered a schooner, the "Casco," to be ready to receive him. On the 28th of the month, he started, as Mr. Colvin has said, "on what was only intended to be a pleasure excursion . . . but turned into a voluntary exile prolonged until the hour of his death": he never again left the waters of the Pacific. The "Casco" proceeded first to the Marquesas, and south and east to Tahiti, passing before Christmas northwards to Honolulu, where Stevenson spent six months and finished *The Master of Ballantrae* and *The Wrong Box.* It was during this time that he paid his famous visit to the leper settlement at Molokai. In 1889, "on a certain bright June day," the Stevensons sailed for the Gilbert Islands, and after six months' cruising found themselves at Samoa, where he landed for the first time about Christmas Day 1889. On this occasion, however, though strongly drawn to the beautiful island, he stayed not longer than six weeks, and proceeded to Sydney, where early in 1890, he published, in a blaze of righteous anger, his *Father Damien: an Open Letter to the Rev. Dr. Hyde of Honolulu,* in vindication of the memory of Father Damien and his work among the lepers of the Pacific. Meanwhile his volume of *Ballads* was published in London.

The last four years of his unquiet life were spent at Samoa, in circumstances of such health and vigour as he had never previously enjoyed, and in surroundings singularly picturesque. In November 1890 he made his abode at Vailima, where he took a small barrack of a wooden box 500 ft. above the sea, and began to build himself a large house close by. The natives gave him the name of Tusitala. He took up the cause of the deposed king Mataafa with extreme ardour, and he wrote a book, *A Footnote to History: Eight Years of Trouble in Samoa* (1892), in the endeavour to win over British sympathy to his native friends. In the autumn of this year he received a visit at Vailima from the countess of Jersey, in company with whom and some others he wrote the burlesque extravagance in prose and verse, called *An Object of Pity,* privately printed in 1893 at Sydney. Whenever the cultivation of his estate and the vigorous championship of his Samoan retainers gave him the leisure, Stevenson was during these years almost wholly occupied in writing romances of Scottish life. *The Wrecker,* an adventurous tale of American life, which mainly belonged to an earlier time, was written in collaboration with Mr. Lloyd Osbourne and finally published in 1892; and towards the close of that very eventful and busy year he began *The Justice Clerk,* afterwards *Weir of Hermiston.* In 1893 Stevenson published the Scottish romance of *Catriona,* written as a sequel to *Kidnapped,* and the three tales illustrative of Pacific Ocean character, *Island Nights' Entertainments.* But in 1893 the uniform good fortune which had attended the Stevensons since their settlement in Samoa began to be disturbed. The whole family at Vailima became ill, and the final subjugation of his protégé Mataafa, and the destruction of his party in Samoan politics, deeply distressed and discouraged Stevenson. In a series of letters to *The Times* he exposed the policy of the chief justice, Mr. Cedercrantz, and the president of the council, Baron Senfft. He so influenced public opinion that both were removed from office. In the autumn of that year he went for a change of scene to the Sandwich Islands, but was taken ill there, and was only too glad to return to Samoa. In 1894 he was greatly cheered by the plan, suggested by friends in England and carried out by them with the greatest energy, of the noble collection of his works in twenty-eight volumes, since known as the Edinburgh edition. In September 1894 was published *The Ebb Tide,* the latest of his books which he saw through the press. Of Stevenson's daily avocations, and of the temper of his mind through these years of romantic exile, a clear idea may be obtained by the posthumous *Vailima Letters,* edited by Mr. Sidney Colvin in 1895. Through 1894 he was engaged in composing two romances, neither of which he lived to complete. He was dictating *Weir of Hermiston,* apparently in his usual health, on the day he died. This was Dec. 3, 1894; he was gaily talking on the verandah of his house at Vailima when he had a stroke of apoplexy, from which he never recovered consciousness, and passed away painlessly in the course of the evening. His body was carried next day by sixty sturdy Samoans, who acknowledged Stevenson as their chief, to the summit of the precipitous peak of Vaea, where he had wished to be buried, with the Pacific Ocean at his feet.

The charm of the personal character of Stevenson and the romantic vicissitudes of his life are so predominant in the minds of all who knew him, or lived within earshot of his legend, that they made the ultimate position which he will take in the history of English literature somewhat difficult to decide. That he was the most attractive figure of a man of letters in his generation is admitted; and the acknowledged fascination of his character was deepened, and was extended over an extremely wide circle of readers, by the publication in 1899 of his *Letters,* which have subdued even those who were rebellious to the entertainment of his books. It is therefore from the point of view of its "charm" that the genius of Stevenson must be approached, and in this respect there was between himself and his books, his manners and his style, his practice and his theory, a very unusual harmony.

The personal appearance of Stevenson has often been described: he was tall, extremely thin, dark-haired, restless, compelling attention with the lustre of his wonderful brown eyes. Whatever may be the ultimate order of reputation among his various books, or whatever posterity may ultimately see fit to ordain as regards the popularity of any of them, it is difficult to believe that the time will ever come in which Stevenson will not be remembered as the most beloved of the writers of that age which he did so much to cheer and stimulate. (E. G.; X.)

R. L. Stevenson's other works include: *Memories and Portraits* (1887); *The Merry Men and other Tales and Fables* (1887); *The Black Arrow* (1888); *Edinburgh: Picturesque Notes* (1889); *Across the Plains, with other Memories and Essays* (1892), and the posthumous works, *Songs of Travel and other Verses* (1896), *St. Ives* (1899), completed by Sir A. T. Quiller Couch; *A Stevenson Medley* (1899); *In the South Seas: experiences . . . on the "Casco" (1888) and the Equator (1889)* (1900). *See* the *Letters of Stevenson to his Family* (1899), with the critical and biographical preface by Mr. Sidney Colvin; *Vailima Letters, to Sidney Colvin* (1895), and the *Life of Robert Louis Stevenson* by Graham Balfour (1901) A complete edition of Stevenson's works was issued at Edinburgh in 1894–98. *Bibliographies* of the works of R. L. Stevenson were published by J. H. Slater (1914) and by W. F. Prideaux (1917).

See Prof. Walter Raleigh, *R. L. Stevenson* (1895); Isobel Strong and Lloyd Osbourne, *Memories of Vailima* (1903); F. A. Swinnerton, *R. L. Stevenson: a critical study* (1914); G. Balfour, *The Life of Robert Louis Stevenson* (1918 rev. ed. 1922); G. E. Brown, *A Book of R. L. S. Works, travels, friends and commentators* (1919); R. O. Masson, *Life of R. L. Stevenson* (Edinburgh, 1923); A. St. John Adcock, *Robert Louis Stevenson: his work and his personality* (1924); J. A. Stewart, *R. L. Stevenson, Man and Writer* (2 vols., 1924); G. S. Hellman, *The True Stevenson: A study in clarification* (1925).

STEVENSON, WILLIAM (d. 1575), probable author of the English comedy *Gammer Gurton's Needle,* was born at Hunwick, Durham, matriculated in 1546, took his M. A. degree in 1553, and became B.D. in 1560. Stevenson was a fellow of Christ's college, Cambridge, from 1551 to 1554 and from 1559 to 1561. He was made a prebendary of Durham in 1560–61 and died in 1575. *Gammer Gurton's Needle* is the second extant English comedy, properly so-called. William Stevenson is known to have written a play which was acted at Christ's college in 1553–54; and in the accounts of Christ's college for 1559–60 is the entry, "Spent at Mr. Stevenson's plaie, 5s." Contemporary Puritan writers in the Marprelate tracts allude to Dr. John Bridges, dean of Salisbury, author of *A Defence of the Government of the Church of England,* as the reputed author of *Gammer Gurton's Needle,* but he obviously could not be properly described as "Mr. S." He took his M.A. degree at Pembroke college, Cambridge, in 1560. He may possibly have been a coadjutor.

See Henry Bradley's essay prefixed to his edition of the play in *Representative English Comedies* (1903). The piece is also reprinted in Dodsley's *Old Plays* (vol. 1., 1744; vol. 2., 1780); in *Ancient British Drama* (1810), vol. 1.; and in J. M. Manley's *Specimens of the Pre-Shakespearean Drama* (Boston, U.S.A., 1897). *See* also H. F. B. Brett-Smith's edition of *Gammer Gurton's Needle* (Percy Reprints, 1920).

STEVENS POINT, a city of central Wisconsin, U.S.A., on the Wisconsin river; the county seat of Portage county. It is on Federal highways 10 and 51, and is served by the Green Bay and Western and the Soo Line railways. Pop. (1920) 11,371 (86% native white). The village was incorporated in 1847 and was chartered as a city in 1858.

STEVENSTON, manufacturing town and parish of Ayrshire, Scotland. Pop. (1921) 8,575. It is situated about 1 m. from Saltcoats on the coast of the Firth of Clyde, 29 m. S.W. of Glasgow by the L.M.S. railway. There are coal-mines, large iron-works and foundries, and, on the sandhills along the shore, the works of Nobel's Explosives company.

STEVINUS, SIMON (1548–1620), Dutch mathematician, was born in 1548 at Bruges and died in 1620 at The Hague or in Leyden. He was director of the "waterstaet," and afterwards quartermaster-general. Stevinus was known to his contemporaries by his military methods and inventions; he invented defence by a system of sluices which was of great importance in the Netherlands. He also invented a carriage with sails which was used on the seashore and carried 26 passengers.

In his *Statics and Hydrostatics* (Leyden, 1586) he enunciated the important theorem of the triangle of forces. This gave a new impetus to the study of statics, which had previously been founded on the theory of the lever. He discovered the hydrostatic paradox that the downward pressure of a liquid is independent of the shape of the vessel, and depends only on its height and base.

In 1586 he published a pamphlet of a few pages, the French translation of which is entitled *La Disme enseignant facilement expédier par Nombres Entiers sans rompuz tous Comptes se rencontrans aux Affaires des Hommes.* In this he treated decimal fractions. Decimal fractions and fractions had been employed for the extraction of square roots some five centuries before his time, but nobody before Stevinus established their daily use. He declared the universal introduction of decimal coinage, measures and weights to be only a question of time. His notation is rather unwieldy. He printed little circles round the exponents of the different powers of one-tenth. For instance, $237\frac{578}{1000}$ was printed

237 ⓪ 5 ① 7 ② 8 ③; and the fact that Stevinus meant those encircled numerals to denote mere exponents is evident from his employing the same sign for powers of algebraic quantities, *e.g.*, 9 ④ − 14 ③ + 6 ① − 5 to denote $9x^4-14x^3+6x-5$.

A number of his writings were translated into Latin by W. Snellius. There are two complete editions in French of his works (Leyden, 1608 and 1634) by Albert Girard. *See* Steichen, *Vie et travaux de Simon Stevin* (Brussels, 1846); M. Cantor, *Geschichte der Mathematik*.

STEWART, STUART or **STEUART,** the surname of a family which inherited the Scottish and ultimately the English crown. Their descent is traced to a Breton immigrant, Alan the son of Flaald, which Flaald was a brother of Alan, steward (or seneschal) of Dol in Brittany. This elder Alan, whose name occurs in Breton documents before 1080, went on crusade in 1097, and was apparently succeeded by his brother Flaald, whose son, the younger Alan, enjoyed the favour of Henry I., who bestowed on him Mileham and its barony in Norfolk, where he founded Sporle Priory. By the daughter of Ernulf de Hesdin (in Picardy), a Domesday baron, he was father of at least three sons: Jordan, who succeeded to the family office of steward of Dol; William, who inherited Mileham and other estates in England, and who founded the great baronial house of Fitz Alan (afterwards earls of Arundel); and Walter, who was made by David I. steward (*dapifer*) or seneschal of Scotland. The Scottish king conferred on Walter various lands in Renfrewshire, including Paisley, where he founded the abbey in 1163. Walter, his grandson, third steward, was appointed by Alexander II. justiciary of Scotland, and, dying in 1246, left four sons and three daughters. The third son, Walter, obtained by marriage the earldom of Menteith, which ultimately came by marriage to Robert, duke of Albany, son of Robert II. Alexander, fourth steward, the eldest son of Walter, third steward, inherited by his marriage with Jean, granddaughter of Somerled, the islands of Bute and Arran, and on Oct. 2, 1263 led the Scots against Haakon IV., king of Norway, at Largs. He had two sons, James and John. The latter, who commanded the men of Bute at the battle of Falkirk in 1298, had seven sons: (1) Sir Alexander, whose grandson George became in 1389 earl of Angus, the title afterwards passing in the female line to the Douglases, and in 1761 to the duke of Hamilton; (2) Sir Alan of Dreghorn, ancestor of the earls and dukes of Lennox, from whom Lord Darnley, husband of Queen Mary, and also Lady Arabella Stuart, were descended; (3) Sir Walter, who obtained the barony of Garlies, Wigtownshire, from his uncle John Randolph, earl of Moray, and was the ancestor of the earls of Galloway, younger branches of the family being the Stewarts of Tonderghie, Wigtownshire, and also those of Physgill and Glenturk in the same county; (4) Sir James, who fell at Dupplin in 1332, ancestor of the lords of Lorn, on whose descendants were conferred at different periods the earldoms of Athole, Buchan and Traquair, and who were also the progenitors of the Stewarts of Appin, Argyllshire, and of Grandtully, Perthshire; (5) Sir John, killed at Halidon Hill in 1333; (6) Sir Hugh, who fought under Edward Bruce in Ireland; and (7) Sir Robert of Daldowie, ancestor of the Stewarts of Allanton and of Coltness. James Stewart, the elder son of Alexander, fourth steward, succeeded his father in 1283, and, after distinguishing himself in the wars of Wallace and of Bruce, died in 1309. His son Walter, sixth steward, who had joint command with Sir James Douglas of the left wing at the battle of Bannockburn, married Marjory, daughter of Robert the Bruce, and during the latter's absence in Ireland was entrusted with the government of the kingdom. He died in 1326, leaving an only son, who as Robert II. ascended the throne of Scotland in 1371. Sir Alexander Stewart, earl of Buchan, fourth son of Robert II., who earned by his ferocity the title of the "Wolf of Badenoch," inherited by his wife the earldom of Ross, but died without legitimate issue, although from his illegitimate offspring were descended the Stewarts of Belladrum, of Athole, of Garth, of Urrard and of St. Fort. On the death of the "Wolf of Badenoch" the earldom of Buchan passed to his brother Robert, duke of Albany, also earl of Fife and earl of Menteith, but these earldoms were forfeited on the execution of his son Murdoch in 1425, the earldom of Buchan again, however, coming to the house of Stewart in the person of James, second son of Sir James Stewart, the black knight of Lorn, by Joan or Joanna, widow of King James I. From Murdoch, duke of Albany, were descended the Stewarts of Ardvoirlich and other families of the name in Perthshire, and also the Stuarts of Inchbreck and Laithers, Aberdeenshire. From a natural son of Robert II. were descended the Steuarts of Dalguise, Perthshire, and from a natural son of Robert III. the Shaw Stewarts of Blackhall and Greenock. The direct male line of the royal family terminated with the death of James V. in 1542, whose daughter Mary was the first to adopt the spelling "Stuart." Mary was succeeded in her lifetime in 1567 by her only son James VI., who through his father Lord Darnley was also head of the second branch, there being no surviving male issue of the family from progenitors later than Robert II. In James V., son of James IV. by Margaret, daughter of Henry VII., the claims of Margaret's descendants became merged in the Scottish line, and on the death of Queen Elizabeth of England, the last surviving descendant of Henry VIII., James VI. of Scotland, lineally the nearest heir, was proclaimed king of England, in accordance with the arrangements made by Lord Burghley and Elizabeth's other advisers. The accession of James was, however, contrary to the will of Henry VIII., which favoured the heirs of his younger sister Mary, wife of Charles Brandon, duke of Suffolk.

By the usurpation of Cromwell the Stuarts were excluded from the throne from the defeat of Charles I. at Naseby in 1645 until the restoration of his son Charles II. on May 8, 1660. On the death of Charles II. without issue in 1685, his brother James, duke of York, ascended the throne as James II., but he so alienated the sympathies of the nation by his unconstitutional efforts to further the Roman Catholic religion that an invitation was sent to the prince of Orange to come "to the rescue of the laws and religion of England." Next to the son of James II., still an infant under his father's control, Mary, princess of Orange, elder daughter of James II., had the strongest claim to the crown; but the claims of the prince of Orange also, even apart from his marriage, were not very remote, since he was the son of Mary, eldest daughter of Charles I. The marriage had strengthened the claims of both, and they were proclaimed joint sovereigns of England on Feb. 12, 1689, Scotland following the example of England on April 11. They left no issue, and the Act of Settlement, passed in 1701, excluding Roman Catholics from the throne, secured the succession to Anne, second daughter of James II., and on her death without issue (1714) to the Protestant house of Hanover, descended from the princess Elizabeth, daughter of James I., wife of Frederick V., count palatine of the Rhine. George, elector of Hanover, eldest son of Sophia (youngest child of the princess Elizabeth), and Ernest, elector of Brunswick-Lüneburg, or Hanover, became sovereign of Great Britain and Ireland. The female issue of James II. ended with the death of Anne. James, called James III. by the Jacobites and the Old Pretender by the Hanoverians, had two sons—Charles Edward, the Young Pretender, who died without legitimate issue in 1780, and Henry Stuart, titular duke of York, commonly called Cardinal York, on whose death in 1807 the male line of James II. came to an end. Henry was also the last descendant in the lineal male line of any of the crowned heads of the race, so far as either England or Scotland was concerned. In the female line, however, there are among the descendants of James I. representatives of the royal Stuarts who are senior to the house of Hanover, for Philip, duke of Orleans (brother of Louis XIV.), married, as his first wife, Henrietta, daughter of Charles I., and, as his second, Charlotte, granddaughter and heiress of the princess Elizabeth (daughter of James I.). By the former, through their daughter, the queen of Sardinia, he was ancestor, among others, of the princess Maria Theresa of Bavaria, who in 1910 was "heir of line" of the house of Stuart, her eldest son, Prince Rupert, being at that time heir to the throne of Bavaria.

See Sir George Mackenzie, *Defence of the Royal Line of Scotland* (1685), and *Antiquity of the Royal Line of Scotland* (1686); Crawfurd, *Genealogical History of the Royal and Illustrious Family of the Stuarts* (1710); Duncan Stewart, *Genealogical Account of the Surname of Stewart* (1739); Andrew Stuart, *Genealogical History of the Stuarts* (1798); Stodart, *House of Stuart* (privately printed, 1855); *An*

Abstract of the Evidence to Prove that Sir William Stewart of Jedworth, the Paternal Ancestor of the Present Earl of Galloway, was the Second Son of Sir Alexander Stewart of Darnley (1801); Riddell, *Stewartiana* (1843); W. Townend, *Descendants of the Stuarts* (1858); R. W. Eyton, *History of Shropshire* (1858), vol. vii.; Bailey, *The Succession to the English Crown* (1879); Skelton, *The Royal House of Stuart* (1890); J. H. Round, *Studies in Peerage and Family History* (1901); S. Cowan, *The Royal House of Stuart* (1908); and T. F. Henderson, *The Royal Stewarts* (1914). The best chart pedigree of the house is that which was prepared for the Stuart Exhibition by W. A. Lindsay.

STEWART, SIR DONALD MARTIN (1824–1900), British field marshal, son of Robert Stewart of Forres, Elginshire, was born at Mount Pleasant, near Forres, on March 1, 1824. He entered the Bengal army in 1840, and served in 1854 and 1855 in the frontier expeditions against the Mohmands, and Afridis Aka and Bari Khel (medal and clasp). In the Indian Mutiny in 1857 Stewart, after a famous ride from Agra to Delhi with despatches, served on the staff at the siege and capture of Delhi and Lucknow, and afterwards through the campaign in Rohilkhand. For nine years he was assistant and deputy-adjutant-general of the Bengal army, commanded the Bengal brigade in the Abyssinian expedition in 1867, and became a major-general in 1868. He reorganized the penal settlement of the Andaman Islands, where he was commandant when Lord Mayo was assassinated, and, after holding the Lahore command, was promoted lieutenant-general in 1877, and commanded the Kandahar field force in the Afghan War in 1878. On hearing of the Maiwand disaster he despatched Roberts with a division on his celebrated march from Kabul to Kandahar, and himself led the rest of the army back to India by the Khyber Pass. Promoted general in 1881, he was for five years commander-in-chief in India, and afterwards member of the council of the secretary of state for India until his death. He was promoted to be field marshal in 1894, and appointed governor of Chelsea Hospital in 1895. He died at Algiers on March 26, 1900.

See G. R. Elsmie, *Sir Donald Stewart* (1903).

STEWART, DUGALD (1753–1828), Scottish philosopher, was born in Edinburgh on Nov. 22, 1753. His father, Matthew Stewart (1715–1785), was professor of mathematics in the university of Edinburgh (1747–1772). Dugald Stewart was educated at Edinburgh and Glasgow. At 19 he acted as substitute for his father in the chair of mathematics at Edinburgh. From 1785 to 1820 he was professor of moral philosophy in the university, though he retired from the active duties of the chair after the death (1809) of his second son, which was a great blow to him. He died at Edinburgh on June 11, 1828.

Stewart's principal work is *Elements of the Philosophy of the Human Mind* (3 vols. 1792, 1814, 1827). He also wrote *Philosophical Essays* (1810), and *The Philosophy of the Active and Moral Powers* (1828). His philosophical views are mainly the reproduction of those of his master Reid.

STEWART, SIR HERBERT (1843–1885), British soldier, born on June 30, 1843, at Sparsholt, Hampshire, was educated at Winchester and entered the army in 1863. Returning from service in India in 1873, he entered the staff college and the Inner Temple. He served in South Africa in the Zulu War and against Sikukuni, and was present at Majuba (1881), where he was made prisoner for a month. In Aug. 1882 he was placed on the staff of the cavalry division in Egypt, and took possession of Cairo after Tel-el-Kebir (Sept. 13, 1882). In 1884 he commanded the cavalry under Sir Gerald Graham at Suakin. For his services in Egypt he was made K.C.B., and was assistant adjutant and Q.M.G. in the south-eastern district in England (April–Sept. 1884). He then joined the expedition for the relief of Khartoum, and commanded the relief column sent by Lord Wolseley across the desert of Metemma. On Jan. 17, 1885, he repulsed an enemy charge near Abu Klea. He was promoted major-general, but died on the way back from Khartoum to Korti, on Feb. 16, 1885, and was buried near the wells of Jakdul.

STEWART, WILLIAM (*c.* 1480–*c.* 1550), Scottish poet and translator, descendant of one of the illegitimate sons of Alexander Stewart, earl of Buchan, the "Wolf of Badenoch," was a member of the university of St. Andrews. He was in orders, and a hanger-on at the court of James V. Portions of his minor verse are preserved in the Bannatyne and Maitland Folio MSS. His chief work is a metrical translation of Hector Boece's *History*, in obedience to the command of James V., who entrusted Bellenden with its translation into Scots prose.

Stewart's version remained in ms. till 1858, when it was edited by W. Turnbull for the "Rolls Series" (3 vols.). The ms. is now in the library of the university of Cambridge.

STEWART, SIR WILLIAM (*c.* 1540–*c.* 1605), Scottish politician, began life as a soldier in the Netherlands, where he became a colonel. In 1582 he was in Scotland, where James VI. made him captain of his guard. Having visited the English court in the king's interest in 1583, Stewart helped to free James from William Ruthven, earl of Gowrie, and to restore James Stewart, earl of Arran, to power; he was made a privy councillor and for a time assisted Arran to govern Scotland. In 1584 he captured Gowrie at Dundee. In 1594 he was knighted and was given lands at Houston. He died before 1606.

STEWART, WILLIAM DOWNIE (1878–), New Zealand politician and publicist, was born at Dunedin on July 29, 1878, his father being a member of the legislative council. In 1914 he entered parliament as member for Dunedin West. A period of war service with the Otago regiment in 1916–17 interrupted his political career, but he was re-elected in 1919 and in 1922 joined the Massey ministry as minister for industries and commerce. From 1926 onwards he was attorney-general, minister of finance, of stamp duties, etc. In 1926 he was acting prime minister. He is joint author (with Professor Le Rossignol) of *State Socialism in New Zealand* (1910).

STEYN, MARTINUS THEUNIS (1857–1916), last president of the Orange Free State, was born at Winburg in that State on Oct. 2, 1857. He was a student in Holland and later in England at the Inner Temple, and was called to the English bar in Nov. 1882. After his return to South Africa he practised as a barrister at Bloemfontein, and in 1889 was appointed state attorney of the Free State. A few months afterwards he became second puisne judge, and in 1893 first puisne judge of the high court. His decisions won him a reputation for ability and sound judgment. In 1895, upon the resignation of President F. W. Reitz, Steyn was the candidate of the pan-Dutch party for the vacant post. The election resulted (Feb. 1896) in a decisive victory for Steyn. As president he linked the fortunes of his State with those of the Transvaal, a policy which led to the extinction of the republic. He took part in the peace negotiations at Klerksdorp in April 1902, but was prevented by illness from signing the instrument of surrender at Pretoria on May 31. In 1908–1909 he was vice-president of the Closer Union Convention, where he showed a conciliatory attitude.

STEYNING (stĕn′nĭng), town in Sussex, England, 12 m. W.N.W. of Brighton by a branch of the S.R. Pop. (1921) 1,875. The church of St. Andrew retains a series of Norman pier-arches in the nave. The Anglo-Saxon church of Steyning mentioned in Domesday is attributed to St. Cuthman, who is said to have settled here before the 9th century, and whose shrine became a resort for pilgrims. In 1086 Steyning was a thriving port, with a market, a mint and two churches. Its decay began in the 14th century owing to the recession of the sea, and it received another blow in the suppression of its priory by Henry IV.

STEYR, a town in Upper Austria at the junction of the Steyr with the Enns. The old town, dominated by a tenth century castle, occupies the peninsula between the streams. Two important new suburbs, Steyrdorf and Ennsdorf, lie across the streams. Steyr is the chief centre of the iron and steel industry of Upper Austria.

STIBNITE, a mineral consisting of antimony sulphide, Sb_2S_3, occurring as bladed or acicular orthorhombic crystals; an important ore of antimony. It was mentioned by Dioscorides and Pliny under the names *stimmi, stibi* and *platyophthalmon* (*πλατυόφθαλμον*); the last name refers to the use which the ancients made of the powdered mineral for darkening the eyebrows to increase the apparent size of the eyes. The Arabic name *al-kohl* (now strangely corrupted to *alcohol*) had reference to the same use. Antimonite is also a common name for this species.

The crystals are prismatic in habit, deeply furrowed longitudinally, and usually terminated by acute pyramidal planes. There is a perfect cleavage (010) parallel to the length of the crystals, and the basal plane (001) is a plane of gliding; the latter gives rise to very characteristic transverse striations or nicks on the cleavage surfaces of crystals which have been bent. The colour is lead-grey, and the lustre metallic and brilliant; crystals become dull on prolonged exposure to light. Cleavage flakes of extreme thinness transmit a small amount of red light, but are more transparent for heat rays. The mineral is quite soft (H=2), and has a specific gravity of 4·6. Stibnite occurs with quartz in beds and veins in gneisses and schists, or with blende, galena, etc., in metalliferous veins. Magnificent groups of brilliant crystals, up to 20 in. in length, were formerly abundant in the antimony mine of Ichinokawa, on Shikoku island, Japan. Large, but dull, crystals have also been found at Lubilhac in Haute-Loire, France. Prismatic and acicular crystals often penetrating tabular crystals of barytes, are common at Baia Sprie in Rumania (formerly Felsőbánya, Hungary). (L. J. S.)

STICK-INSECT, the name given to certain orthopterous insects of the family Phasmidae, deriving their name from a resemblance to the branches and twigs on which they live and feed. The resemblance is produced by the great length and slenderness of the body and legs. Protection is afforded to some species, like *Haaniella grayi* from Borneo, by sharp thornlike spines. The anterior wings, when present, are small; but the posterior wings are sometimes large and beautifully coloured. The colouring, however, is only visible when the wings are expanded and in use. Many species are wingless at all ages. As in the leaf-insects, to which the stick-insects are closely allied, the egg cases are very similar to seeds. Stick-insects attain their largest size and greatest profusion of species in the tropics, one N. Queensland species, *Palophus titan,* reaching a length of 10in. Species of small size are found in southern Europe one belonging to the genus *Bacillus* advancing as far north as the middle of France. They freely regenerate their legs and antennae when amputated. In certain conditions the stump of an amputated antenna will regenerate a leg (*see* REGENERATION IN ANIMALS).

STICKLEBACK, a group of small fishes (*Gasterosteus*) which inhabit the fresh and brackish waters as well as the coasts of the temperate zone of the northern hemisphere. The majority have a compressed well-proportioned body, which in the marine species is of a more elongate form. Their mouth is of moderate width, oblique, and armed with small teeth. The head is protected by hard bone. There are a series of scutes protecting the sides. The first dorsal fin and the ventrals are transformed into pointed formidable spines, and joined to firm bony plates of the endoskeleton. A remarkable degree of variability is shown by many species. Sticklebacks construct a nest for the reception of the spawn, which is jealously guarded by the male until the young are hatched, from ten to eighteen days after oviposition. He also protects them for the first few days of their existence.

Sticklebacks are short-lived animals said to reach an age of three or four years. In spring each male selects a territory, which he fiercely defends and to which he invites all females, until the nest is filled with ova. At this period he assumes a dress of blue and red. The eggs are comparatively large, one female depositing from 50 to 100.

The three-spined stickleback (*G. aculeatus*) is found everywhere in northern and central Europe, northern Asia, and North America.

The ten-spined stickleback (*G. pungitius*) is smaller than the three-spined species, rarely exceeding 2in. in length. Its geographical range nearly coincides with that of the other species.

The sea-stickleback (*G. spinachia*) attains a length of 7in., and is armed with 15 short spines. It is common round the British coasts. At suitable localities which are sheltered from the waves and overgrown with seaweed, especially in rock-pools and shallows covered with *Zostera,* one or two males establish themselves with their harems. The nest is firmly attached to seaweed.

STIGAND (d. 1072), archbishop of Canterbury, is first mentioned in 1020. He was then chaplain to Canute and afterwards to his son, Harold Harefoot, and after the death of Canute appears to have acted as the chief adviser of his widow, Emma. In 1043 he was consecrated bishop of Elmham and in 1047 was translated to Winchester; he supported Earl Godwine in his quarrel with Edward the Confessor, and in 1052 arranged the peace between the earl and the king. In this year the archbishop of Canterbury, Robert of Jumièges, having been outlawed, Stigand was appointed to the archbishopric; but Pope Leo IX. and his two successors refused to recognize him. In 1058, however, Benedict X. gave him the pall, but this pope was deposed in the following year. Stigand is said by Norman writers to have crowned Harold in Jan. 1066; but this ceremony was probably performed by Aldred, archbishop of York. Stigand submitted to William, and assisted at his coronation. But the Conqueror was anxious to get rid of him. In 1070 he was deposed by the papal legates and was imprisoned at Winchester, where he died, probably on Feb. 22, 1072. Stigand was an avaricious man and a great pluralist, holding the bishopric of Winchester after he became archbishop of Canterbury, in addition to several abbeys.

See E. A. Freeman, *The Norman Conquest* (1870–76), vols. ii., iii. and iv.; and J. R. Green, *The Conquest of England* (1899), vol. ii.

STIGMATIZATION, the infliction of *stigmata,* used with specific reference to the supposed supernatural infliction of wounds like those of Christ.

In St. Francis of Assisi we have the first example of the alleged miraculous infliction of stigmata. Remembering the sufferings of our Lord, in his cell on Mount Alverno in 1224, we are told by his biographers, Thomas of Celano and Bonaventura, that the Lord appeared to Francis as a seraph and produced upon his body the five wounds of Christ; of these we are told that the side wound bled occasionally, though Bonaventura calls it a scar, and the wounds in the feet had the appearance and colour of nails thrust through. After his death St. Clare endeavoured, but in vain, to extract one of these. Pope Alexander IV. and other witnesses declared that they had seen these marks both before and after his death. The divinely attested sanctity of their founder gave to the newly established order of Franciscans a powerful impulse, so that they soon equalled and threatened to overshadow in influence the previously founded order of St. Dominic.

The reputation of the latter order was, however, similarly raised in the next century by the occurrence of the same wonder in the case of a sister of the third rule of St. Dominic, Catherine Benincasa—better known as St. Catherine of Siena. From her biographer's account we gather that she was subject to hystero-epileptic attacks. In one of these attacks, when she was twenty-three years old, she received the first stigma. In spite of her great reputation, and the number of attesting witnesses, this occurrence was not universally believed.

The instances of masculine stigmatization are few. Benedict di Rhegio, a Capuchin at Bologna, had the marks of the crown (1602); Carolus Sazia, an ignorant lay brother, had the wound in his side. Dodo, a Praemonstratensian lay brother, was fully stigmatized, as also was Philip de Aqueria. The marks after death were found on the heart of Angelos del Pas, a minorite of Perpignan, as also on Matheo Carery in Mantua, Melchior of Arazel in Valentia, Cherubin de Aviliana (an Augustinian), and Agolini of Milan. Walter of Strassburg, a preaching friar (1264), had the heart-pain but no mark, and the same was the case with a Franciscan, Robert de Malatestis (1430), and James Stephanus. On Nicholas of Ravenna the wounds were seen after death, while John Gray, a Scotsman and Franciscan martyr, had one wound on his foot.

Several later instances have been recorded. Anna Katherina Emmerich, a peasant girl born at Münster in 1774, afterwards an Augustinian nun at Agnetenberg, was even more famous for her visions and revelations than for the stigmata. Biographies, with records of her visions, have been published by Brentano at Munich in 1852 and the Abbé Cazalès at Paris (1870). Colombe Schanolt of Bamberg (1787) was fully stigmatized, as also was Rose Serra, a Capuchin of Ozieri in Sardinia (1801), and Madeleine Lorger (1806).

The last case recorded is that of Louise Lateau, a peasant girl, at Bois de Haine, Hainault, upon whom the stigmata appeared on the 24th of April, 1868. This case was investigated by Professor Lefebvre of Louvain, who for fifteen years was physician to two lunatic asylums. In her there was a periodic bleeding of the stigmata every Friday, and a frequent recurrence of the hystero-cataleptic condition. Her biography has been written by Lefebvre and published at Louvain (1870).

Bibliography.—(1) St. Francis: *Acta Sanctorum* for October, ii.; Celano, *Vita Prima S. Francisci* (edition London, 1908); K. Hase, *Franz von Assisi* (1856 and 1892; denies the reality of the stigmata); P. Sabatier, *Vie de saint François d'Assise* (1894; Eng. tr. same year); W. J. Knox-Little, *St. Francis of Assisi* (1904); both of whom criticise Hase's arguments; T. Jörgensen, *Saint Francis of Assisi* (Eng. tr. 1912); Father Cuthbert, *Life of St. Francis of Assisi* (1912); and for medical studies, A. Bournet, *St. François d'Assise* (1893) and T. Cotelle, *St. François* (1895). (2) On the general subject: A. Imbert-Gourbeyre, *Les stigmatisées* (2nd ed. 1886); *La stigmatisation* (1894); J. J. von Görres, *The Stigmata* (Eng. tr. 1883).

STILBENE, a glistening colourless crystalline hydrocarbon melting at 124° C, and boiling at 306° C, and soluble in alcohol or ether. It is prepared either by the action of sodium on benzylidene (benzal) chloride, $C_6H_5{\cdot}CHCl_2$, or by passing toluene over heated lead oxide. Stilbene is symmetrical diphenylethylene, $C_6H_5{\cdot}CH{:}CH{\cdot}C_6H_5$, and many of its derivatives are known to exist in two structural forms exhibiting stereoisomerism of the type shown by fumaric and maleic acids. It is chiefly of interest as being the basis of several important synthetic dyes. *Stilbene azo-dyes,* 4:4′-Diaminostilbene-2:2′-disulphonic acid, $NH_2{\cdot}C_6H_3(SO_3H)CH{:}CH{\cdot}C_6H_3(SO_3H){\cdot}NH_2$, prepared from *para*nitrotoluene*ortho*sulphonic acid by successive treatment with aqueous caustic soda and alkaline zinc dust, when diazotised and coupled with β-naphthylamine and its sulphonic acids, furnishes substantive cotton dyes known as Hessian Purples M.

Stilbene colours.—Various cotton yellows and oranges are obtained by boiling *p*-nitrotoluene-*o*-sulphonic acid with aqueous caustic soda alone (Chlorazol yellow), in the presence of oxidisable substances such as glycerol, sodium sulphite, or gallic acid (Chlorazol Fast Orange) or with oxidising agents such as sodium hypochlorite (Chlorazol Fast Yellow).

Diphenylacetylene or *tolane,* $C_6H_5{\cdot}C{:}C{\cdot}C_6H_5$, colourless crystals melting at 60° C, results from the action of alcoholic potash on stilbene dibromide. (G. T. M.)

STILBITE, a mineral of the zeolite group consisting of hydrated calcium aluminium silicate, $CaAl_2(SiO_3)_6+6H_2O$. Usually a small proportion of the calcium is replaced by sodium. Crystals are monoclinic, and are invariably twinned, giving rise to complex groups and characteristic sheaf-like aggregates. The colour is usually white, sometimes red, and on the perfect cleavage (parallel to the plane of symmetry) the lustre is markedly pearly; hence the name stilbite (Gr. στίλβειν, to shine) given by R. J. Haüy in 1796. After the separation of heulandite from this species in 1818, the name desmine (δέσμη, a bundle) was proposed, and this name is now employed in Germany. The hardness is 3·5 and the specific gravity 2·2. Stilbite occurs with other zeolites in the amygdaloidal cavities of basic volcanic rocks; it is sometimes found in granite and gneiss, and exceptionally in metalliferous veins. Beautiful, salmon-pink crystals occur with pale green apophyllite in the Deccan traps near Bombay and Poona; white sheaf-like groups encrust the calcite (Iceland-spar) of Berufjord near Djupivogr, Iceland; and crystals of a brick-red colour are found at Old Kilpatrick, Dumbartonshire.

STILES, EZRA (1727–1795), American clergyman and educationalist, seventh president of Yale college, was born on Nov. 29, 1727 in North Haven, a parish of New Haven (Connecticut). He graduated at Yale in 1746; was licensed to preach in 1749 and was a tutor at Yale in 1749–55. He also preached in 1750 to the Indians at Stockbridge, was admitted to the bar in 1753, and practised in New Haven for two years. After pastorates at Newport (R.I.) and Portsmouth (N.H.) he became in 1778 president of Yale college and professor of ecclesiastical history, becoming for a few years after 1780 professor of divinity and lecturing on many subjects. He died in New Haven on May 12, 1795. His wise administration as president made possible the speedy recovery of Yale college after the War of Independence; his intellectual and theological breadth helped to secularize and strengthen the college. He carefully kept thermometric and meteorological statistics; he imported silkworms and books on silk culture; he corresponded with many litterati; he undertook the study of Hebrew at the age of 40 and became an able scholar; in short, his hunger for knowledge was insatiable. On Franklin's recommendation he was made a doctor of divinity by the University of Edinburgh in 1765, and he was awarded other honorary degrees in his own country. Dr. Stiles published a number of sermons, an *Account of the Settlement of Bristol, Rhode Island* (1785); and a *History of Three of the Judges of King Charles I.* (1794). His *Literary Diary* (3 vol., 1901) was edited by F. B. Dexter, who quotes largely from Dr. Stiles's *Itineraries. Extracts from the Itineraries and Other Miscellanies* with selections from Dr. Stiles's correspondence prepared by the same editor appeared in 1916. Both give a valuable picture of New England life and contemporary figures.

See the *Life of Ezra Stiles* (1798), by his daughter's husband, Abiel Holmes, the father of Oliver Wendell Holmes, and the life by J. L. Kingsley in Jared Sparks, *American Biography* (ser. 2, vol. vi., 1845).

STILICHO, FLAVIUS (?–408), Roman general and statesman, was the son of a Vandal who had served as an officer in the army of the emperor Valens (364–378). He himself entered the imperial army at an early age and speedily attained high promotion. He had already become master of the horse when in 383 he was sent by Theodosius (379–395) at the head of an embassy to the Persian king, Sapor III. His mission was very successful, and soon after his return he was made count of the domestics and received in marriage Serena, the emperor's niece and adopted daughter. In 385 he was appointed master of the soldiery in Thrace, and shortly afterwards directed energetic campaigns in Britain against Picts, Scots and Saxons, and along the Rhine against other barbarians. Stilicho and Serena were named guardians of the youthful Honorius when the latter was created joint emperor in 394. Rivalry had already existed between Stilicho and Rufinus, the praetorian praefect of the East. Consequently in 395, after a successful campaign against the Germans on the Rhine, Stilicho marched east, with the design of displacing Rufinus; and by connivance with the barbarians he procured the assassination of Rufinus at the close of the year, and thereby became virtual master of the empire. In 396 he fought in Greece against the Visigoths, but an arrangement was effected whereby their chieftain Alaric was appointed master of the soldiery in Illyricum (397). In 398 he quelled Gildo's revolt in Africa and married his daughter Maria to Honorius. Two years later he was consul. He thwarted the efforts of Alaric and Radagaisus to seize lands in Italy by his victories on the Danube at Pollentia and Verona in 401–3.

In a second campaign against Radagaisus, who led a large force of various Germanic peoples into Italy in 405, he surrounded the barbarian chieftain on the rocks of Fiesole and starved him into surrender. Early in 408 he married his second daughter Thermantia to Honorius. It was rumoured about this time that Stilicho was plotting with Alaric and with Germans in Gaul and taking other treasonable steps in order to make his own son Eucherius emperor. The facts are doubtful. It is certain, however, that he was suspected by Honorius and abandoned by his own troops, and that he fled to Ravenna, and, having been induced by false promises to quit the church in which he had taken sanctuary, was executed on Aug. 23, 408.

The principal sources for the life of Stilicho are the histories of Zosimus and of Orosius and the flattering verses of Claudian. *See* T. Hodgkin, *Italy and her Invaders,* vols. i. and ii. (Oxford, 1880); E. Gibbon, *Decline and Fall of the Roman Empire,* edited by J. B. Bury, vol. iii. (1902); P. Villari, *The Barbarian Invasions of Italy,* translated by L. Villari, vol. i. (New York, 1902); S. Dill, *Roman Society in the last century of the Western Empire* (1899); Mommsen in *Hermes* xxviii.; and K. Birtin, *Spätrömische Charakterbilder* (Leipzig, 1919).

STILL, ANDREW T. (1828–1917), founder of osteopathy, was born in Jonesboro, Va., on Aug. 6, 1828. His family moved in 1837 to Macon county, Missouri, and later to the Shawnee reservation near Kansas City, Kansas. Still took an active part in settling the slave question in Kansas, and in 1847 was elected to the Kansas State legislature on the Free State ticket. He began searching for other means than medicine to combat disease and formulated his principles of osteopathy in 1874. He underwent a long period of opposition, but finally, in 1892, founded the American School of Osteopathy at Kirksville, Mo., in conjunction with William Smith, a Scottish physician. In 1922 the Andrew T. Still College of Osteopathy and Surgery was founded and merged with the original American school. He was the author of *The Philosophy of Osteopathy* (1899), *Autobiography of Andrew T. Still* (1897) and *Osteopathy, Research and Practice* (1910).

See "Andrew T. Still," *Missouri Historical Review*, vol. xix., 1924, by Ray G. Hulburt; E. R. Booth, *History of Osteopathy*.

STILL, JOHN (1543?–1608), bishop of Bath and Wells, was born at Grantham, Lincs. He studied at Christ's college, Cambridge. He was appointed in 1570 Lady Margaret professor of divinity, subsequently held livings in Suffolk and Yorkshire, and was master successively of St. John's College (1574) and of Trinity College (1577). Still was vice-chancellor of his university in 1575–76 and again in 1592–93, and was raised to the bishopric of Bath and Wells in 1593. He died on Feb. 26, 1608, leaving a large fortune from lead mines discovered in the Mendip Hills. He was for some time generally believed to be the author of the English comedy *Gammer Gurton's Needle*, which is now ascribed to William Stevenson (*q.v.*)

STILL ENGINE: *see* INTERNAL COMBUSTION ENGINE.

STILLINGFLEET, EDWARD (1635–1699), English divine, was born at Cranborne, Dorset, on April 17, 1635. He graduated from St. John's college, Cambridge, in 1652, and in the following year was elected to a fellowship. At Sutton, Beds., of which he was vicar, he published (1659) his *Irenicum* in which he sought to give expression to the prevailing weariness of the faction between Episcopacy and Presbyterianism, and to find some compromise. He looks upon the form of church government as non-essential, but condemns Nonconformity. Although in 1680 he published his *Unreasonableness of Separation*, his willingness to serve on the ecclesiastical commission of 1689, and the interpretation he then proposed of the damnatory clauses of the Athanasian creed, are proof that to the end he leaned towards toleration. His rapid promotion dates from 1662, when he published *Origines sacrae, or a Rational Account of the Christian Faith as to the Truth and Divine Authority of the Scriptures and the Matters therein contained*. In 1665 the earl of Southampton presented him to St. Andrew's, Holborn, two years later he became prebendary of St. Paul's, in 1668 chaplain to Charles II., in 1670 canon residentiary, and in 1678 dean of St. Paul's. He was also preacher at the Rolls Chapel and reader at the Temple. Finally he was consecrated bishop of Worcester on Oct. 13, 1689. During these years he was ceaselessly engaged in controversy with Nonconformists, Romanists, Deists and Socinians. His various learning, his dialectical expertness, and his massive judgment, rendered him a formidable antagonist; but the respect entertained for him by his opponents was chiefly aroused by his recognized love of truth. He was one of the seven bishops who resisted the proposed Declaration of Indulgence (1688). The range of his learning is most clearly seen in his *Bishop's Right to Vote in Parliament in Cases Capital*. His *Origines Britannicae, or Antiquities of the British Church* (1685), is a strange mixture of critical and uncritical research. In his closing years he had some controversy with John Locke, whom he considered to have impugned the doctrine of the Trinity. He died at Westminster on March 28, 1699.

A collected edition of his works, with life by Richard Bentley, was published in London, 6 vols. (1710); and a useful edition of *The Doctrines and Practices of the Church of Rome Truly Represented* was published in 1845 by William Cunningham.

STILL-LIFE PAINTING, the art of painting inanimate objects for their beauty of colour, line or arrangement. It was first developed as an individual branch of easel painting by the artists of the Netherland school of painters. Families of artists chose this simple line of art for their life's work. Gold and silver cups, flagons and plates of porcelain and delft, oriental rugs and draperies, Venetian and Bohemian glass richly ornamented, and even jewels, scientifically arranged for scintillating effects, were motifs for some of the most brilliant artists. Simple kitchen utensils of brass and copper, with meat, fish and vegetables, made fine subjects for colour and line. The sparkle of metals, the glitter of wet fish, the deep and rich tones of meat and vegetables—what better material could the painter desire!

Exquisite drawing, with painstaking draughtsmanship as a primary factor, resulted in paintings that were sought not only by the rich burghers, but by visiting princes and ambassadors. In every museum may be found these masterpieces, and although not so numerous as the many rows of portraits, *genre* and religious canvases, they, nevertheless, hold their high place in Dutch art.

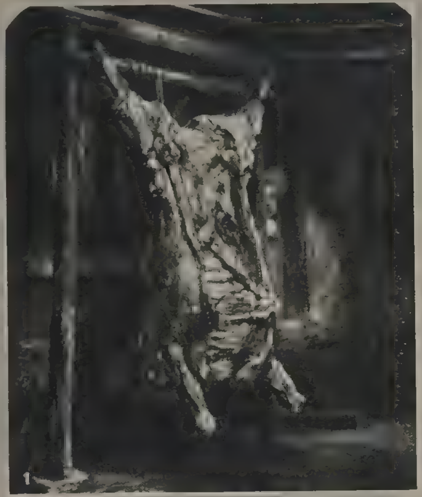
The Flemish and Dutch artists felt, and so did many true lovers of the fine arts of that time, that the subject of a picture was not the only motif worth while; that an arrangement beautifully composed, either for luxurious abundance or for simplicity in colour, tone, values and line, would make a noble work of art, in spite of what higher thought might find in portraying character in the portrait and deep feeling in the religious picture. They argued that a well painted still-life was a greater art production than a badly painted Madonna, however well conceived.

Subject-matter.—Pictures of the life of the people themselves, their houses, gardens, the interior of the splendidly furnished homes of merchants and aristocrats, rich in hangings and elaborate in table service, made beautiful settings for the painter. The everyday life of the people around the artist showed him just what he wanted. Besides, it furnished a subject that was simpler to do than the literary picture, as well as being more straightforward and true. People in silk and velvet, visiting in well-appointed rooms to listen to music or to partake of wine and cake or fruit, served on silver or choice porcelain, were none the better as subjects than a girl scouring a brass kettle in the kitchen.

That greatest part of the painter's knowledge, the observation of values, which means rendering the lights and shadows of a subject regardless of local colour, was first thoroughly understood by these artists, and is the basis of all sound painting. From the work of these men, still-life developed. The principle is the same, the interiors being to a great extent still-life. There is usually very little expression or movement needed for the figures. However well painted the heads, the clothes, even the glass of amber-coloured wine in the lady's hand, seem almost of the same interest as the head. Take the figures out and the pure still-life is the result. The simple composition of a few peaches on a piece of delft with a silver pitcher and an ornamented glass half full of wine is all that a master like Willem Kalf needs to make a supreme painting.

Technique.—Often in the galleries and at exhibitions, critical visitors, some of whom are professional painters, ask: "What is still-life?" Reproducing the roundness and firmness of a red apple is not very different from the modelling of a head. Lovers of painting look for something different in a canvas, something that for them means beauty or truth—and not every one sees the same beauty in a picture painted by a master. Take Velázquez' "Aguador" for an example; to the painter, a quiet study of modelling, with remarkable still-life; to one with perhaps no ability as a painter, a thoughtful study of a man's head; to another a beautiful head of a boy. Velázquez had a number of interesting still-life pictures. In "The Steward" and "Old Woman Frying Eggs," each has a single figure in the composition, but the pictures are evidently made for close studies of inanimate life, dead fish, meat, jars and glass, masses of objects, scattered all over the canvas. Rembrandt's "Flayed Ox" in the Louvre is a great example of noble quality, rich in colour, bold in treatment, closely observed in values, and of great simplicity—a masterpiece.

Pieter Aertsen, early 16th century, one of the first absolute still-life painters, although at times introducing figures in the background of some of his pictures, painted pictures of meats, vegetables, etc., in the kitchen or larder. His large canvas in Uppsala, representing a butcher-shop with a calf's head, a side of beef, a pig's head and sausages, fowl, fish and all sorts of gruesome details of what one expects to find in such a place, is typical. The canvas is overfilled, every small place is crowded, and



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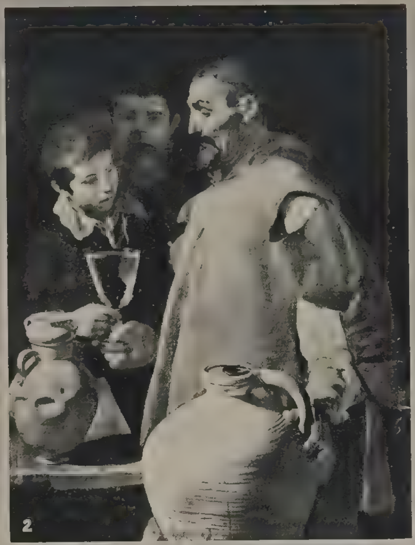

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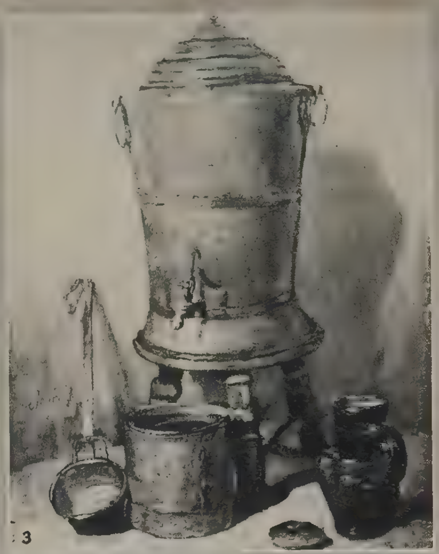

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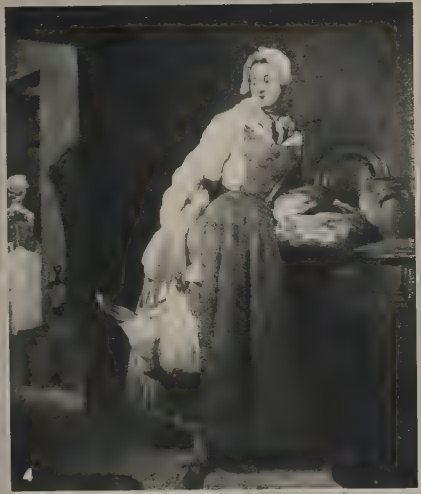

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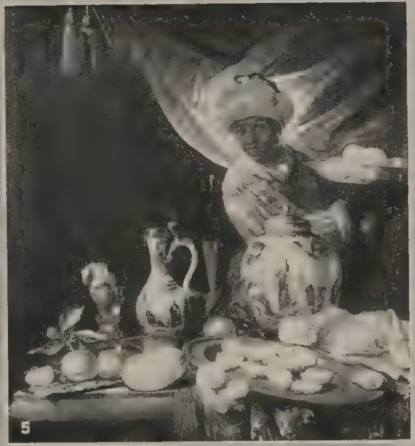

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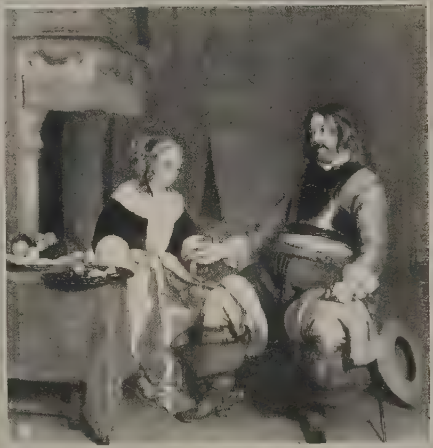

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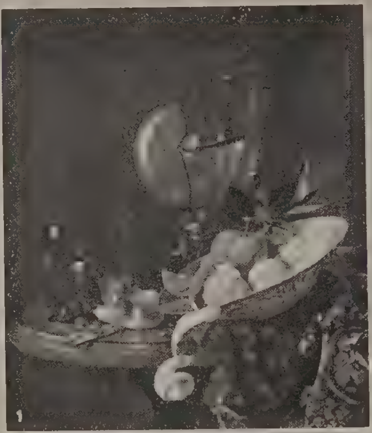
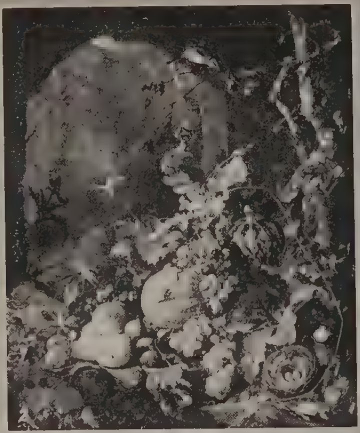
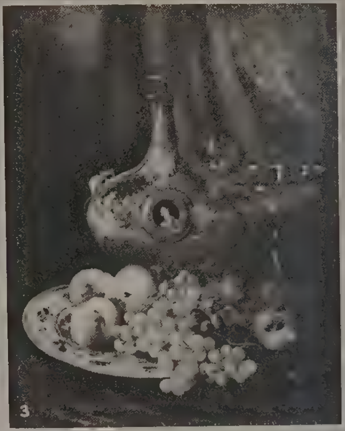
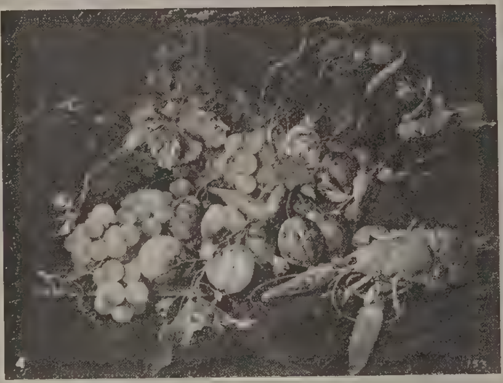
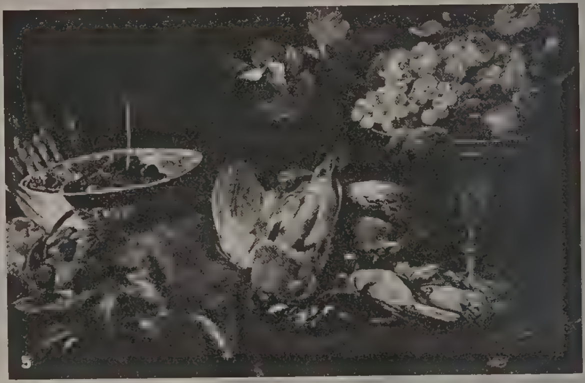
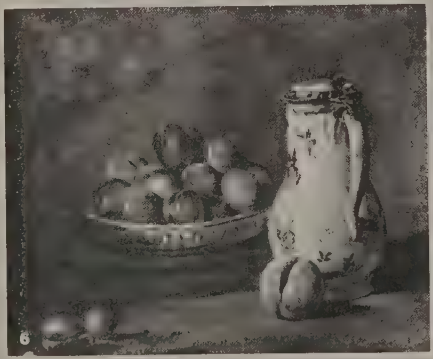
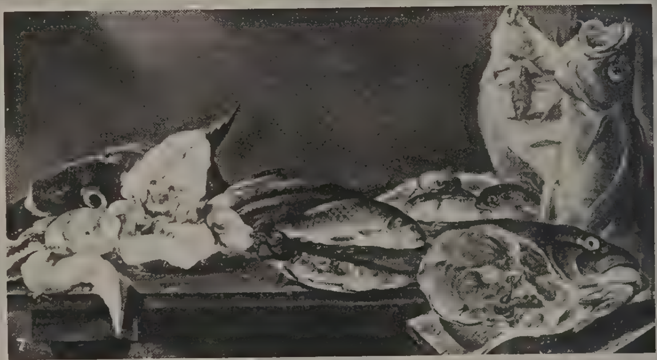
STILL–LIFE PAINTINGS

1. "Flayed Ox," by Rembrandt (1606–1669). Bold treatment, rich colour, values closely observed. Now in Louvre. 2. "Aguador de Sevilla" by Velazquez (1599–1660). Quiet study of modelling. In collection of His Grace the Duke of Wellington. 3. "La Fontaine," superb canvas, one of Chardin's favourite works. Chardin (1699–1779) was able to see and reproduce beauty in simple utensils of the kitchen. In the Metropolitan Museum of Art, New York. 4. Chardin's "La Pourvoyeuse," one of the three most famous paintings by this master of still life; light, colour and harmony emphasized. Now in Louvre. 5. Still life by Emil Carlsen (1853–   ), meticulous attention paid to the small details. 6. "Le Gallant Militaire," by Ter Borch (1617–1681). Painted in the adopted style of the Dutch. Values and tonality closely observed. In Louvre

STILL-LIFE PAINTING

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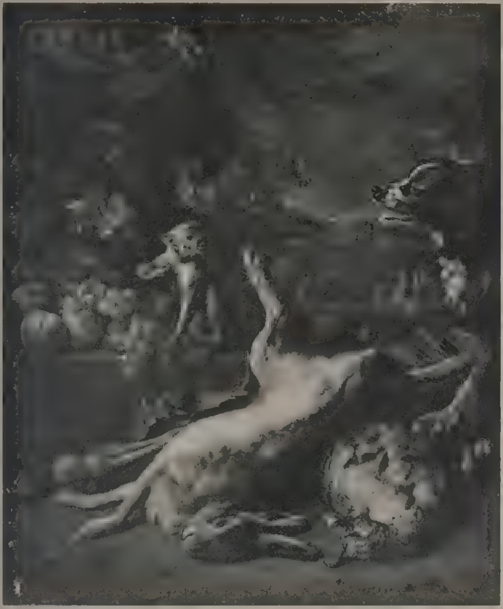
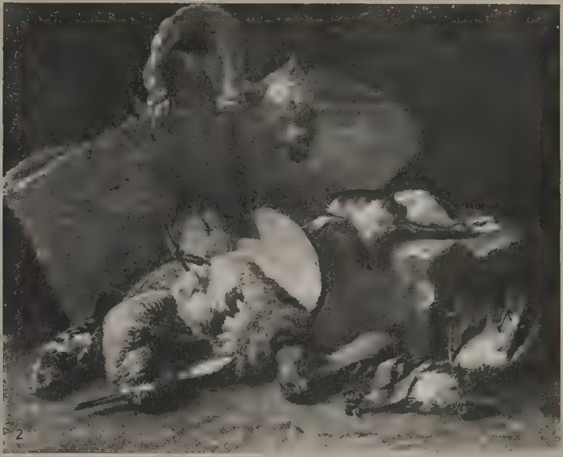
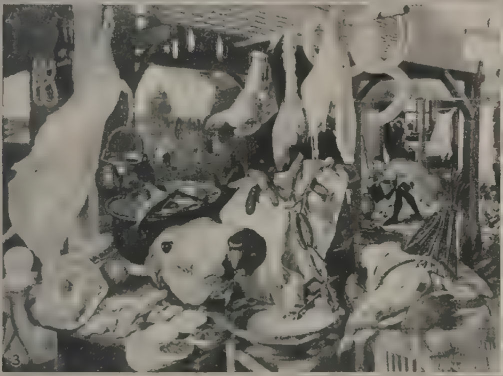
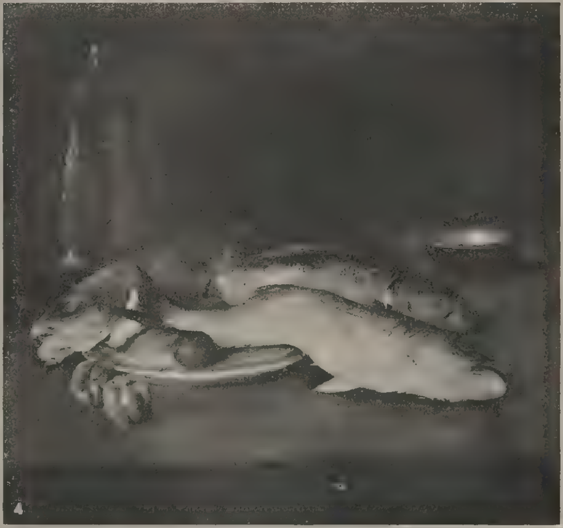
FISH, FRUIT, AND GAME

1. "Still Life" by Willem Kalf (1622–93), who needed only the simple composition of a few peaches, a pitcher and an ornamental wine glass to make a masterpiece. Dutch
2. "Large Still Life With Bird's Nest" by Jan Davidsz Van Heem (1606–84). Dutch. Van Heem's pictures are drawn and coloured exquisitely. His use of chiaroscuro was very effective
3. "Still Life," one of Antoine Vollon's pictures (1833-1900). French. Most of this painter's work was done in one sitting. He painted somewhat after the Dutch manner. In the Louvre
4. "Lobster, Fruit and Flowers" by Cornelius Van Heem (1631–95), son of Jan Davidsz Van Heem. Dutch
5. "Study of Still Life" by Frans Snyder (1579–1657). Flemish. Snyder painted many typical models of still life during the early part of his career. In the Rijks Museum
6. A Still Life by Jean Baptiste Siméon Chardin (1699–1779) depicting a bowl of fruit and a pitcher. Every colour value is observed. Now in Phillips Memorial Gallery, Washington, D.C. French
7. "Fish on a Table" a still life by Alexander Adriaenssen (1587–1661). German









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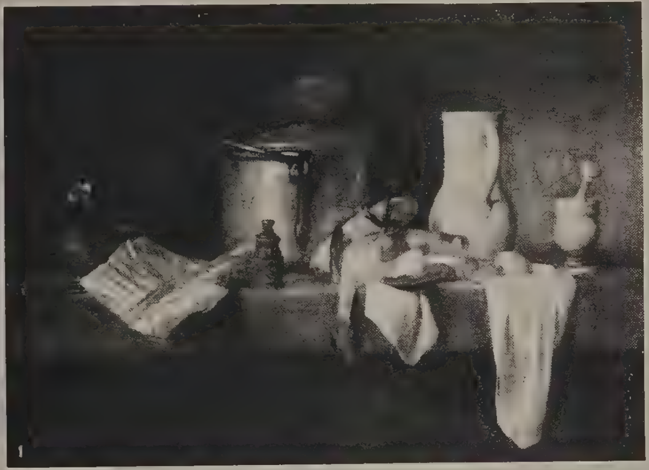
EXAMPLES OF STILL-LIFE ART

1. "Fruit and Game" by Jan Weenix (1640–1719), highly decorative, luxurious surroundings, garden background. Dutch. In Rijks Museum
2. "Dead Game" by Jan Fyt (1611–61), pupil of Franz Snyder (1579–1657), realistic in quality of the painting of the feathers. In The Metropolitan Museum of Art, New York
3. "The Butcher Shop" by Pieter Aertsen (1507-73). Fine quality, excellent perspective, gruesome details have not been overlooked.
4. "Fish," a still-life painting by William Chase (1849–1916), American. In the Metropolitan Museum of Art, New York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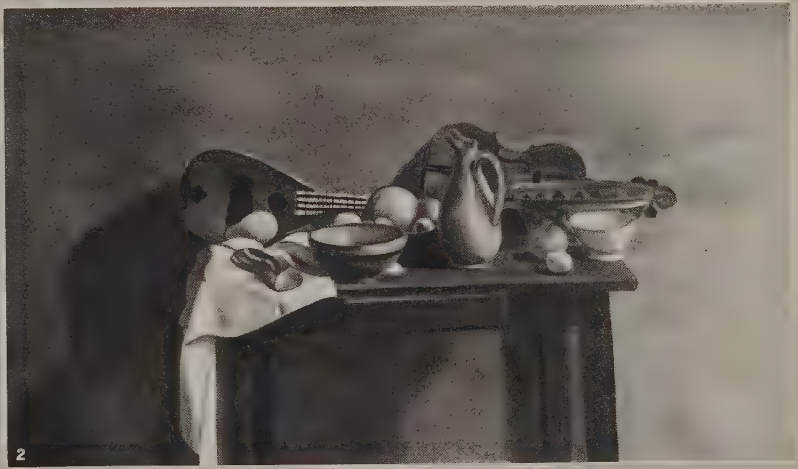
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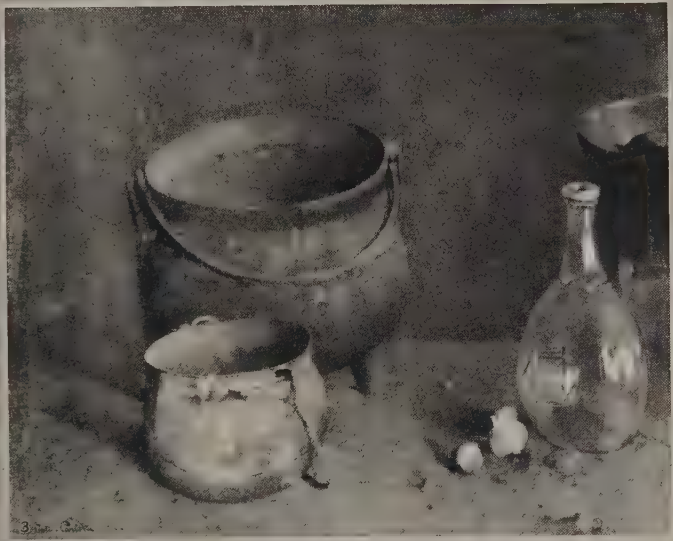
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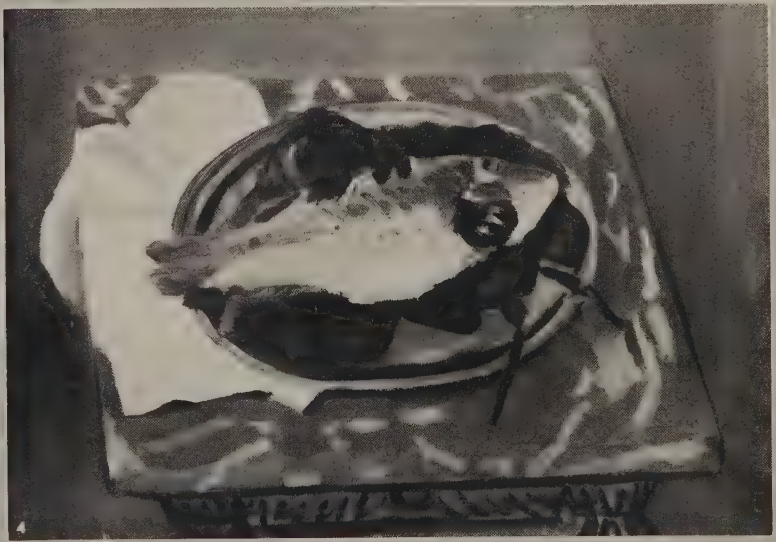
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ARTISTIC STILL-LIFE CANVASES

1. "Kitchen Table" by Jean Baptiste Siméon Chardin (1699–1779); splendid handling of white pigment, as shown in treatment of white jug and fowl. French. Museum of Fine Arts, Boston
2. "The Table" by André Derain (1880–   ), who combined the influence of Cézanne and Gauguin with the primitive. French
3. "Hearthstone" by Emil Carlsen (1853–   ), characterised by simplicity of treatment and faithful portrayal of homely utensils. American
4. "Fish" by Henri Matisse (1869–   ), noted for sureness and simplicity in his drawings. French. In the Tate Gallery, London

although correct in drawing, well coloured and a picture most interesting, it is in questionable taste.

Abraham van Beyeren (1620–75) stands out as one of the foremost painters of fish, producing well composed paintings, glowing with bright colours and glistening surfaces. The painting of wet, sparkling fish gives opportunities to the student for the study of brilliant light against the deep and rich notes in the wet fish, and as the fish very soon deteriorates in colour and form, the canvas must be painted quickly, in the heat of enthusiasm, thus bringing forth the finest results, the most spontaneous work.

Joachim Buckelaer painted fish, as did Alexander Adriassen and, in their late years, Vollon, Manet and Chase.

Jan Davidszoon de Heem and his son, Cornelius de Heem, the two most celebrated members of a large family of still-life painters, are separately noticed. Jan was one of the earliest and ablest. The realism of the individual flower or peach was more desired by these painters than the ensemble of the picture. Jan van Huysum (*q.v.*) reached the top as a flower painter whose style was similar to that of the de Heems.

Willem Kalf, like Willem Claesz Heda, had finer perception of tone and envelopment. Both were painters of rich objects that were executed in the adopted style of the Dutch, but with keen observation of values and tonality; they were taught by masters like Vermeer and Terborch.

Franz Snyders's large game compositions are highly decorative, his fruit rich in colour, well drawn and painted, but overfilled with details and without concentration of the motif. No air in them! The pictures of game that his pupil, Jan Fyt, painted are well studied, realistic in the weight of deer and hare, and in the quality of the painting of fur and feathers. Jan Weenix was a highly decorative painter of dead game in luxurious surroundings, garden backgrounds with decorated vases, the implements for the hunt and its spoils.

In all this interesting still-life work it was always the manner that was considered superior to the matter, and it was always the school that called for excellence of craftsmanship. Every master had his pupils who followed his style; father taught son, and the son taught his son; it was a trade that had to be learned.

Without absolute knowledge of his tools and the preparation of the canvas or panel, one did not count for much in the craft. So-called "visions" were not considered in the Netherlands, as they were in Italy. Pictures that could be studied and loved at short range were called for, and the work could not be carelessly done. Therefore, something was often missing, even in this beautiful work. It left no room for imagination. It was only for the eye—charming to look at, but nothing to dream about—and was generally the work of the painter and rarely of the artist.

Chardin.—Jean Baptiste Simeon Chardin lifted still-life to a higher plane in art than the Hollanders and Flemings of former years. Understanding their methods, he added to their technique air and light as the aim to search for. His simplicity saw beauty in his daily surroundings; his honesty rendered them with absolute truth. Every utensil in his kitchen we know—the copper water-fountain, the charcoal brazier, the brass kettles, the handsome water-jar, the bread knife, as well as the large loaf of bread, the herrings, cuts of meat, onions and pieces of china. Chardin's living-room, we know, with the straight-backed chairs and the bird in its cage on a stand. We know the housewife with her white apron—and how splendid a white! Chardin's whites are miracles of painting. The white jug and the white fowl in the still-life in the Boston museum are unequalled. Few painters of all time have been able to handle white pigment as Chardin could. J. G. Whistler was among the few.

Among his earliest pictures was the "Skate," now in the Louvre. This was accepted by the academy as his diploma picture, simply painted and freer in treatment than other canvases of his early career. He painted a great many interiors, with one or two figures. Again and again it is the light that predominates, the atmosphere of the room or rooms, for we often look through an open door into another room, and that room full of light. Every figure has its weight, stands soundly on its feet and is well in its distance from the onlooker and from the wall behind. As still-life painting or interior with figure, it has every quality known; every colour value is observed, the drawing is easy, never overdrawn, and still never slighted. Chardin's textures are rendered as only a master could paint them; metal is metal and cloth is cloth; every edge, the despair of the average painter, is firm but well blended; light and air are over and around every figure or object. This is still-life painting, an answer to "What is still-life?"

Later Still-life Artists.—Chardin died in 1779, and for nearly a century there were no still-life painters of note; there was practically no interest in *nature morte*. When Courbet started his bold and vigorous manner of painting, he was alone; he painted what he saw and in a manner of his own invention. Whatever in nature looked worth painting he painted—figures, landscape, marines and still-life. His still-life canvases are done truthfully and spontaneously, and are of a flat, well-coloured technique. Several of his pictures have a stag in them, similar in motion to those of Snyders or Weenix, but with more weight and greater originality.

Manet was an artist who painted for excellence, and his still-life work, of which he did a great deal, is always of a high order. Simple and full of light, the canvas is never overfilled. Manet was also an individual who saw with his own eyes and painted in a flat manner, local colour and values being purposely slighted.

Antoine Vollon painted landscapes, but is better known for his still-life, in which he was very prolific. Most of his work was done in one sitting, and in a decorative, well-arranged, somewhat Dutch manner. His picture of "Fish" in the Luxembourg is a splendid piece of painting, with its dark shadows, almost monotone, and the wet and slimy fish in brilliant light. His reputation was widespread while he was alive, but seems somewhat duller at present; however, it will likely come back again, as in the case of Chardin.

Bonvin and Fantin-Latour were men of well-merited reputation. Fantin-Latour's flower paintings are tastefully arranged and finely executed. Bonvin's work, simple and truthful, is based on Chardin's methods.

Of the American painters, William M. Chase (1849–1916) painted fish, pots and brass kettles, and pictures of great brilliancy. Julian Alden Weir's flowers are noted for their exquisite delicacy and beauty. (*See* also PAINTING; FLOWER PAINTING.)

(E. CN.)

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STILLMAN, WILLIAM JAMES (1828–1901), American painter and journalist, was born at Schenectady (N. Y.), June 1, 1828. He graduated at Union college, Schenectady, in 1848. He studied art under Frederick E. Church and early in 1850 went to England, where he fell so much under the influence of Rossetti and Millais that on his return home in the same year he speedily became known as the "American Pre-Raphaelite." He studied art under Yvon in Paris, returned to the United States and devoted himself to landscape painting on Upper Saranac Lake in the Adirondacks and in New York City, where he started the *Crayon.* When it failed for want of funds, Stillman removed to Cambridge, Massachusetts. He returned to England, and afterwards painted with Ruskin in Switzerland. He was in Normandy in 1861 when the American Civil War broke out. His health was too weak for him to serve in the Northern ranks and he was appointed United States consul in Rome. In 1865 he resigned, but immediately afterwards he was appointed to Crete. He was an editor of *Scribner's Magazine* for a short time. When in London lived with D. G. Rossetti. When the insurrection of 1875 broke out in Hercegovina he went there as a correspondent of *The Times,* and his letters from the Balkans aroused so much interest that the British government was induced to lend its countenance to Montenegrin aspirations. In 1877–83 he served as the correspondent of *The Times* at Athens; in 1886–98 at Rome. After his retirement he lived in Surrey, where he died on July 6, 1901. He wrote *The Cretan Insurrection* 1866–1868 (1874), *On the Track of Ulysses* (1888), *Billy and Hans* (1897) and *Francesco Crispi* (1899).

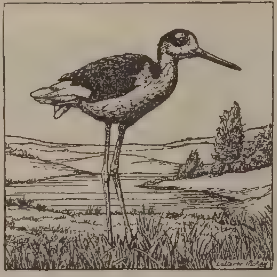
See his *Autobiography of a Journalist* (Boston, 1901).

STILLWATER, a city of eastern Minnesota, U.S.A., on the St. Croix river, at the head of Lake St. Croix, 20 m. N.E. of Saint Paul; the county seat of Washington county. It is served by the Chicago, Milwaukee, St. Paul and Pacific, the Chicago, St. Paul, Minneapolis and Omaha, and the Northern Pacific railways. Pop. (1920) 7,735; (1928 local estimate), 9,000. The city has a picturesque situation on bluffs high above the river. It is the seat of the state prison (established 1851); a shipping point for the agricultural products of the region; and a manufacturing centre of growing importance. Before the exhaustion of the forests, it had a large trade in pine lumber. Stillwater was settled in 1843, laid out in 1848, and chartered in 1854. The "Stillwater Convention" of 1848 was the first step toward the erection of Minnesota Territory.

STILO PRAECONINUS, LUCIUS AELIUS (*c.* 154–74 B.C.), of Lanuvium, the earliest Roman philologist, belonged to the equestrian order. His aristocratic sympathies were so strong that he voluntarily accompanied Q. Caecilius Metellus Numidicus into exile. At Rome he divided his time between teaching and literary work. His most famous pupils were Varro and Cicero, and amongst his friends were Coelius Antipater, the historian, and Lucilius, the satirist, who dedicated their works to him. Only a few fragments of his works remain. He wrote commentaries on the hymns of the Salii, and (probably) on the Twelve Tables; and investigated the genuineness of the Plautine comedies, of which he recognized 25, four more than were allowed by Varro. The rhetorical treatise *Ad Herennium* has been attributed to him by some modern scholars.

See Cicero, *Brutus,* 205–207, *De legibus,* ii. 23, 59; Suetonius, *De grammaticis,* 2; Gellius iii. 3, 1. 12; Quintilian, *Inst. orat.* x., 1, 99; monographs by J. van Heusde (1839) and F. Mentz (1888); Mommsen, *Hist. of Rome,* bk. iv. ch. 12, 13; J. E. Sandys, *History of Classical Scholarship* (2nd ed., 1906); M. Schanz, *Geschichte der römischen Literatur* (1898), vol. i.; Teuffel, *Hist. of Roman Literature* (Eng. trans., 1900), p. 148.

STILT (*Himantopus himantopus*), a bird of the plover family (*see* PLOVER), remarkable for the extreme length of its slender legs. The bill is long and straight; the legs red; the wings and back black; the head, neck and lower parts white. The sexes are alike. Its food consists of small anthropods, which it obtains by wading in shallow water. It ranges over Europe and Asia, not breeding northward of the Danube valley. The nest is a slight structure on the margin of a pool or lake, and contains four eggs, which resemble those of the oyster-catcher (*q.v.*). In America, from Oregon southward to Brazil, occurs the black-necked stilt, *H. nigricollis.* Other species occur in South America, Australia and New Zealand. The stilts are allied to the avocets (*q.v.*), and, like them, spend much time wading in shallow water.



THE STILT (HIMANTOPUS HIMANTOPUS)

STILTS, poles with footrests fixed at a certain distance above the ground. They were originally designed for use in crossing rivers and marshes. As a means of amusement stilts have been used by all peoples in all ages, as well as by the inhabitants of marshy or flooded districts. The city of Namur in Belgium, which formerly suffered from the overflowing of the rivers Sambre and Meuse, has been celebrated for its stilt-walkers for many centuries. Not only the townspeople but also the soldiers used stilts. The governor of Namur having promised the archduke Albert (about 1600) a company of soldiers that should neither ride nor walk, sent a detachment on stilts, which so pleased the archduke that he conferred upon the city perpetual exemption from the beer-tax, no small privilege at that time.

The home of stilt-walking at the present day is the department of Landes in Gascony, where, owing to the impermeability of the subsoil, all low-lying districts are converted into marshes. Stilts used by children are very long, the upper half being held under the arms; they are not strapped to the leg.

STIMSON, HENRY LEWIS (1867–), American lawyer and statesman, was born in New York city on Sept. 21, 1867, and educated at Yale (A.B., 1888) and Harvard (A.M., 1889) universities. He attended the Harvard Law school and in 1891 was admitted to the New York bar. He was subsequently a member of the firms of Root and Clark, 1893–97; Root, Howard, Winthrop and Stimson, 1897–1901, and after 1901 of Winthrop and Stimson. His abilities as a lawyer brought him into prominence and in 1906 he was appointed U.S. attorney for the southern district of New York State. This position he relinquished in 1910 to become the unsuccessful candidate of the Republican party for governor of New York. In 1911 he was appointed secretary of War by President Taft, in which office he continued from May 1911 to March 1913. He subsequently resumed his law practice, which was interrupted during U.S. participation in the World War by his service in France as colonel of the 31st Field Artillery. In 1927 he was sent by President Coolidge as a special commissioner to Nicaragua, where he met President Diaz and the rebel leader Moncada and was instrumental in persuading both leaders to lay down their arms on condition that the United States would supervise the 1928 election. His success on this mission, together with his study of the Philippine question in 1926, led to his appointment, in Dec. 1927, as governor-general of the Philippine Islands, in which position he succeeded Maj.-gen. Leonard Wood, whose policies he continued to carry out with notable success. Early in 1929 he was appointed secretary of State by President Hoover and in March of that year he took over the duties of his new office. He is the author of *The American Policy in Nicaragua* (1927) and numerous magazine articles.

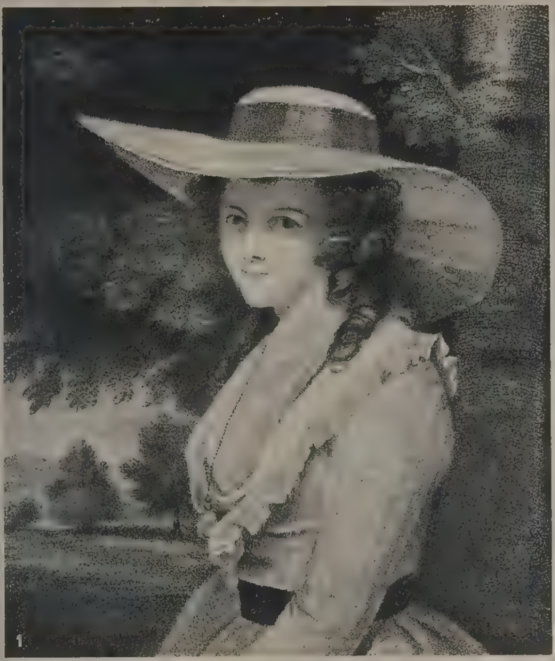
STINKHORN (*Phallus*), a genus of basidiomycete fungi, so called from the carrion-like smell of the spore-cap, which breaks down into a slimy, dripping mass. Flies are attracted by the smell, and disperse the spores.

STINK-WOOD, a South African tree, known botanically as *Ocotea bullata,* and a member of the family Lauraceae. Other names for it are Cape walnut, stinkhout, Cape laurel and laurel wood. It derives its name from having a strong and unpleasant smell when freshly felled. It is used for building in South Africa and is said to be a substitute for teak and equally durable. The wood is dark walnut or reddish brown to black with a yellow sapwood, and the grain extremely fine, close, dense and smooth.

STINNES, HUGO (1870–1924), German industrialist, was born in Mülheim on Feb. 12, 1870. Educated as a mining engineer, he entered his grandfather's firm in 1890, but two years later established a business of his own, with a capital of 50,000 marks. The business expanded steadily and came to include, besides dealing in coal, the ownership of coal mines, barges, river steamers and sea-going vessels. Stinnes organized an international business in coal, including the importation of coal from England. He built up a fleet of steamers trading in the North Sea, the Baltic, the Mediterranean and the Black Sea. He also established iron and steel factories. During the World War he commanded a large share of the industrial work required by the German authorities, and rapidly increased his shipping interests. In 1920 he entered the Reichstag as a member of the German People's Party (the former National Liberal party). He began to buy up newspapers, whose democratic opinions were quickly modified in accordance with his own. In 1921 he was reported to be contemplating the formation of a super-trust to control the whole of German industry. He died in Berlin April 10, 1924. After his death the business, conducted by his son, rapidly shrank. In June 1925 a conference of bankers was called to investigate the financial affairs of the trust; and bit by bit the great organization was liquidated and sold. In Oct. 1925 a new company was registered at Hamburg under the title of Hugo Stinnes Coal Trade and Shipping Co., Ltd., the Stinnes family retaining 40% of the shares.

STIPPLE AND CRAYON ENGRAVING. Stipple-engraving was a little art of prettiness and daintiness, particularly well adapted to the translation of anecdotic pictures of a sentimental, mildly romantic, or domestic character, such as were

STIPPLE AND CRAYON ENGRAVING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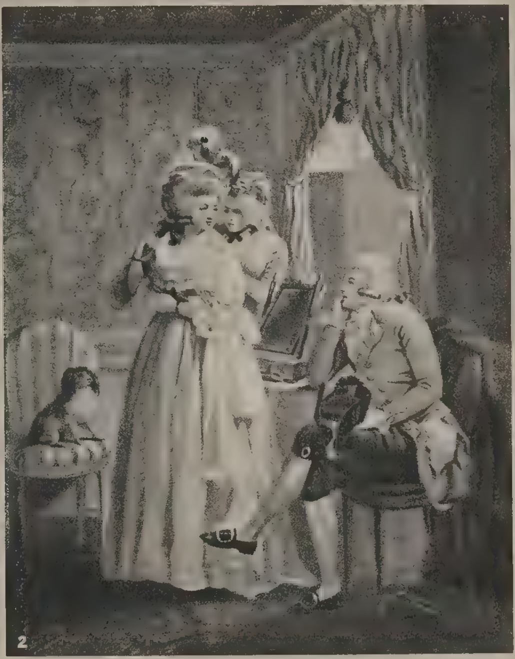
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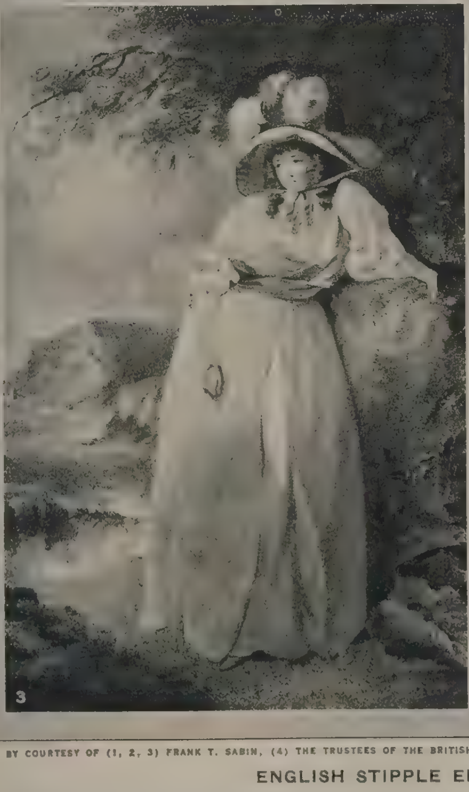
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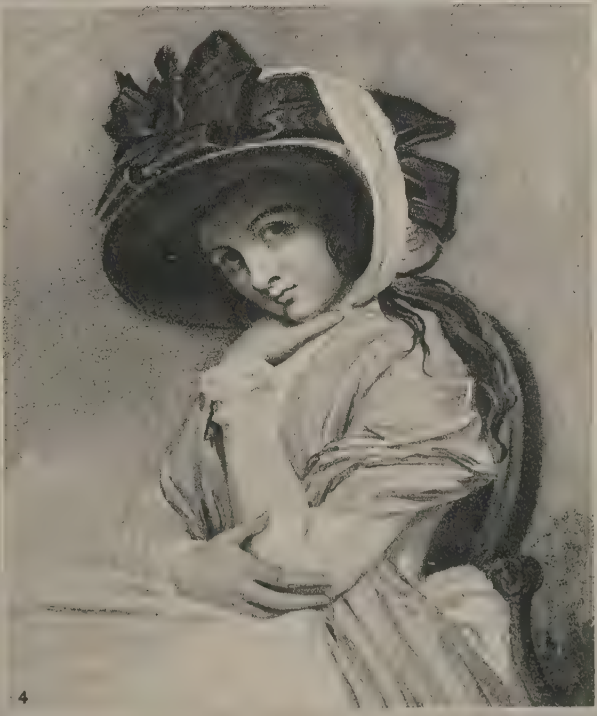
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ENGLISH STIPPLE ENGRAVINGS OF THE 18TH CENTURY

Stipple engraving consists of a design drawn in a series or group of dots through an etching ground on a copper plate, and bitten with acid, then completed with dots made directly in the copper by a curved stipple-graver and perhaps a toothed wheel called a roulette

1. "Countess Spencer," engraved by Francesco Bartolozzi (1727–1813) after the painting by Sir Joshua Reynolds (1723–92). 2. "Dressing for the Masquerade," engraved by John Raphael Smith (1752–1812) after the painting by George Morland (1763–1804). 3. "Constancy," engraved by William Ward (1766–1826) after the painting by George Morland. 4. "Emma," engraved by John Jones (1745–97) after the painting by George Romney (1734–1802)

turned out in great numbers to supply a vogue in the English market during the reign of George III., many of which, popular in their day, survive only in the colour-prints and, though rarely of much artistic value, are yet now highly valued for their merit in survival. Nevertheless there were in the brief hey-day of the art a few among the multitude of designers and engravers who, realizing its limitations, made the most of its qualities, and these, such as J. R. Smith, William Ward and John Jones, the great mezzotinters Charles Wilkin, Thomas Burke, and whenever he chose to do so, Francesco Bartolozzi, with Peltro William Tomkins, Knight, Cheeseman, Schiavonetti, and others of the school, used the medium with individuality, undeniable charm and some artistic effect.

As a separate method, stipple-engraving came to England from France probably about 1764, by way of the crayon manner and the pastel, and these had evolved originally from the dotted manner, to which Ludvig von Siegen refers, in announcing the wonders of his own invention of mezzotint in 1642, as one of the modes of engraving which it was not. The dotted manner, a process of punching the plate with awl and mallet, called *opus mallei,* was used for its own sake with pictorial effect by Jan Lutma, an Amsterdam goldsmith, and the son of Rembrandt's sitter; but graven dots had been used earlier as accessory to line-engraving by Giulio Campagnola, Ottavio Leoni, and others, while in England the earliest important engraver of portraits, William Rogers, in Queen Elizabeth's reign, had stippled the face of the Queen, while Lucas Vorsterman used dots also to suggest the flesh in his head of Charles I.

But in the 18th century, when the crayon and pastel drawings of Boucher and others were popular in France, the aim of the engravers was to reproduce their texture on the copper-plate. The idea was in the air, so to speak, and several were engaged in the attempt to materialize it. Thus the invention of the crayon manner was claimed separately by Jean Charles François, Gilles Demarteau, who used his own version of it with artistic feeling, and Louis Marin Bonnet, an ingenious engraver to whom we owe at least the "pastel manner." This was a subtle development of the crayon mode admitting colour variety from a series of plates, as we may see in Bonnet's really fine print, *La Tête de Flore,* after Boucher, but François seems to have been actually the first in the field. The means used to imitate crayon drawing resembled soft-ground etching, though to produce the appearance of the chalk lines the etching-ground was perforated by tools of the roulette order, and various kinds of needles, while, after the usual biting by the acid, the finishing touches were given by graver, dry-point and roulette, though one often fancies the methods of soft-ground had been employed. François taught this crayon engraving, and with it the application of colour in printing *à la poupée,* to William Wynn Ryland, a young English line-engraver, who had been studying with Le Bas in Paris, and who, when funds were lacking after his return to London, bethought him of the new manner of engraving he had learnt. Then having called Bartolozzi into collaboration, they both modified and developed it as stipple-engraving.

The new method proved very easy of accomplishment, simple and rapid. The outline was etched in a series of dots, and all the shadows were put in with large or closer dots, or tiny groups of dots. When all the biting was over, the ground was removed, and the finishing was done with dry-point and stipple-graver, a curved tool. Then the printing was done with black, red, or several coloured inks, a rag-stump, or *poupée,* being used, and the plate freshly cleaned for each impression. Beginning by translating the pretty pseudo-classical designs of Angelica Kauffman and Cipriani, which acquired a very popular vogue, Ryland and Bartolozzi found the new method exceedingly profitable. To the ready hand of Bartolozzi it came almost as a fairy gift, with the facilities of the medium linking themselves to his sweet caressing sense of beauty. Indeed, he developed it with richer character in its fine shades than the unfortunate Ryland could do, as we may see in many notable prints after Reynolds and other distinguished painters. All the painters of the day were anxious to share in the profits so readily made by the stipple-prints which were filling the print-sellers' windows, and few native engravers could resist the easy attraction of the new method, while it brought also Italian and French engravers to learn it, and work here for the English market. There was also, up to the war with revolutionary France in 1793, a great trade in English prints on the continent, and Bonnet and other French engravers, adopting the stipple method, tried to get a share in this trade by issuing prints with titles often in misspelt English. Sir Robert Strange, the eminent line-engraver, launched an indignant tirade against stipple, and even denied its claim to be regarded as engraving at all, though there was no denying its efficacy as a medium for colour-printing, the white of the paper, showing between the tinted dots, affording a peculiarly luminous quality, and thus giving it a superiority over the coloured mezzotint, though it must be admitted that rarely was the stipple or the mezzotint of old time completely printed in colours, some portions invariably being left to be coloured by hand. Nevertheless, the popularity of stipple continued as long as the special subjects for which it was used remained in fashion, and as long as the leading 18th century painters and engravers survived the period of their comparatively short though successful collaboration, but it really waned with the advent of colour-lithography. Stipple-engraving is rarely practised nowadays as a separate art, though a recent attempt has been made to revive it for original expression by Dorothy Woollard. As a medium for original colour-printing it has completely given place to aquatint, woodcut or wood engraving, lithography, or relief-etching from several plates.

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STIRES, ERNEST MILMORE (1866–), bishop of Long Island, was born in Norfolk, Va., on May 20, 1866. He received the degree of B. Litt. at the University of Virginia in 1888, and from 1889–91 continued his studies at the Episcopal Theological seminary of Virginia, receiving the degree of D.D. at Trinity college in 1901. The degree of LL.D. was conferred upon him at Kenyon college in 1903. He received his first appointment as rector at West Point in 1891, and in 1893 went to the Church of the Good Shepherd in Augusta, Ga. In the same year he was called to Grace church, Chicago, where he remained until 1901. He then accepted a call to St. Thomas's church, New York. Under his pastorate the parish became one of the most important in the country. He was consecrated bishop of Long Island on Nov. 24, 1925.

STIRLING, WILLIAM ALEXANDER, Earl of (*c.* 1567–1640), Scottish poet and statesman, generally known as William Alexander, was born at Menstrie House, near Stirling, about 1567, and probably educated at Stirling Grammar school. He may also have been to the universities of Glasgow and Leyden. He followed James VI. to England, where he became one of the gentlemen-extraordinary of Prince Henry's chamber. For the prince he wrote his *Paraenesis to the Prince . . .* (1604), a poem in eight-lined stanzas on the theme of princely duty. He was knighted in 1609; in 1614 he was appointed master of requests, and in July 1615 to a seat in the Scottish privy council. In 1613 he began a correspondence with Drummond of Hawthornden. In 1621 he received from James I. enormous grants of land in America, including Nova Scotia and New Brunswick, and was appointed lieutenant-governor of the new colony which, however, was ceded to the French in 1632. (*See* Nova Scotia: *History.*) From 1626 till his death he was the king's secretary for Scotland, and in 1630 was created viscount Stirling and Lord Alexander of Tullibody. In 1631 he edited and published a translation of the Psalms said to be by James I. In 1639 he became earl of Donovan. He died on Feb. 12, 1640, in London.

Alexander's poetical miscellanies and minor verse include *Aurora,* containing the first fancies of the author's youth (1604); *An Elegie on the Death of Prince Henrie,* and shorter pieces. He also wrote four tragedies, *Darius* (1603); *Croesus* (1604); *The Alexandrean* (1605), and *Julius Caesar* (1607); the first two of which were published together in 1604 as the *Monarchicke Tragedies;* they are didactic poems or dialogues rather than plays, but they contain some fine soliloquies. Of Alexander's heroic poem *Jonathan* only the first book was written. *Domesday,* or *The Great Day of the Lord's Judgment* (1614) is a dreary production, in 12 books or "hours," in eight-lined stanzas. A collected edition of his work appeared in 1637, with the title *Recreations with the Muses* (folio), but did not include *Aurora* and the *Elegie.* A complete modern reprint *The Poetical Works,* etc., was published in 3 vols. (Glasgow, 1870).

His *Encouragement to Colonies* was edited for the Bannatyne Club by David Laing (1867), and by Edmund F. Slafter, in *Sir W. Alexander and Amer. Colonization* (Prince Society, Boston, Mass., 1865). *See* also E. F. Slafter, *The Copper Coinage of the Earl of Stirling, 1632* (1874); *The Earl of Stirling's Register of Royal Letters relative to the Affairs of Scotland and Nova Scotia from 1615–1635* (edit. C. Rogers, with biographical introduction 1884–85); C. Rogers, *Memorials of the Earl of Stirling* (1877); the introduction to the *Works* (1870) referred to above; the *Register of the Privy Council of Scotland, passim;* and the bibliography for William Drummond (*q.v.*) of Hawthornden.

STIRLING, WILLIAM ALEXANDER, titular EARL OF (1726–1783), American soldier, was born in New York city. He served first as commissary and then as aide-de-camp to Governor William Shirley at the beginning of the French and Indian War, and in 1756 he accompanied Shirley to England, where he prosecuted his claim to the earldom of Stirling. In 1759 an Edinburgh jury declared him to be the nearest heir to the last earl of Stirling, and in 1761 he returned to America and assumed the title of Lord Stirling by which he was afterwards known in America. He became a member of the New Jersey provincial council and surveyor general of the colony. In 1775 he sided with the patriot cause and was appointed colonel of a regiment in New Jersey. In March he became brigadier-general, and for a time was in command at New York, and supervised the fortification of the city and harbour. At the battle of Long Island he was taken prisoner, but was soon afterwards exchanged, and in Feb. 1777 became a major-general. He participated in the battles of Trenton, Princeton, Brandywine and Germantown, and especially distinguished himself at Monmouth. He took an active part in exposing the Conway Cabal, presided over the court-martial of General Charles Lee, and enjoyed the confidence of Washington to an unusual degree. In Oct. 1781 he took command of the northern department at Albany to check an expected invasion from Canada. He died at Albany on Jan. 15, 1783. He was a member of the board of governors of King's college (now Columbia university) and was devoted to the study of mathematics and astronomy.

See W. A. Duer, "Life of William Alexander, Earl of Stirling," in Vol. ii. of the *Collections of the New Jersey Hist. Soc.* (1847).

STIRLING, royal, municipal and police burgh, parish, river port and county town of Stirlingshire, Scotland. Pop. (1921), 21,345. It is finely situated on the right bank of the Forth, $39\frac{3}{4}$ m. N.W. of Edinburgh and $29\frac{1}{2}$ m. N.E. of Glasgow, being served by the L.N.E. and L.M.S. railways. The old town occupies the slopes of a basaltic hill (420 ft. above the sea) terminating on the north and west in a precipice. The modern quarters have been laid out on the level ground at the base, especially towards the south. Remains of a town wall exist at the south end of the Black walk. Formerly there were two main entrances—the South port and the "auld brig" over the Forth to the north, a high-pitched structure of four arches, now used only by foot-passengers. It dates from the end of the 14th century and was once literally "the key to the Highlands." Just below it is the bridge erected in 1829 from designs by Robert Stevenson, and below this again the railway viaduct. The castle crowning the hill is of unknown age, but from the time that Alexander I. died within its walls in 1124 till the union of the crowns in 1603 it was intimately associated with the fortunes of the Scottish monarchs. It is approached from the esplanade, on which stands a colossal statue of Robert Bruce. The main gateway, built by James III., gives access to the lower and then to the upper square, on the south side of which stands the palace, begun by James V. (1540) and completed by Mary of Guise. The east side of the quadrangle is occupied by the parliament house, a Gothic building of the time of James III., now used as a barrack-room and stores. On the north side of the square is the chapel royal, founded by Alexander I., rebuilt in the 15th century and again in 1594 by James VI. (who was christened in it), and afterwards converted into an armoury and finally a store-room. Below it is Gowan hill, and beyond this the Mote or Heading hill, on which Murdoch Stuart, 2nd duke of Albany, his two sons, and his father-in-law the earl of Lennox, were beheaded in 1425. In the plain to the south-west were the King's gardens, now under grass, with an octagonal turf-covered mound called the King's Knot in the centre. Farther south lies the King's park. On a hill of lower elevation than the castle and separated from the esplanade by a depression styled the Valley—the tilting-ground of former times—a cemetery has been laid out. Here is the Virgin Martyrs' Memorial, in memory of Margaret Maclachlan and Margaret Wilson, who were drowned by the rising tide in Wigtown bay for their fidelity to the Covenant (1685); the large pyramid to the memory of the Covenanters, and the Ladies' rock, from which ladies viewed the jousts in the Valley. Adjoining the cemetery on the south is the parish church, portions of which may have formed part of the first church, founded by David I. Since the Reformation it has been divided into two churches. The choir (the East church) was added in 1494 by James IV., and the apse a few years later. At the west stands the stately battlemented square tower. The nave (the West church) is a transition between Romanesque and Gothic, with pointed windows. The crow-stepped Gothic gable of the south transept affords the main entrance to both churches. The choir is in the Decorated and Perpendicular styles. Within its walls Mary Queen of Scots was crowned in 1543, when nine months old, and in the same year the earl of Arran, regent of Scotland, abjured Protestantism; in 1544 an assembly of nobles appointed Mary of Guise queen-regent; on July 29, 1567, James VI. was crowned, John Knox preaching the sermon, and in Aug. 1571 and June 1578 the general assembly of the Church of Scotland met. James Guthrie (1612–1661), the martyr, and Ebenezer Erskine (1680–1794), founder of the Scottish Secession Church, were two of the most distinguished ministers. To the south-west of the church is Cowane's Hospital, founded in 1639 by John Cowane, dean of gild, and now used as a gildhall. Adjoining it is the military prison. Near the principal entrance to the esplanade stands Argyll's Lodging, erected about 1630 by the 1st earl of Stirling. On his death in 1640 it passed to the 1st marquess of Argyll and is now a military hospital. Broad street contains Mar's Work, the palace built by John Erskine, 1st (or 6th) earl of Mar, about 1570, according to tradition, out of the stones of Cambuskenneth Abbey; the old town house, erected in 1701 to replace that in which John Hamilton, the last Roman Catholic archbishop of St. Andrews, was hanged for alleged complicity in the murders of Darnley and the regent Moray; the town cross, restored in 1891, and the house which was, as a mural tablet says, the "nursery of James VI. and his son Prince Henry." The Smith institute, founded in 1873 by Thomas Stewart Smith, an artist, contains a picture-gallery, museum and reading-room. Woollen spinning and manufactures are the staple industry, and iron-founding, carriage-building and agricultural implement-making are also carried on, in addition to furniture factories, cooperage and rubber works. There is some shipping from the small harbour, which is accessible only at high water.

Stirling is under the jurisdiction of a council with provost and bailies, and, with Falkirk and Grangemouth, returns a member to Parliament. The Abbey Craig, an outlying spur of the Ochils, $1\frac{1}{2}$ m. north-east of Stirling, is a thickly-wooded hill on the top of which stands the Wallace monument (1869), a baronial tower, with a valhalla containing busts of eminent Scotsmen. Cambuskenneth abbey, on the left bank of the Forth, about 1 m. E.N.E. of Stirling, was founded by David I. in 1147 for monks of the order of St. Augustine. Several Scots parliaments met within its walls. At the Reformation Mary Queen of Scots bestowed it on the 1st earl of Mar (1562), who is said to have used the stones for his palace in Stirling. All that remains of the abbey is the massive, four-storeyed tower, the west doorway and the foundations of some of the walls. The bones of James III. and his queen, Margaret of Denmark, who were buried within the precincts, were discovered in 1864 and re-interred next year under a tomb at the high altar.

Stirling was known also as Snowdoun, which became the official title of the Scots heralds. The Romans probably had a station here. In 1119 it was a royal burgh and under Alexander I. was one of the Court of Four Burghs (superseded under James III. by the Convention of Royal Burghs). In 1174 it was handed over to the English in security for the treaty of Falaise, being restored to the Scots by Richard I. The earliest known charter was that granted in 1226 by Alexander II., who made the castle a royal residence. The fortress was repeatedly besieged during the wars of the Scottish Independence. In 1304 it fell with the town to Edward I. The English held it for ten years, and it was in order to raise the Scottish siege in 1314 that Edward II. risked the battle at Bannockburn. Edward Baliol surrendered it in 1334 in terms of his compact with Edward III., but the Scots regained it in 1339.

From this time till the collapse of Queen Mary's fortunes in 1568, Stirling almost shared with Edinburgh the rank and privileges of capital of the kingdom. It was the birthplace of James II. in 1430 and probably of James III. and James IV. In 1571 an attempt was made to surprise the castle by Mary's adherents, the regent Lennox being slain in the fray, and seven years later it was captured by James Douglas, 4th earl of Morton, after which a reconciliation took place between the Protestants and Roman Catholics. It was occupied in 1584 by the earls of Angus and Mar, the Protestant leaders, who, however, fled to England on the approach of the king. Next year they returned with a strong force and compelled James VI. to open the gates, his personal safety having been guaranteed. In 1594 Prince Henry was baptized in the chapel royal, which had been rebuilt on a larger scale. After the union of the crowns (1603) Stirling ceased to play a prominent part on the national stage. The privy council and court of session met in the town in 1637 on account of the disturbed state of Edinburgh. In 1641 Charles I. gave it its last governing charter, and four years afterwards parliament was held in Stirling on account of the plague in the capital, but the outbreak of the pest in Stirling caused the legislators to remove to Perth. During the Civil War the Covenanters held the town, to which the committees of church and state adjourned after Cromwell's victory at Dunbar (1650), but in August next year the castle was taken by General Monk. In 1715 the 3rd duke of Argyll held it to prevent the passage of the Forth by the Jacobites, and in 1746 it was ineffectually besieged by Prince Charles Edward.

STIRLING NUMBERS, in mathematics. In the year 1730 James Stirling, in his *Methodus Differentialis* introduced into analysis two sets of numbers which, because of their uses in various branches of analysis, their properties, and the methods used in their computation, have continued to attract the attention of mathematicians.

One of the latest writers on the subject, Professor Nielsen of Copenhagen has named them "Stirling numbers of the first and second kind" in honour of their discoverer.

Definitions.—The Stirling numbers of order n of the first kind may be defined as the co-efficients in the expansion of

$$(1+x)(1+2x)\cdots(1+nx)=1+{}_nS_1x+{}_nS_2x^2+{}_nS_3x^3+\cdots$$

in ascending powers of x, while the Stirling numbers of the second kind are found in

$$\frac{1}{(1+x)(1+2x)\cdots(1+nx)}=1-{}_nT_1x+{}_nT_2x^2-{}_nT_3x^3+\cdots,$$

also in ascending powers of x.

This definition immediately leads to the following theorems:

(*a*) The P^{th} Stirling number of order n of the first kind is equal to the sum of the products of the first n integers taken P at a time without repetition.

(*b*) The P^{th} Stirling number of the second kind of order n is equal to the sum of the products of the first n integers taken P at a time with repetitions.

Stirling used the numbers now named after him as a tool for expressing X^n as a series of factorials.

$$\begin{aligned}
x^2&=x(x-1)+x,\\
x^3&=x(x-1)(x-2)+3x(x-1)+x,\\
x^4&=x(x-1)(x-2)(x-3)+6x(x-1)(x-2)+7x(x-1)+x,\\
x^5&=x(x-1)(x-2)(x-3)(x-4)+10x(x-1)(x-2)(x-3)-\\
&\qquad+25x(x-1)(x-2)+15x(x-1)+x.
\end{aligned}$$

The coefficients of the various factorials (1·1; 1·3·1; 1·6·7·1; 1·10·25·15·1) are the Stirling numbers of the second kind. For about 150 years mathematicians considered it important to be able to express algebraic expressions in form of sequences of factorials. The result was a rich literature consisting of memoirs dealing with the peculiarities of this method of expression. In the year 1846 Weierstrass proved the general futility of this mode of notation, and since then the subject of "factorial notation" has slowly but surely been eliminated as a topic of discussion in mathematical literature. At present it is used only in certain problems of finite summation, in theories of interpolation, and as an example illustrating some of the uses of the Stirling numbers.

Applications.—George Boole in his treatise on the calculus of finite differences calls attention to the "system of numbers expressed by $\Delta^n\,O^m$ (differences of nothing)" without indicating whether he realized that these numbers were already used by Stirling. The formula given by Boole for $\Delta^n\,O^m$ may well be used for the calculation of the above mentioned coefficients T; *i.e.*, the Stirling numbers of the second kind,

$$\frac{1}{n!}\,{}_nT_{m-n}=n^m-\binom{n}{1}(n-1)^m+\binom{n}{2}(n-2)^m-\binom{n}{3}(n-3)^m+\cdots$$

The Stirling numbers of the second kind (T) also appear in the expansion of $(e^x-1)^p$. Thus,

$$\begin{aligned}
\frac{1}{2!}(e^x-1)^2&=\frac{x^2}{2!}+\frac{{}_2T_1x^3}{3!}+\frac{{}_2T_2x^4}{4!}+\cdots\\
\frac{1}{3!}(e^x-1)^3&=\frac{x^3}{3!}+\frac{{}_3T_1}{4!}x^4+\frac{{}_3T_2x^5}{5!}+\cdots\\
\frac{1}{p!}(e^x-1)^p&=\frac{x^p}{p!}+\frac{{}_pT_1}{(p+1)!}x^{p+1}+\frac{{}_pT_2}{(p+2)!}x^{p+2}+\cdots
\end{aligned}$$

Formulas.—Of the recurring formulas the most important are

$$\begin{gathered}
{}_{n+1}S_p={}_nS_p+n\cdot{}_nS_{p-1},\\
{}_{n+1}T_p={}_nT_p+n\cdot{}_{n+1}T_{p-1}.
\end{gathered}$$

Of the independent formulas developed by various writers, none is suitable for practical purposes; but theoretically the following formulas which appear in a work by Ettinghausen (1826) are important:

$${}_nS_p=\Sigma\,\frac{(n+1).}{a!\,b!\,c!\cdots1^a\,2^b\,3^c\cdots}$$

for all integral values of $a,b,c\ldots$ satisfying the equations:

$$\begin{gathered}
a+b+c+\cdots=p+1,\\
a+2b+3c+\cdots=n+1,
\end{gathered}$$

and

$${}_nT_p=\Sigma\,\frac{(n+p)!}{a!b!c!\cdots1^a(2!)^b(3!)^c\cdots}$$

for all integers satisfying the equations

$$\begin{gathered}
a+b+c+\cdots=p,\\
a+2b+3c+\cdots=n+p.
\end{gathered}$$

Relations between the S's and the T's are given by

$${}_nT_p=\begin{vmatrix}
{}_nS_1 & 1 & \cdots & 0\\
{}_nS_2 & {}_nS_1 & \cdots & 0\\
\cdot & \cdot & \cdots & \cdot\\
\cdot & \cdot & \cdots & 1\\
{}_nS_p & {}_nS_{p-1} & \cdots & {}_nS_1
\end{vmatrix},\ \text{and}\ {}_nS_p=\begin{vmatrix}
{}_nT_1 & 1 & \cdots & 0\\
{}_nT_2 & {}_nT_1 & \cdots & 0\\
\cdot & \cdot & \cdots & 0\\
\cdot & \cdot & \cdots & 1\\
{}_nT_p & {}_nT_{p-1} & \cdots & {}_nT_1
\end{vmatrix}.$$

The second formula is evidently obtained from the first by interchanging the *T's* and the *S's*.

It has also been observed (*Amer. Math. Monthly,* 1928) that the Stirling numbers of the first kind can be obtained by performing the algebraic divisions,

$$\frac{2+x}{(1-x)^5},\quad \frac{6+8x+x^2}{(1-x)^7},\quad \frac{24+58x+22x^2+x^3}{(1-x)^9}\ \ldots$$

while the Stirling numbers of the second kind appear in the quotients of

$$\frac{1+2x}{(1-x)^5},\quad \frac{1+8x+6x^2}{(1-x)^7},\quad \frac{1+22x+58x^2+24x^3}{(1-x)^9}\ \ldots$$

The Stirling numbers have many important relationships to the Bernoulli numbers (*q.v.*), Euler numbers (*q.v.*), and the tangential coefficients, and there are numerous formulas connecting them. In fact, there is a way of regarding the Bernoulli numbers as a species of Stirling numbers; that is $(e^x-1)^n$ always gives, when expanded, Stirling numbers; and when we let $n=-1$, we obtain a well-known expansion giving the Bernoulli numbers.

The consideration of $(e^x-1)^{-n}$ leads to what may be called ultra-Stirling numbers, a subject which, like the ultra-Bernoulli and ultra-Euler numbers has been very little studied.

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STIRLINGSHIRE, midland county, Scotland, bounded north by Perthshire, north-east by Clackmannanshire and the Firth of Forth, south-east by Linlithgowshire, south by Lanarkshire and the detached part of Dumbartonshire and south-west and west by Dumbartonshire; area 288,842 ac. (excluding water). In the north-west the Grampians culminate in Ben Lomond (3,192 ft.), and the centre is occupied by the Lennox hills. The oldest rocks are the Dalradian schists in the north-west beyond a great fault which runs from near the bottom end of Loch Lomond in a north-easterly direction across Scotland. On the south-eastern side of the fault are the conglomerates and sandstones of Lower Old Red Sandstone age, followed by the Upper Old Red series. Then follows the Carboniferous system occupying the rest of the county. The true coal-measures are well-developed between Grangemouth and Stenhousemuir and about Falkirk. Intrusive sheets of basalt have penetrated the Carboniferous rocks and are quarried for road metal; Abbey Craig and Stirling Castle hill are formed of one of the more important of these intrusions. Much boulder clay covers the older rocks and an interesting blue marine clay is found beneath it in the Endrick valley. The Carse of Stirling is overlaid by the muds and sands of the 50-ft. raised beach; and traces of the 100-ft. beach also are found.

The chief river is the Forth, which forms most of the northern boundary. The other important streams are the Carron, rising in Campsie fells and flowing to the Forth at Grangemouth; the Endrick, which, rising in Fintry hills, empties itself into Loch Lomond; the Kelvin, which, from its source in Kilsyth hills, flows southwest to the Clyde at Glasgow after a run of 22 m.; and the Avon, rising in the detached portion of Dumbartonshire, and flowing to the Forth. The principal lochs include the greater part of the eastern waters of Loch Lomond; a small portion of the upper end of Loch Katrine, and Loch Arklet, in the north-west area, which, like Loch Katrine, provides part of the water supply of Glasgow. The Forth and Clyde canal crosses the south-eastern corner of the county from Grangemouth to Castlecary.

History and Antiquities.—The wall of Antonius, built by Lollius Urbicus, in A.D. 142, connecting the Forth and Clyde, passed through the south-east of the county, in which it is locally known as Graham's Dyke. At Castlecary and Camelon many relics have been found. The Camelon causeway ran eastwards from Castlecary and crossed the rampart at Camelon, whence it proceeded northwards to Stirling and the Forth, where there was a station near the present bridge of Drip. Thence it crossed the river to Keir and Dunblane in Perthshire. After the withdrawal of the Romans the county once more fell into the hands of the native inhabitants, who, however, gradually retired before the advance of the Saxons and Scots. By the time of Malcolm Canmore (d. 1093) the lowland area had become settled, but the highland tract remained a disturbed and disturbing region until the pacification following the Jacobite rising of 1745–6. The county played a conspicuous part in the struggle for Scottish independence, being particularly associated with many of the exploits of Sir William Wallace and Robert Bruce. The three great battles of the independence were fought in the shire—Stirling Bridge (1297), Falkirk (1298), Bannockburn (1314). James III. was stabbed to death in a cottage in the village of Milton after the battle of Sauchieburn (1488), but apart from the disastrous defeat of the Covenanters at Kilsyth (1645) and the transitory triumph which Prince Charles Edward won at Falkirk (1746), the history of the shire practically centres in that of the county town.

Agriculture and Industries.—The arable soils are of two kinds, locally distinguished as "carse" and "dryfield," the rest of the land being composed of pasture, moor and peat. The "carse" extends along the valley from Buchlyvie to the eastern boundary. The soil consists of the finest clays, without stones, but interspersed with strata of marine shells. It has been largely stripped of the overlying peat, and by draining, subsoil ploughing and the use of lime has been converted into a rich soil, especially adapted for wheat and beans. The "dryfield," which occupies the valleys and the higher ground bordering the carse, is fertile and suited for potatoes and turnips. Oats and wheat are the chief grain crops. Beans are also extensively grown. The cattle are comparatively few, but numbers of sheep, chiefly black-faced, are raised. The average size of the holdings is from 70 to 80 acres. Birches grow on the lower slopes of the mountains in Buchanan and Drymen, and oaks on the banks of Loch Lomond. Larch and Scots fir are the leading trees in modern plantations.

The coalfield of the south-east supplies the staple industry, and coal is also mined in the east, near the Forth and Clyde canal. Iron ore and fireclay are also obtained, while granite, limestone and sandstone are quarried. The ironworks at Carron near Falkirk are important and nails are made at St. Ninians and elsewhere. Woollens are manufactured at Stirling and Bannockburn; calico-printing and bleaching are established in the south-west, especially at Lennoxtown and Milton, and there are chemical works at Falkirk and Denny. Tanning, iron-founding, paper-making, brewing and distilling are carried on at different places, and shipbuilding at Grangemouth, the chief port. The southern and south-eastern districts are served by the L.N.E. railway from Edinburgh to Glasgow (via Falkirk) and the L.M.S. railway from Glasgow to Stirling (via Larbert), while branches connect Grangemouth, Denny and other places with the through-lines. A L.N.E. line crosses the shire, mostly in the north, from Stirling to Balloch, and there is a line of the same company from Glasgow to Aberfoyle.

Population and Administration.—In 1921 the population was 161,719. The principal towns are Falkirk (pop. 33,308), Stirling (21,345), Grangemouth (9,723), Kilsyth (7,600), Stenhousemuir (4,601), Denny and Dunipace (5,130), Bridge of Allan (3,579), and Bonnybridge (3,168). The shire returns a member to parliament with Clackmannan, and Stirling, Falkirk and Grangemouth one member. The police burghs include Falkirk, Grangemouth, Kilsyth, Denny and Dunipace and Bridge of Allan. The shire forms a sheriffdom with the counties of Dumbarton and Clackmannan, but there is a resident sheriff-substitute at Stirling and another at Falkirk. The shire is under school board jurisdiction, and there are high schools at Stirling and Falkirk.

STJERNHJELM, GEORG (1598–1672), Swedish poet and scholar, whose original name was Göran Lilja, was born at Wika in Dalecarlia on Aug. 7, 1598. He took his degree at Greifswald, and spent some years in travelling over every quarter of Europe. Gustavus Adolphus gave him a responsible post at Dorpat in 1630, and raised him next year to the nobility. After the king's death, Christina attached him, as a kind of poet laureate, to her court in Stockholm. His property lay in Livonia, and when the Russians plundered that Province in 1656 the poet, who was in temporary disgrace at the court, was reduced to extreme poverty for two or three years. He subsequently became judge at Trondhjem, member of the council of war (1661) and president (1667) of the College of Antiquities at Stockholm. He died at Stockholm on April 22, 1672. His greatest poem *Hercules* (pr. 1653) is a didactic allegory in hexameters, written in very musical verse, and with almost Oriental splendour of phrase and imagery. *Bröllops-Besvärs Ihugkommelse,* a sort of serio-comic epithalamium in the same measure, is another brilliant work. His masques, *Then fångne Cupido* (Cupid Caught) (1649), *Freds-afl* (The Birth of Peace) (1649), and *Parnassus triumphans* (1651), were written for the entertainment of Queen Christina. He can scarcely be said to have been successful in his attempt, in the first two of these, to introduce unrhymed song-measures.

Stjernhjelm was an active philologist, and left a great number of works on language, of which only a few have been printed. He also wrote on history, mathematics, philosophy and natural science, producing original and valuable work on every subject he attempted. There is a full list of his writings in the *Svenskt biographiskt Lexikon,* vol. xv. (Uppsala, 1848).

STOA, a public building of ancient Greece, whose roof is supported by one or more rows of columns, usually placed adjacent to the agora (*q.v.*), and used either for a sheltered promenade or as a market hall. Extensive remains of stoae exist at Assus. At Athens, there are remains of the stoa of Attalus II. (159–138 B.C.); the so-called stoa of Hadrian is, in reality, a part of the great library of Hadrian.

STOBAEUS, JOANNES, so called from his native place Stobi in Macedonia, the compiler of a valuable series of extracts from Greek authors. Of his life nothing is known, but he probably belongs to the latter half of the 5th century A.D. From his silence in regard to Christian authors, it is inferred that he was not a Christian.

The extracts were intended by Stobaeus for his son Septimius, and were preceded by a letter briefly explaining the purpose of the work and giving a summary of the contents. From this summary (preserved in Photius's *Bibliotheca*) we learn that Stobaeus divided his work into four books and two volumes. In most of our MSS. the work is divided into three books, of which the first and second are generally called Ἐκλογαὶ φυσικαὶ καὶ ἠθικαί (Physical and Moral Extracts), and the third Ἀνθολόγιον (*Florilegium* or *Sermones*). The differences in arrangement between the work as we have it and the summary in Photius, combined with its fragmentary nature in places, suggests that what we have is a later Byzantine epitome. The first book teaches physics—in the wide Greek sense—by means of extracts. It is often untrustworthy: Stobaeus betrays a tendency to confound the dogmas of the early Ionic philosophers, and he occasionally mixes up Platonism with Pythagoreanism. The third and fourth books, like the larger part of the second, treat of ethics and politics. In all, Stobaeus quotes more than five hundred writers.

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STOCK. When money is invested, the investor requires some tangible evidence of his investment and some measure of its size. Moreover, when, as is usually the case, he is one of many investors in the same object, means must exist of defining rigidly and legally the proportion held by each. This is true whether he invests his capital in a loan to a government, municipality or trading concern, or acquires a definite share of the last-named.

This evidence of the existence, nature and size of his holding consists either of "stock" or of "shares." Stock in Great Britain can be issued, bought, sold or redeemed in any odd amount. A share is indivisible and represents, as its name implies, a definite proportion of the total nominal value of the property. This is the vital distinction, which is best clarified by an example.

Stock is always expressed in "so many pounds, shillings and pence face value." Thus "£200 consols" means "£200 face value of British Consolidated Stock." The face value, in conjunction with the rate of interest, determines the dividend. Thus the rate of interest upon consols is 2½ per cent., and so the dividend upon £200 consols is £5 per annum. Face value has no connection with the market value. Thus a sale of £200 consols may fetch no more than £100 in cash. Market value depends simply upon the current price, which is usually quoted in pounds cash per £100 stock. Thus, at a market price of 60, £200 consols could be bought and sold for £120 cash. Stock is always bought and sold in quantities expressed in face value, viz.: a sale of £215.6.8 stock, or a purchase of £350.10.4 stock. Shares are always bought and sold by number, viz.: 352 Courtaulds ordinary shares. (*See* SHARES.)

The chief forms of stock are as follows—(*A*) Government (British, colonial or foreign), municipal (British, colonial or foreign) and debenture stock (railways, shipping, trading, manufacturing, etc.). In every case the stock is evidence of a loan made to the Government, municipality, railway, etc. The stock may be redeemable or it may be irredeemable. The total amount issued is usually limited, but the borrower may have power to issue more at his discretion. It may be issued at par (*i.e.,* £100 stock for £100 cash) or at a premium or a discount, *i.e.,* at more or less than £100 cash. It may be redeemable at par or at a premium. It may have definite, tangible security behind it, such as a lien on the customs revenues or upon the manufacturer's plant, or it may be secured simply by the word of the borrower. The vital point is that it is measured in, bought and sold according to, and its dividends based upon, its face value.

(*B*) Preferred, ordinary and deferred stock. Such stock is evidence of a definite share in the property owned by the issuing company—of which each stockholder is *ipso facto* a member. By virtue of his holding, he is entitled to a share of the net profits, after interest on debentures has been met, and to certain rights, privileges and liabilities, according to his class of holding. His stock comes under the broad heading of capital stock. As a rule, capital is issued in the form of shares and not stock, and so the reader is referred to the article on SHARES for any further description. Two points only need here be mentioned. The first is that dividends are always declared in the form of "so much per cent. on the face value of the stock." The second is that, in case of liquidation, any available assets are divided among the stockholders, class by class, in the same proportion as that borne by the face value of their holding to the total face value of the whole of the outstanding stock in the class to which they belong.

For forms of issue, *see* TRANSFER. (N. E. C.)

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UNITED STATES

The usage of the terms "stocks" and "shares" in the United States is quite different from that in England. In the United States stock signifies the ownership in the business held by the many persons who have bought interest in it and who are known as the stockholders. It does not carry the idea of a loan but indicates always an actual purchase of part ownership. Loans to either private businesses, governments or municipalities are represented by "bonds," except in the case of New York city, which still adheres to the English usage and still has outstanding its "stock," which is to all intents and purposes equivalent to the municipal bonds of other American cities. The aggregate ownership or stock of an American corporation is divided into a large number of units or shares, of which each stockholder may hold one or many. The share, then, is one of the units of ownership. This ownership is represented by "certificates of stock," and when a person buys one or more shares of stock he receives as evidence of this ownership a certificate of stock filled in for the proper number of shares. This is a convenient and practical method of representing ownership, because the ownership can readily be transferred by the transfer of the certificate. (*See* TRANSFER.) Owners of stock in a corporation participate in the prosperity of the company by receiving their proportionate share of any profits that the board of directors sees fit from time to time to divide among them. This division of surplus is generally made annually, semi-annually or quarterly, and all moneys or other property so divided among the shareholders is called a dividend.

CLASSES OF STOCK

Stock of a corporation is a commodity which the corporation must sell in order to raise the funds necessary for the business, and therefore it is incumbent upon the corporation to make this commodity as attractive as possible, this in order not only that it may be disposed of easily but also at an advantageous price. Stocks are issued, therefore, in several classes providing numerous combinations of the three elements, income, control and risk. The average buyer of securities wants as large and as steady an income as possible with the smallest risk, and takes comparatively little interest in the control. The cautious investor will take a smaller income if there be less risk attached, whereas the speculatively inclined will take a greater risk for the chance of greater income. Instances often occur where control of the company is the chief end sought by the stock-buyer and he will practically ignore both present risk and income to get the control. The two great divisions or classifications of stock are "common" and "preferred."

Common Stock is simply ownership in the corporation, carrying with it all the usual rights of stockholders (unless otherwise specified) but no special privileges or preferences. These fundamental rights of stockholders are: (1) To proportionate ownership in the undivided assets of the corporation and to a certificate stating this ownership in shares. (2) To transfer ownership of his shares. (3) To receive dividends when earned and declared by the board of directors. (4) To inspect the corporate books. (5) To subscribe, in proportion to his holdings, to any new issue of stock. (6) To proportionate control through voting power. (7) To vote on other questions affecting the corporation property as a whole. (8) To protect the corporation against wrongful acts of a majority. (9) To restrain *ultra vires* acts of the corporation. (10) To share in the proceeds of dissolution.

Preferred Stock is stock which, while it possesses the same rights and privileges as common stock (unless otherwise specified), has in addition certain more or less valuable and desirable preferences. It may be preferred as to assets, dividends or both, but in ordinary parlance the term "preferred stock" means preferred as to dividends.

Being preferred as to assets means that in case of dissolution of the company, the holders of the stock will receive their portion of the proceeds of dissolution before holders of other stock not preferred as to assets will participate. This preference is, of course, of no service to the stockholder as long as his company is prosperous and in no danger of dissolution, but in the case of weak companies the preference tends to give his stock a higher market value than stock not so preferred. And in the case of actual dissolution where the assets are not sufficient to satisfy all, the preference will prove to be most valuable.

"Preferred as to dividends" means that this stock is entitled to a specified rate of dividend out of the earnings before any dividend is given to the stock not so preferred. It does not mean that a certain dividend is guaranteed but merely that if any amount of the earnings be declared as a dividend, the amount necessary to pay the specified rate of dividend on the preferred stock, or such part of such dividend as possible, must be used for this purpose before any is allocated to pay a dividend on non-preferred stock. If the entire amount declared as a dividend is absorbed by the dividend on the preferred stock, it means simply that the non-preferred or common stock gets nothing. In prosperous companies, however, it is usually possible to pay the stipulated rate to the preferred stock and still have sufficient moneys left to pay an equal or even larger rate to the common stock. It is ordinarily only fair that the common stock should get more in view of the fact that it takes a risk by permitting the preferred stock to take out its share of dividend first.

It is sometimes deemed advisable to have several issues of preferred stock, one taking procedure over the next, just as ordinary preferred takes precedence over common. These several issues are then usually classified as 1st preferred, 2nd preferred, 3rd preferred and so on, or sometimes as preferred A, preferred B, preferred C.

These two great classes of stock, common and preferred, have not by any means satisfied the wants of investors and speculators, and hence a large number of variations have grown up, particularly in preferred stock, affecting the income, control or risk of the stockholders in various manners. The more important of these various classes will be explained.

Non-Participating and Participating.—Non-participating preferred stock is stock which, through the terms of its issue and sale, is to receive a preferential dividend at a stipulated rate, usually about 6%, and nothing whatever beyond that, all other dividend, regardless of its amount, going to the common stock.

Participating preferred stock is that which is to receive first its preferential dividend at the stipulated rate and after that is to participate or share with the other stock in the remainder of the funds declared as dividend. This participation or sharing may be done in one of a number of ways, but regardless of the manner of participation, if the preferred stock shares in any way in the dividend over and above its stipulated rate, it is participating stock. The methods of participation are generally known as "participating simply," "participating immediately" and "participating specially."

Simple Participating.—Simple or ordinary participation is an arrangement whereby the preferred stock first gets its dividends up to the specified rate; after that the common stock will be paid dividends as far as possible up to and including the same rate that the preferred has received; if, after having paid both the preferred and the common the same rate of dividend, there be anything left of the total amount declared as dividend, it is shared or participated in by both the preferred and common alike, just as though they were only one class.

The term "preferred stock" in itself means that it is simply participating.

Participating Immediately.—Preferred stock is said to be immediately participating when the arrangement for apportioning the dividend among the classes of stock provides that the preferred stock first receives dividend up to the specified rate and that immediately thereafter without first giving the common stock a dividend payment at the same rate, all the remainder of the dividend money is allotted to all stock alike, regardless of whether it be preferred or common.

Participating Specially.—The above described methods of participation are, however, by no means the only ones. As a matter of fact, the number of methods of participation is limited only by the ingenuity of the company organizers. It is possible, for instance, to have the preferred get 6%, then the common 6%, then the preferred all the remainder; or the preferred 6%, then common 6%, then preferred 4%, then common 2% and the remainder *pro rata;* or preferred 5%, then common 6%, then all the remainder to preferred and common in the proportion of two to one; or any other arrangement whatever that may be provided in the certificate of incorporation, which in this respect constitutes a contract between the company and the stockholder.

Non-cumulative and Cumulative.—The dividends on preferred stock may be non-cumulative or cumulative. Provision is often made in the certificate of incorporation that if sufficient dividends are not declared in any one year to pay the full dividend on the preferred stock, there is no obligation on the part of the corporation to make up the deficiency in any subsequent year. This means that dividends or parts of dividends not paid to preferred stockholders in any given year are lost to them forever. Stock governed by this provision is known as "non-cumulative."

Cumulative preferred stock, on the other hand, is stock, the stipulated dividend of which, if not paid in full in one or more years, carries over from year to year till fully paid. When dividends have not been declared, or have been declared in amount insufficient to pay the full specified rate of dividend on this cumulative preferred stock, they are in arrears and as long as they are unpaid they constitute a claim on future earnings prior to any dividend claim of the common stock. In other words, common stockholders are not entitled to receive any dividend as long as the cumulative preferred stock dividends are in arrears. In case the certificate of incorporation makes no provision concerning whether or not the preferred stock dividend is to be cumulative, it has been held by the courts that the dividend shall be cumulative.

Companies sometimes provide that their preferred stock shall be non-cumulative for several years, after which it shall become cumulative. This provision relieves the company of the necessity of paying full dividends on the preferred stock during the early years when earnings are expected to be small or of having the dividend accumulate as a charge against future years, and yet assures the stock almost as good selling power as if it were fully cumulative from the first.

Redeemable Stock.—Preferred stock, or certain classes of preferred stock, are occasionally made redeemable. This means that the company has the option under the conditions and on terms specified in the certificate of incorporation, of redeeming or buying back the stock from the stockholders. This redemption right rests, of course, entirely with the company, and stockholders can neither compel nor refuse redemption of their stock. Some advance notice of intended redemption is usually provided for, and a redemption price is generally set at a premium so as to compensate the holder for the loss of his investment and give him an opportunity to seek a re-investment of his money without suffering loss of income in the interim. Redemption at a premium is not universal, however, many companies having the redemption price set at par. If the redeemable stock has the voting power, its redemption has considerable effect upon the control of the company because of the elimination of all the votes represented by it.

Redeemability also may have a material effect upon the market price of a stock, the tendency being to keep the market price lower than it otherwise might be. If the stock is redeemable at 110 and has an investment value of 140, a buyer would in all probability refuse to pay this much for it, fearing that the corporation might exercise its redemption privilege and deprive him of his stock at 110, thus bringing about a considerable loss. If, on the other hand, the investment value is below the redemption price, the redemption feature would ordinarily have no effect on the market unless to make the stock slightly less attractive because of the fact that there is an upper limit to the possible price rise.

Convertible Stock.—One or more classes of stock may be made convertible, that is, exchangeable at the option of the holder, into some other specified security. Conversion, unlike redemption, is always at the option of the holder. The certificate of incorporation may make certain stipulations or set a certain time limit for the conversion, but within these restrictions the stockholder can demand the conversion at his pleasure. The most usual conversion permitted is from preferred to common stock. Convertible stock of this type is quite popular because it enables the holder to receive preference as to dividends when the earnings are small and there is little left for the common dividends, and yet permits him to trade in his stock for common in case the earnings become large and the common is receiving large returns.

The matter of control also frequently enters, as non-voting preferred stock is often convertible into voting common stock. This feature will sometimes induce stockholders to convert, even at a financial loss. Occasionally, stock is issued which is convertible into bonds. This is rare, however, and is hedged about with various protective stipulations. In the first place, such conversion should be only at the option of the company, for if this were not the case, holders of such stock in a weak or insolvent company could convert their stock into bonds and thus share in the proceeds of dissolution ahead of many creditors and on an equal footing with other bondholders of the company who acquired them through *bona fide* purchase, which is manifestly unfair. The money which stockholders pay into the company for their ownership is a part of the owned capital of the company, and it is upon the strength of this owned capital and the security afforded by it that the company is enabled to obtain its borrowed capital through the sale of bonds. If, therefore, a large number of stockholders are permitted to convert their stock into bonds, thus becoming creditors of the company instead of part owners, it naturally means increase of bonded debt with no increase whatever of assets, and lessens the value of all other bonds.

Protected Preferred Stock.—Recently some companies have been making some of their preferred stock especially attractive as an investment by "protecting the dividend." This means simply that after the preferred dividend is paid, a certain amount is placed each year in a reserve or sinking fund, before the dividend is paid to the common stock. This sinking fund is built up to some required size and is to be used to pay the preferred dividends in case of poor years when the current surplus would not be sufficient. When this fund reaches the stipulated size, it is not built up further, but the dividends can then go direct to the common stock without the fund payment coming in ahead. If the fund is depleted, however, by being drawn on to meet a preferred dividend in a poor year, it must be built up to full requirements again as before.

Debenture Stock.—This term is very rarely used in the United States. It is an English expression meaning, in reality, not stock at all but a bond, corresponding to the American debenture bond. In American finance, however, the name has been adopted occasionally and applied to a special type of stock conferring rights, superior to both preferred and common, something in the nature of a prior preference stock. The best known example of this use of the term is the debenture stock of the General Motors Corporation.

Prior Preference Stock.—Prior preference stock, or prior lien stock, is a term rarely used but indicates usually that, after the issuance of the regular preferred stock, another issue has, with the consent of the old stockholders, been issued having a claim prior to that of all other stocks on dividends or assets. Upon issue, it becomes a first preferred stock and the other names serve merely as convenient descriptions. The prior preferred stock of the Goodyear Tire and Rubber Company and the preferred stock of the Market Street Railway Company of San Francisco are examples.

Guaranteed Stocks.—Guaranteed stock is stock whose dividend payments are guaranteed by some other company, usually one which is using the property of the issuing concern. Railway companies frequently lease and operate the property of other companies and, as part of the rental, guarantee the payment of dividends at a certain rate to all the stockholders. Although such operation is most general among railway companies, it is frequently practised among industrials also. Preferred stock is sometimes referred to as guaranteed stock, a term which, of course, is erroneous. A corporation cannot guarantee its own stock and cannot issue a guaranteed stock.

Voting and Non-voting Stock.—All stockholders have the inherent right to participate in the management of the corporation through voting for directors and on other matters. Non-voting stock may be issued, however, and purchasers of such stock voluntarily surrender their voting rights. It is generally customary to give the vote to the common stock and to withhold it from the preferred. The vote may be apportioned among several classes of stock in any desired manner as long as at least one class of stock is vested with voting power. If stock is issued as voting stock, however, such stock cannot be deprived of the vote without the consent of the holder.

Vetoing Stock.—Vetoing is the name given to stock which has not general voting power but is entitled through provision of the certificate of incorporation to vote on certain questions. Thus a certain issue of preferred stock may be voteless except on the question of the issue of additional preferred stock on which question it is given the voting right.

It is quite common to give to non-voting preferred stock the right to vote after its dividends have not been paid for a certain number of years and to continue this voting power as long as the dividends are unpaid, or in case of cumulative preferred stock as long as dividends are in arrears. In such cases this stock is sometimes given the right to vote along with the common, sometimes the exclusive voting right, and sometimes the right to elect the majority of the board of directors.

Par Value and Non-par Value Stock.—For a great many years each share of stock of a corporation was given a nominal or par value, the common unit being a share with a par value of $100. The sum of all of the $100 shares constitutes the nominal value of all the authorized stock of the company. This par value, however, does not necessarily represent any real value, though many people are misled by it. A share of stock may have a par value of $100 while the book value may be $80 and its actual market value $60. The nominal or par valuation of stock is, therefore, purely artificial. It furnishes a basis or principal amount upon which to reckon dividends on a percentage basis, but otherwise is no indication of real value.

Since 1912 there has grown up the practice of issuing shares of stock without any nominal or par value, known variously as non-par value, or no-par value stock, stock without par value, and unvalued shares. The issuance of non-par value stock is now permitted by the law of 32 States, and the extent of its use may be judged by the fact that about 10% of all the charters filed in New York for the five years ending in 1928 contained provisions for the issuance of such stock. The statutes usually provide that such stock shall be sold by the company at a price not less than that prescribed in the certificate of incorporation, or the fair market value, or as may be from time to time set by the board of directors provided that the certificate of incorporation confers this authority, or for such consideration as shall be consented to or approved by the holders of the majority of shares at a meeting called to vote on the question. All non-par value shares sold in accordance with these legal provisions are deemed fully paid and non-assessable and the holder of such shares is not liable to the corporation or to the creditors in respect thereto. Every certificate of stock without par value must show the total number of such shares authorized, as well as the number represented by the certificate, and also the authorized number of par-value shares, if any, and their par value, thus making it possible to determine the proportionate interest in the net assets of a corporation which a given stock certificate represents. Having no par value or base on which to estimate a percentage dividend, the total dividend allotment is divided equally among all the non-par value shares outstanding, and declared as so many dollars per share. (J. H. B.)

See T. Conyngton, *Corporate Organization and Management* (4th ed., 1919); A. H. Stockder, *Business Ownership and Organization* (1922); R. W. Pomeroy, *Common Stocks* (1927), and J. Moody's *Manual of Investments* (pub. annually).

STOCKBRIDGE, a town of Berkshire county, Massachusetts, U.S.A., on the Housatonic river, near the western boundary of the State; served by the New York, New Haven and Hartford railroad. Pop. (1925) 1,830 (State census). It is a summer and autumn resort, and a region of historic interest. Within its area of 24 sq.m. are Lake Mahkeenac or Stockbridge Bowl, Ice Glen (where caverns are lined with ice even in midsummer), and Monument mountain (1,710 ft.). In 1736 a plantation 6 m. square (including the present town of Stockbridge) was laid out for the Mohican Indians who had come to the Housatonic valley from the west bank of the Hudson when white settlements began to encroach on their territory, and among whom John Sergeant had established a mission in 1734. In 1739 this "Indian Town" was incorporated as the town of Stockbridge. The Indians held their lands in severalty. They had a school and a church which was under the charge of Jonathan Edwards from 1750 to 1758. Many of them fought on the American side during the Revolution. In 1783–88 nearly all of them moved to New York, where they built New Stockbridge 14 m. S. of the present site of Utica, and by 1829 most of them had gone to Wisconsin.

STOCKBROKER, an agent who deals in stocks and shares. He need not be a member of any recognized stock exchange, nor of an association of stock exchanges. He need not confine his energies to dealing in only such securities as those which are quoted in a stock exchange. The broker-member of the London stock exchange is an agent for the buying and the selling of stocks and shares of any description, and his status is kept strictly clear from that of a stockjobber, so far as the London stock exchange rules are concerned. The broker, if a stock exchange member, acts as an agent; seldom as a principal. He does not as a rule buy from a client nor sell to a client. He buys or sells on behalf of the client, and takes a certain amount of commission, the extent of which is laid down in stock exchange rules for members of the stock exchange as his remuneration for doing the business. He is not allowed, in the London stock exchange, to buy 100 shares from a client say at £5 and sell them simultaneously to another client at £5 5s. To do this would be acting as a principal, which is, according to the London stock exchange rules, the part assigned to a stockjobber.

The man who would become a broker in the London stock exchange usually finds that the best way of achieving his end is to obtain a seat in the office of a stock exchange firm, entering either as an office boy or a clerk, and gradually working his way through the various stages which stand between the outsider and the full-blown member of the stock exchange. He can become a member without delay, provided he is able to obtain three sureties who will guarantee, in the sum of £500 each, the fulfilment of his obligations for four years from the date of his admission. If the candidate has served as a clerk in the stock exchange for four years previously to the lodging of his application-form, two sureties, or recommenders, only are required, who must each enter into an obligation as above mentioned, but for £300 apiece. The scale of the London stock exchange charges, both for admission fee and annual subscription, is substantially less in the case of the experienced man. Every candidate for membership must obtain a nomination, the price of which varies considerably. When first created some years before the war, a nomination reached the value of £700. After the war, nominations became at one time practically valueless. Several are known to have changed hands at £5 apiece. After that an improvement set in, and the price rose above £1,000, but it varies very widely, according, on the one hand, to the demand that there happens to be for stock exchange membership, and on the other, the supply of nominations available by reason of the death or resignation of members.

Strict rules govern the stockbroker in the London stock exchange, and many of the provincial stock exchanges have modelled their rules upon them. He must be a British subject; he has to apply for re-election every year; he must state whether he intends to act as broker or jobber; he must not be a principal in any business other than that of the stock exchange, nor must he be a member of, or subscriber to, any other institution where dealings in stocks and shares are carried on. His wife, also, must not be engaged in business. His duties bring him into contact with members of the public, his clients, and with fellow-members of the stock exchange, brokers and jobbers alike, and he acts as agent between the public on the one side and members of the stock exchange on the other. He is required to have a general knowledge of all the markets in which he is called upon to deal, and he must be prepared to give reasonable answers to the hundreds of questions with which he is plied on all sorts of subjects. Drawing his business from members of the public, he is obliged to have offices, a staff of clerks, telephones, and all the paraphernalia connected with correspondence, being involved in heavier expenses on this account than the jobber, whose outgoings are on a more modest scale. The broker's life is more arduous than that of a jobber, involving longer hours and the exercise of unlimited patience, for he has to make allowance for the fact that the majority of his clients do not grasp the intimate details of what is after all a very technical business. He may, for instance, have a perfectly clear idea of what "cum dividend" and "ex dividend" imply, but it is not an easy matter to impart the same information to a country client who seldom deals in stock and shares. His first daily duty, after having digested the financial parts of his newspaper, is to deal with the correspondence that has reached him, and extract from it the orders that he will take into the stock exchange for execution when the markets open, as they do at about half-past ten, the official time being a quarter to eleven. There he buys or sells War Loan in one market, Kafirs in another, artificial silks in another, going through various parts of the House that have no strict delimitations, one market impinging on the next. The men round the markets who deal in specialized stocks and shares are the jobbers, and to them the broker proceeds, knowing that he will be able to get a double price made to him, at the higher of which he can buy and at the lower of which he can sell without the jobber knowing in advance which of the two courses he intends to take in executing his client's order.

The outside broker is governed only by the laws of the land, whereas the member of the stock exchange is controlled by the rules laid down for the conduct of business in his own exchange. The outside broker is free to advertise (which the member of the stock exchange may not do), and is exempt from paying entrance fees or subscriptions. He can approach whom he likes with offers to buy or sell shares, acting as agent or principal as it suits him. Some outside firms specialize in somewhat unfamiliar stocks and shares, just as in the stock exchange itself there are broker firms who make a feature of one particular market, though they are ready to deal in anything else in which they get an order. The public is protected in dealing with members of recognized stock exchanges, for the committees of those exchanges exercise a stricter control over their members than does the law over outside firms. (W. L.)

United States.—A stockbroker is an agent who deals in stocks, bonds and other securities either on or off an organized exchange. Legally, the relationship between the broker and customer is not only that of agent and principal but becomes that of creditor and debtor and that of pledgee and pledgor when the customer purchases on margin and the broker furnishes the required additional funds secured by collateral. The relationships between brokers and their customers are governed by the various and differing State statutes, custom, business policy and the constitutions and rules of the organized exchanges. The New York Stock Exchange does not permit a corporation to become a member; consequently brokerage houses with membership on the exchange are partnerships.

The distinction between brokers and jobbers, which obtains in London, does not exist in the United States. On the New York Stock Exchange all brokers are free to trade with one another and with the public as they choose provided they conform with the constitution and rules of the exchange. Brokers on the New York Stock Exchange may be divided, according to the special nature of their business, into five groups: (1) commission brokers, those who act for the public at a commission fixed by the exchange; (2) "two-dollar" brokers, who act as agents for other member brokers on the exchange at a rate of $2.50 per 100 shares (the old name still prevailing although the $2 rate has been superseded); (3) floor or room traders, those who buy and sell for themselves and for their own profit; (4) specialists, who specialize in certain securities and may act as commission brokers or floor traders but who ordinarily do not come into contact with the public; and (5) the odd-lot dealers, who supply or buy from commission brokers a sufficient number of odd lots to equal the full 100 shares, which is the minimum amount that may be purchased or sold on the exchange. While very few houses deal in odd lots, they usually have several representatives on the exchange and probably one-fourth of all the business done on the exchange originates in odd lots. The odd-lot dealer enables the small investor to trade in a few stocks or shares within a small fraction above the price at which large lots are bought and sold.

Brokers who are members of the New York Stock Exchange are controlled rigidly by the constitution, rules and customs of the exchange in an effort to secure fair competition and the proper relationship between the broker and his customer. For example, a broker may not take the side of the market opposite his customer, his charges are regulated, he must report accurately the status of his business to the exchange, he may not advertise securities falsely and the advertising by the firm of itself is regulated explicitly by the exchange. Other American stock exchanges in general are modelled after the New York Exchange. Brokers not connected with organized exchanges are regulated by the laws of their respective States and also by Federal laws. (W. E. S.)

STOCK EXCHANGE or **BOURSE,** a market for the purchase and sale of securities, such as shares, stocks and bonds. Markets for dealing in securities have existed for centuries. They had their beginnings usually in a few men meeting regularly in a certain place, a coffee house or restaurant, who for a commission were prepared to act as intermediaries between buyers and sellers. As their business grew, these men formed themselves into a sort of association, and rules were framed to regulate the conduct of their business. With the growth and wider distribution of wealth, the volume of stock exchange business has steadily expanded, and in the past quarter of a century the growth has been more rapid than in any similar period. Nowadays, practically everyone in highly-civilized countries has dealings with a stock exchange, or bourse as it is called on the Continent. The development of joint stock enterprise could never have reached its present stage but for the facilities which the stock exchanges provide for dealing in securities. Their primary function is to liquefy capital by enabling a person who has invested money in, say, a factory or a railway, to convert it into cash by disposing of his share in the enterprise to someone else. Without the stock exchange, capital would become immobilized, for once invested there would be no means of liquefying it.

London.—London is the greatest of the world's stock exchanges in the range and volume of its transactions. Although New York has made great progress in recent years, London is by far the most international stock exchange in the world, the range of its business covering every corner of the earth and every class and type of security. It was not until the latter part of the 18th century that the London stockbrokers definitely formed themselves into a stock exchange with premises of their own. They had been in the habit of meeting and doing business in the Royal Exchange and neighbouring places, but in 1773 those who had hitherto met at "Jonathan's" (Coffee House), in Change Alley, moved to a room in Sweeting's Alley to which the name of "The Stock Exchange" was formally given, the building becoming known as "The Stock Exchange Coffee House" or "Tavern." Business grew apace and in 1801 a group of members raised £20,000 of capital in 400 shares of £50 each for the purpose of providing an adequate building and acquired a site in Capel Court, Bartholomew lane, which to-day is one of the entrances to the "house."

The new building of the members was opened in 1802. At that time the members of the stock exchange numbered about 500. Rules were drawn up for the conduct of business and for regulating membership of the "house." It was provided that all future members should be admitted by ballot, and members were required to pay a subscription of 10 guineas each for themselves and 5 guineas for their clerks. It was always the general intention that the shares should be held by members but there was always a large number (and until quite recently a majority) of members who did not hold shares. The first extension was made in 1823 when the floor space was nearly doubled by the addition of a second room for dealings in foreign stock. In 1854 the two rooms with some small additions were rebuilt as one in the form of a dome with two transepts. Several subsequent extensions of this building have been made, the principal one being in 1885 when another dome was added. The stock exchange building occupies the greater portion of the triangular area formed by Throgmorton street, Bartholomew lane and Old Broad street. Outwardly it is an uninspiring structure, but the interior is both spacious and handsome.

The premises and property of the London stock exchange are owned by an association called "The Stock Exchange," the capital of which is in 20,000 shares of unlimited liability. On each of these shares £36 has been paid up. No one person may hold more than 200 shares, and only members can be registered as shareholders, except in the case of those who acquired their shares from proprietors who held them before Dec. 31, 1875. The new deed of settlement took effect on Jan. 1, 1876, when the number of proprietors was 268. In 1928 the number was 2,712. When a shareholder dies his shares must be sold to a member within two years. There is a ready market for the shares, for the dividends are handsome. Recently they have amounted to £10 per share. The income of the Stock Exchange (for 1927–28 it amounted to £231,583) is derived from the annual subscriptions of members and their clerks and from entrance fees paid by new members and from rents and investments. The fees have been raised from time to time; members admitted before March 25, 1876, and members admitted with two sureties before March 25, 1879, pay an annual subscription of only £21. The present annual subscription for new members with three sureties, is 100 guineas, and for new members with two sureties—that is to say, a clerk who has served four years in the house—50 guineas. The present entrance fees are 600 guineas for a member with three sureties and 300 guineas for one with two sureties. The present entrance fees for authorized clerks—clerks authorized to deal—are 50 guineas and for unauthorized clerks 15 guineas; and their annual subscriptions amount to 100 guineas and 30 guineas respectively. For clerks admitted to the settling room only, no entrance fee is payable, but an annual subscription of 10 guineas is payable for each clerk. These subscriptions and fees are fixed annually by the trustees and managers.

The property of the Stock Exchange is under the control and administration of nine trustees and managers, who are appointed by the shareholders. Every five years three retire, and are eligible for re-election. If two vacancies occur they are immediately filled, but in the case of one vacancy it is not filled until the annual meeting. The trustees and managers have no control over business transactions on the Stock Exchange, which are in the hands of the committee for general purposes, numbering 30 members, who are elected annually. This body regulates the transaction of business on the Stock Exchange, makes others and repeals rules and regulations for the same, is charged with the admission and discipline of members and their clerks, and is generally responsible for the good order and government of the members. Its work is so heavy that sub-committees are formed to deal with particular matters.

Securities cannot be dealt in on the Stock Exchange except by permission of the committee, and conditions have to be fulfilled before that permission is granted. This is one of the most important new rules of the Stock Exchange. Before the war any security could be dealt in without the permission of the committee, and all that the latter were called upon to do was to fix a special settlement for the completion of the first transactions. Sometimes weeks would elapse before a special settlement was applied for and granted, and sometimes none was applied for or granted. Grave abuses occasionally arose in connection with the marketing of new shares in this way. This licence to deal has been abolished, and the interests of the public are much better protected than they used to be. The discipline of the stock exchange is very strict and the committee deals severely with any members guilty of improper conduct. The committee settles disputes between members and also between members and their clients. It has power to suspend or expel a member. Membership is for 12 months only, and thus everyone who wishes to remain a member must apply to the committee for re-election. The year ends on March 24. An important innovation was made in the year 1904, when it was decided to restrict the growth of membership. Prior to that date it was possible to become a member without the nomination of a retiring member. As a result, in active times membership rapidly increased, and when dull times came the competition for business became extremely keen. The rule passed in that year virtually stopping the growth of membership is the most important rule affecting the Stock Exchange passed in the present century. In the ordinary way the only method by which a person may become a member is to obtain a nomination (by purchase) from an existing member who must retire in his favour. Nominations may be obtained from a former member, or, if he has not disposed of his nomination, from the legal personal representative of a deceased member. Nominations, which are personal and non-transferable, are usually purchased, and the cost may be as high as £2,000. To-day (1928) the cost is about £1,150. A candidate for membership must be recommended by three members, who become sureties for him during the first four years in £500 each, or £1,500 altogether. A certain number of clerks who have completed four years' service are admitted each year without nomination. The number of such admissions is left to the discretion of the committee; in 1927–28 the number of such new admissions was 20.

The fact that the Stock Exchange is owned by the shareholders and controlled by their elected trustees and managers, while a separate body, the stock exchange committee, appointed by the members, controls and regulates business, has constituted what is known as dual control. The committee has no funds of its own and cannot initiate or control the expenditure of the money subscribed by the members. While the arrangement has worked remarkably smoothly, it is nevertheless anomalous and various efforts have been made to terminate it. But none of them has succeeded. Since Nov. 23, 1904, every member admitted with two sureties has been obliged to become the owner of at least one share and every member with three sureties must hold three shares; under this arrangement the dual control is not likely to be abolished for a long time to come. One of the most interesting innovations on the stock exchange has been the introduction in 1928 of a pension scheme for members' clerks. The scheme was floated by the Clerks' Provident Fund with the blessing of the committee, but it is really unofficial and voluntary. Members, however, have generously supported the scheme, which in time will no doubt be generally adopted.

The London Stock Exchange contains two notable monuments, the Boer War memorial and the memorial to those who fell in the World War.

By custom, each market has a special place allotted to it; for instance, the space immediately in front of the World War memorial is the market for British Government securities and other gilt-edged stocks. Dealers or jobbers in these securities take up their posts in this space every day, and dealers in other classes of securities similarly occupy the floor space allotted to their particular markets. In this way the locality of a market can be readily and easily found by the brokers who go to the house to buy or sell securities for their clients. There is an important distinction between brokers and dealers. Brokers are not allowed to deal on their own account, nor can dealers act as brokers. Their functions are defined by a rule which was last amended in 1908 and took effect as from Feb. 1, 1909. The dealer or jobber occupies a position similar to that of the wholesale dealer in commodities. He keeps a stock of particular securities, say oil shares, and his function is to buy oil shares when they are offered to him and to sell them if they are wanted. He quotes two prices for a share, a buying price, which is the lower, and a selling price, which is the higher, and the difference represents his profit. A broker acts for the public which desires to buy or sell securities. Ordinarily, both for buying and selling securities, though under certain circumstances only for buying, a commission is charged. On receiving an order to deal in a certain security, a broker goes to a jobber in that market, and asks for a price, mentioning the amount of stock which he desires to deal in, but he does not disclose whether he is a buyer or a seller. The jobber "makes a price," *i.e.,* gives two prices; at one he is prepared to buy and at the other to sell. If the broker is satisfied with the price, or if it conforms with the price limit fixed by his client, he will tell the jobber that he sells or buys as the case may be, at the price quoted. On the other hand, if he is dissatisfied, the broker will ask for a closer price, and if the jobber is anxious to do business, will make a closer price, and the bargain is then made. A jobber's business requires special qualifications. It has been said that a jobber is born, not made. There is much truth in this. The most successful jobbers have a flair for the business. They must be men of good nerve, cool judgment, and ready to deal under any ordinary conditions. They must be men of financial standing, considerable experience, with an understanding of market psychology.

The number of members (1928) is nearly 4,000 and these employ about 2,000 clerks who have the right of entry to the house. The hours of business are nominally from 10.45 A.M. to 4 P.M. No bargains, however, are marked after 3.30 for inclusion in the lists published in the evening of the same day. Late bargains are marked and published the following day. During the war and for some time after, it was compulsory to mark all bargains, but owing to pressure of business, this excellent rule was abolished. Bargains are to-day recorded at the option of dealers or on request by brokers for their clients. During the period of compulsory marking, the stock exchange had to issue a list of securities which were not included in the official list. This list is known as the supplementary list. Fortunately this continues to be published, though it is not so useful as it might be owing to optional marking. Since the war broke out no sessions have been held on a Saturday, and it seems unlikely that they will ever be resumed unless the public insistently demands it. This is improbable, for the reason that since 1914 Saturday has become to an increasing extent a day of clearing up. The banks have shortened their hours of work on a Saturday by closing at noon instead of at 1 o'clock, and this would have to be altered before the stock exchange would be justified in opening on a Saturday. The movement towards making Saturday more and more a holiday is the result of the increasing intensity of business. The motor car and the telephone make it possible to transact far more business in a day than was possible 30 years ago, and the hustle of modern business life renders more rest essential. Moreover, on the stock exchange great improvements in working practices have been introduced in recent years, and the efficiency of dealers' and brokers' staffs is much higher. The volume of work they transact in a day is far larger than before the war, the population of investors having enormously increased. Except in the gilt-edged market, every bargain a broker executes for his client is "for the account," unless otherwise specified. This means that the bargain will be completed—*i.e.*, the stock handed over and paid for—on the next settling day. The usual period of the account is a fortnight, but there are four 21-day accounts in the course of a year. Settling days are usually fixed for a Thursday, the passing of tickets—ticket day—takes place on a Tuesday, and making-up day is Monday, prices for the settlement of current securities being fixed at 11.30 A.M. Brokers on executing an order for a client send to him a contract note which sets forth the details of the transaction, the price obtained or to be paid, the amount of brokers' commission, of stamp and transfer fee, and the amount of the contract stamp. Later, as settlement day approaches, a further note is sent to a client who has bought stock, requesting him to forward the purchase money. In the case of a speculative transaction the same procedure is adopted, except that the client, if he has bought stock, is required not to pay the total purchase money, but merely the difference between the price which he gave and the price fixed on making-up day if the latter is lower than the former. If, however, the security has risen in price, the client receives a cheque for the difference between the price at which he bought and the making-up price. A rate of interest or contango, is charged for the facilities of buying and holding stock without paying for it. Contangoes vary in accordance with the current rate of interest. Usually they are higher on the more speculative securities than on the investment type. The rate of a contango is also affected by the state of the "open" account, as it is called, in a particular share.

If there is a large "bull" account—*i.e.*, a large number of speculative purchases for a rise—and dealers are anxious to discourage further buying, the contango may rise to 10% or more. Rates are generally lower on the more active shares and higher on the less active, which means that there are fewer people ready to carry the latter type of share. Shares in which the market is narrow and difficult, cannot be contangoed. Some speculators sell for a fall as well as buy for a rise. Facilities for technically lending shares to speculators who have sold them are also provided, and the rate of interest charged for lending stock is called "backwardation." This varies with the size of the "bear" account, as a speculative sale is called. If the "bull" account open in a stock is larger than the "bear," there will be a contango rate and no backwardation rate, and *vice versa.* Since the war the facilities for carrying over bargains from account to account have been greatly reduced, but speculation has not diminished. The speculators have merely changed their methods. The banks, instead of lending money to members of the stock exchange as largely as formerly, for relending to their clients, now lend freely to their own customers on stock exchange collateral. This is a safer method, for a bank rarely allows its client to borrow more than he can repay. Another popular device of speculators is to gamble during one account only. If markets are rising, a speculator will buy at the beginning of an account and sell towards the end, and *vice versa.* Speculation is cheaper in this form, for by completing his operation in one account, the operator pays only one commission. During one of the periods of stock exchange depression before the war a movement was started and carried to a successful conclusion for fixing a scale of minimum commissions. It was fixed on a generous scale, for after the war little change was made in spite of the great increase in all other prices and costs. The inflation of capital values, of course, helped to swell considerably the volume of business. (C. J. Mi.)

New York.—The New York Stock Exchange traces its origin to a small group of stock-brokers in New York who, shortly after the American Revolution, bought and sold securities under an old buttonwood-tree which once stood in lower Wall street. In 1792 this group of curb-brokers signed an agreement as to the methods to be followed in the business; in 1817 the gradual increase in the volume of trading led to the formation by these stock-brokers of a definite association, and the hiring of indoor quarters for their market.

The purpose of the Exchange, then as now, can best be explained by reference to its present constitution, which declares "Its objects shall be to furnish exchange rooms and other facilities for the convenient transaction of their business by its members; to maintain high standards of commercial honor and integrity among its members; and to promote and inculcate just and equitable principles of trade and business." Legally, the Exchange is a voluntary association; it has never obtained a charter or assumed the form of an incorporated body. Ever since the reorganization of the Exchange in the '70s, membership has been limited to 1,100 members; thus, one wishing to become a member of the Exchange must purchase a membership (or "seat") from the estate of a deceased member, or from some living member who is retiring from the business. Candidates for membership in the Exchange must also be formally elected by the committee on admissions, after this committee has investigated their previous business careers and records. They must also agree without qualification to obey and abide by the constitution and rules of the Exchange, carrying as they do powers of broad and sweeping character over all phases of their business as Exchange members.

The legislative and judicial powers of the Exchange are vested in its governing committee of 42 members; each governor holds office for four years and each year ten governors come up for election. In addition to the governors, the officers of the Exchange consist of a president, treasurer, assistant to the president, secretary, first assistant secretary, accountant and economist. Routine work of the Exchange is supervised by standing sub-committees of the governing committee, while special or temporary matters may be handled by special sub-committees of that body. Where circumstances have rendered it more convenient and desirable, certain regular routine functions of the market have been organized in the form of subsidiary corporations, all the stock of which is held by the governors as trustees for the members; for example, the Stock Clearing Corporation handles and supervises the work of clearing and settling Exchange contracts, etc., the New York Quotation Company supervises the distribution by tickers of the quotations which are collected on the Floor of the Exchange; the New York Stock Exchange Building Company holds title to the physical assets of the Exchange; and the New York Stock Exchange Safe Deposit Company provides safekeeping facilities for the securities held by Exchange members.

The constitution and rules of the New York Stock Exchange were first drafted in 1817. During the intervening century, the New York securities market was probably subjected to intense pressure from a greater variety of sources than any great securities market in history. In addition to foreign and domestic wars, there was added experience with all manner of currency difficulties, booms, depressions, periods of intense activity and periods of practical stagnation. In consequence the code of rules which govern Exchange members in their relationships and their business has been fully tested by extreme and various forms of economic pressure, and they are for this reason all the more fundamentally adequate and sound to-day.

In 1928 the market value of securities listed on the New York Stock Exchange amounted to approximately $82,000,000,000. Ready purchasing and selling within this enormous field of investment were facilitated by the branch offices of Stock Exchange member firms, connected with the New York head offices by private wires; there were in 1928 962 of such branch offices located in 292 cities representing 41 States of the Union and four foreign countries. Share quotations were distributed on 5,547 stock tickers and bond prices on 889 bond tickers.

To study the gradual accession of different sorts of securities to the New York Stock Exchange market is to review the whole panorama of American economic development for more than a century past. The original New York securities market sprang from the trading in Alexander Hamilton's U.S. 6% Government bond issue which funded the revolutionary debt, as well as dealings in the original stock of the first U.S. Bank. Shortly afterward, shares of the earliest fire and marine insurance companies and of the earliest local incorporated banks were added to the list. Another wave of economic development brought into the market many State bonds which represented canals and turnpikes, the construction of which the various States of the Union were undertaking. In 1836 occurred the first trading in steam railway securities, which for the greater part of a century was to constitute the principal occupation of the market, as the enormous railway systems spread across the great plains and over the Rockies to the Pacific. The discovery of petroleum in Pennsylvania and coal in this and other eastern States was also soon reflected in the market by the appearance there of oil and mining shares. After the Civil War, in addition to the great railway consolidations of the time, industrial and utility securities were listed. A final stage was reached in 1915, when the market began not only to reabsorb and distribute among American investors American securities long held by the creditor countries of Europe, but also to list foreign government (and subsequently foreign corporate) securities of Europe and other continents. Thus to-day the New York Stock Exchange is not only the leading security exchange of America, whose listings broadly reflect the whole panorama of American economic life, but also an international securities market of constant activity and steadily expanding scope.

(E. H. H. S.)

Paris.—The Paris bourse, unlike the London stock exchange, is subject to Government control and supervision. It is an influential body, and is an institution of great financial and political strength. *Agents de change,* who are the members of the bourse, are nominated by decrees countersigned by the minister of finance or by the minister of commerce and industry. The *agents de change* must be Frenchmen, and in full possession of civic and political rights. They form the aristocracy of the bourse. They constitute what is known as the *parquet,* a privileged space on the floor of the bourse to which only they have access. The rest of the bourse is known as the *coulisse.* The *parquet* of the bourse elects a *chambre syndicale* or committee, which makes the rules for the conduct of business. Although in law the liabilities of individual members are no concern of the bourse, in practice the *chambre syndicale* meets the liabilities of any defaulting member. Each member owns what is called a charge, for which he has paid a sum varying from 1,500,000 f. to 2,000,000 f. to his predecessor by a private arrangement. In addition a member must deposit 250,000 f. as caution money and 120,000 f. in the *caisse commune* of the *chambre syndicale. Agents de change* enjoy a monopoly in regard to various kinds of legal business, and they possess other privileges not shared by members of the *coulisse.* They may buy or sell certain securities for cash, whereas the *coulissiers* may only deal for delivery in the settlement. Securities dealt in by the *coulisse* are known as *valeurs en banque,* and the *coulisse* is often described as the *marché en banque.* The *agents de change* issue the official price list of securities each day, but the *coulisse* issues an unofficial list of its own. Being less restrictive and broader, the *coulisse* provides much the bigger market, and its business is much larger in volume than that of the *parquet.* The market for foreign securities is in the *coulisse,* some of the members of which are very wealthy. Practically all Continental securities are in bearer form; that is to say, they are not registered or inscribed, but change ownership by passing from hand to hand. Great care is taken to protect dealings in bonds which may pass so easily. The *agents de change,* for instance, publish the *Bulletin officiel des oppositions,* which gives the designations and the numbers of securities dealings in which are suspended because they have been stolen or lost. It is imperative for those dealing in Continental bonds to examine this list before taking delivery of bonds in case they may be on the "stopped" list. As in London, the settlement of transactions takes place every fortnight, in the middle and at the end of the month. Dealings in French Government securities, however, are paid for, and the securities are taken up, at the end of every month. The Paris Bourse has not the same international importance as London. Before the war the French investor confined his investments to French securities. Russian bonds, certain Brazilian and Argentine and other South American securities, and a few United States bonds, Rio Tinto copper shares, oil shares, mostly Russian, and South African gold mining shares. Turkish and Egyptian securities have had a certain vogue, as well as sundry issues of the lesser European States and municipalities. Occasionally the French have taken to big speculative ventures. Inspired by the success of the Suez canal investment, for instance, many Frenchmen supported the Panama Canal Company, but huge sums were lost in that enterprise. That disaster gave a severe blow to speculative enterprise in France, where it has never been really liked, for the average Frenchman prefers to invest, and not to speculate or gamble. The banking houses of France are all represented in the bourse, and much of the investment business of the bourse is really done through the banks. During the period of currency depreciation in France a great deal of money was invested abroad in spite of the prohibition on the export of capital, but the major part of this money was invested in very high-class British and American securities, and an inconsiderable part was deposited with banks at interest. Business begins on the Paris bourse at 11 o'clock and lasts until 3 o'clock. It is usually opened on Saturdays, but in the summer months it remains closed on that day. Unofficial business may be conducted outside the official hours, and at times many transactions are entered into after the bourse has been closed.

The last great reorganization of the Paris bourse took place in 1898. There had been much criticism of the monopoly given to the 60 stockbrokers in Paris. The number was increased to 70, and a new table of brokerage was drawn up, and other articles were modified. It effected, however, no real change in the bourse organization, and the public demand for real reorganization was really turned, but not satisfied. However, the *parquet* wisely allowed certain breaches of their monopoly privileges, which served in effect to reduce the dissatisfaction with their monopoly conditions. *Remisiers* are allowed to make contracts by themselves provided that they record every day their transactions on the pad of an agent, who in return for a percentage of the brokerage hands them an official contract. Another violation of the law which has been accepted is the transaction of business for future delivery by the *parquet.* It was due to the competition of the curb-brokers.

Germany.—The Berlin *Börse,* like the Paris bourse, is subject to Government control and to legal enactments. It does not enjoy the freedom of the London or New York stock exchange, and speculation is frowned upon and discouraged on the German bourses. The official hours of the bourse are from 12 to 2 and on Saturdays from 11 to 1 o'clock. Dealings, however, are allowed to take place for 30 minutes after the official closing hour, and the prices are published in the papers. These quotations, however, are not official, and are not subject to the control of the bourse committee. During the months of July and August, which are regarded as holiday months, no session of the bourse is held on Saturdays. There is no entrance fee for a new member, and no fixed annual subscription. The finance committee of the bourse fixes the annual payment of a member according to the amount and volume of business of each firm. Certain fees are charged in respect of the partners who wish to visit the stock exchange, and, as in London, fees have to be paid for each authorized clerk and employee. The application of a new member must be supported by three members of the bourse, and each member supporting the application has to guarantee the candidate in the sum of 5,000 Reichsmarks. Members of the Berlin bourse are not necessarily rich men; membership may be granted to men of relatively small resources. The brokers (*makler*) are appointed more out of regard for their character than for their resources. They carry on business under conditions laid down by the Government, and it is subject to the supervision and control of high State authorities. In 1896 legislation was passed which severely restricted business on the Berlin bourse. It was intended to put a check on speculation in stocks for future payment and delivery. This forced speculators to transact their business abroad, especially in London, Brussels and Amsterdam. Since the war conditions have become freer. The method of doing business on the Berlin bourse is peculiar. Orders to buy or sell securities are settled at official prices which are fixed every day. The fixing of these prices is determined by the relation of the current demand to the supply. The public have no trouble, therefore, in checking the price they pay or receive, as the case may be. The Frankfort bourse holds two sessions, a morning and an evening session, but though dealings are carried on later than in Berlin, it is not a more important stock exchange. The securities dealt in are similar, and the official prices quoted are virtually the same. During the stabilization process, the bourse was overrun by "free" brokers and jobbers—a result of large-scale dismissals of clerical staffs by the banks. The bourse authorities, however, took steps to check this influx, and the "free" jobbers and brokers largely declined. Improvements were made at the same time in the technical equipment and practices of the bourse, greatly facilitating the clearing system of dealing in securities. Business is nowadays done on normal lines, but the market has not recovered its former activity and importance owing to the great destruction of capital caused by the inflation of the currency during and after the war.

Amsterdam.—The Amsterdam bourse as it exists to-day was founded in 1876, and up to quite recent times its members, like those of the London stock exchange in earlier days, had to transact their business in a building which also housed persons engaged in commercial business. In 1876 the bourse consisted of 435 members, whereas the present (1929) number is nearly 800; the entrance fee, which was then 25 guilders, is now 2,000 guilders, and in the same period the annual subscription has been raised from 30 to 80 guilders. The bourse, members of which must be Dutch or nationalized Dutch, is open from 1.30 to 2.45 (Amsterdam time). There are members and authorized clerks, as in London, but there is no line of demarcation between brokers and jobbers. Some firms combine broking and jobbing, and others work as bankers and brokers. The banks are all members of the bourse, and have their clerks therein, but they also do business through other members. Transactions are all for cash, except those in the shares of the Netherlands Trading Company, in which there is a monthly settlement. Three quotations are made during the day in less active stocks, on the basis of which business is done. The Amsterdam bourse is particularly interested in oil shares, especially Royal Dutch; the shares of various Dutch East Indies trading and planting companies; the securities of one or two leading Dutch industries; and one or two artificial silk shares. Before the World War an important international market existed. This disappeared during the war, but lately a number of Belgian, French and German industrial shares have been introduced, and for some of these there is an active market. The American railway market, however, which before the war was one of the most active in the bourse, has now dwindled to small proportions. A large number of foreign bonds are now dealt in, and a part of many of the placings of German and other foreign bonds in the United States has also been issued in Amsterdam, and they are quoted on the bourse there. In recent years the yield from the duty payable on stock exchange transactions has varied from rather less than 5,000,000 florins to nearly 6,000,000 florins.

(C. J. Mr.)

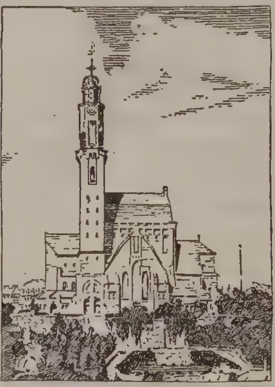
STOCKHOLM, the capital of Sweden, on the east coast, not far south of the junction of the Baltic Sea and the Gulf of Bothnia. The population of Stockholm in 1751 was 61,040; in 1850, 93,070; in 1880, 176,875; in 1900, 300,624; in 1928, 466,000.

Origin.—Before Stockholm arose, Björkö, Sigtuna and Uppsala were places of great importance. Björkö ("the isle of birches"), by foreign authors called Birka, was a kind of capital where the king lived occasionally at least; history speaks of its relations with Dorestad in the Netherlands, and the extensive refuse heaps of the old city, as well as the numerous sepulchral monuments, show that the population must have been large. But though situated at a central point on Lake Mälar, it was destroyed, apparently before the beginning of the 11th century (exactly when or by whom is uncertain); and it never recovered. Sigtuna, lying on the shore of a far-reaching northern arm of Lake Mälar, also a royal residence and the seat of the first mint in Sweden, where English workmen were employed by King Olaf at the beginning of the 11th century, was destroyed in the 12th century. Stockholm was founded by Birger Jarl, it is said, in or about 1255, at a time when pirate fleets were less common than they had been, and the government was anxious to establish commercial relations with the towns which were now beginning to flourish on the southern coast of the Baltic. The city was originally founded as a fortress on the island of Stadholm. The castle was erected at the north-eastern corner, and the city was surrounded with walls having fortified towers on the north and south. It came to be called Stockholm ("the isle of the log," Latin *Holmia*, German *Holm*); the true explanation of the name is not known. During the middle ages the city developed steadily, and grew to command all the foreign commerce of the midlands and north, but it was not until modern times that Stockholm became the capital of Sweden. The mediaeval kings visited year by year different parts of the kingdom.

Situation.—Stockholm is famed for the beauty and physical characteristics of its situation. The coast is here thickly fringed with islands (the *skärgård*), through which a main channel, the Saltsjö, penetrates from the open sea, which is nearly 40 m. from the mainland. A short stream with a fall normally so slight as to be sometimes reversed by the tide, drains the great lake Mälar into the Saltsjö. The scenery of both the lake and the *skärgård* is similar, the numerous islands low, rocky, and generally wooded, the waterways between them narrow and quiet. The city stands at the junction of the lake and the sea, occupying both shores and the small islands intervening. From the presence of these islands a fanciful appellation for this city is derived—"the Venice of the North"; but actually only a small part is insular. There are three main divisions, Staden, the ancient nucleus of the city, properly confined to Stadholmen (the city island) which divides the stream from Mälar into two arms, Norrström and Söderström; Norrmalm on the north shore of the channel, and Södermalm on the south.

Staden.—Ancient origins are apparent in the narrow and winding streets, though the individual houses are not very old, owing to the ravages of frequent fires. A few, however, preserve antique narrow fronts with gables, as in some of the North German towns. The old market, still called Stortorg (great market) is now one of the smallest in Stockholm. At the north angle of the island is the Royal Palace (*Slott*). The original building was destroyed by fire in 1697, the body of Charles XI. being with difficulty rescued from the flames. A new palace after designs of Nicodemus Tessin the younger (d. 1728) was not completed, owing to wars and the general distress, until 1754; while a restoration carried out in 1901 included many ornamental details devised by the architect and executed at the expense of King Oscar II. The new town hall designed by Östbergand recently completed combines Swedish traditional styles with Italian influences.

West of the palace are the offices of the majority of the ministries, some of them in the former buildings of the Royal Mint. Beyond these, on the west side of the island, is a square named from the palace on its northern side, the Riddarhustorg. The Riddarhus (house of the nobility) was the meeting-place of the Council of the Nobles until 1866, and its hall is adorned with the armorial bearings of noble families. The north fore-court has a statue (1890) of Axel Oxenstjerna, the chancellor, by J. Börjeson. In Riddarhustorg is a statue of Gustavus Vasa, unveiled in 1773 on the 250th anniversary of his accession. South-west of the Royal Palace is the Storkyrka (great church), dedicated to St. Nicholas, the oldest church of Stockholm, greatly altered from its original state. The date of its foundation is 1264; but it was practically rebuilt in 1726–1743. Within it is richly adorned with paintings and wood-carving. Staden is the commercial centre of the city. At the broad shipping quay (*Skeppsbro*) which flanks the palace on the north and east, most of the seagoing steamers lie; and the exchange, custom-house, numerous banks and merchants' offices are in the immediate vicinity. Riddarholmen (nobles' island), lying immediately west of Stadholmen, contains the old Franciscan church (*Riddarholmskyrka*), no longer used for regular service, which since the time of Gustavus Adolphus has been the burial-place of the royal family. It has recently been restored, and contains mediaeval paintings, and many trophies of the European wars of Sweden. On one side of it stands the old house of parliament; on the other a statue of Birger Jarl, the reputed founder of the city. On Riddarholm also are various government offices, and most of the steamers for Mälar and the inland navigation lie alongside its quays.



BY COURTESY OF SWEDISH STATE RAILWAYS

THE ENGELBREKTSKYRKAN, NORRMALM, A CHURCH NAMED AFTER ENGELBREKT, SWEDISH PATRIOT, WHO WAS ASSASSINATED IN 1436

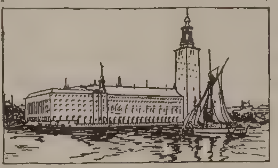
Norrmalm.—Staden is connected with Norrmalm by the Norrbro (north bridge) and Vasabro, the first crossing Helgeandsholmen (the island of the Holy Spirit), on which are situated the new Houses of Parliament and the Bank of Sweden. A third bridge connects with the main thoroughfare of Norrmalm, Drottningsgatan (Queen Street). The Norrbro gives upon Gustaf-Adolfs-Torg, where a statue of that king stands between the royal theatre, royal opera house and the palace of the crown prince. Norrmalm is the finest quarter of the city, with broad straight streets, several open spaces with gardens, and handsome buildings. East and north of the theatre royal, the Karl-den-Tolftes-Torg and Kungsträdgård (royal garden) form the most favoured winter promenade. There are a statue of Charles XII. and a fountain with allegorical figures, by J. P. Molin, also a statue of Charles XIII., and in the small Berzelii Park close at hand one of the chemist J. J. Berzelius. Near Drottningsgatan is the Klara church, the burial-place of the poet K. M. Bellman, and west of this, occupying one side of a square, is the central railway station. In the building of the academy of science is the national museum of natural history, including mineralogical, zoological, and ethnographical departments.

Other Districts.—On the island of Kungsholm, S. of Vasastad, are the Caroline medical institute, several hospitals, including the Serafimer (1752), the royal mint and factories. Östermalm, lying east, that is, on the seaward side, of Norrmalm, is a good residential quarter, containing no public buildings of note, save the barracks of the Swedish Guards and the fine royal library, which is entitled to receive a copy of every work printed in Sweden. The library stands in the beautiful park of Humlegård (hop-garden), in which is also a statue of Linnaeus. South of Östermalm, and east of the Kungsträdgård and Staden, lies the peninsula of Blasieholm (formerly an island) and, connected by bridges, the islands of Skeppsholm and Kastellholm, the three forming the foreground in the beautiful seaward view from the Norrbro. On the first is the national museum (1866), a Renaissance building, containing historical, numismatic and art-industrial collections, with ancient and modern sculptures, picture-gallery and engravings. The numismatic collection is notable for its series of Anglo-Saxon coins. About 11,000 pieces came from the island of Gotland, some dating from 901–924, but the majority are later. In front of the museum is a bronze cast of the famous group of J. P. Molin (1859), the Bältespännare (belt-bucklers), representing an early form of duel in Scandinavia, in which the combatants were bound together by their belts.

East of Skeppsholm an inlet, Ladugårdslandsviken, so named from the proximity of the former royal farm-yard (*ladugård*), and bordered on the mainland by a quay with handsome houses called Strandvägen, throws off a narrow branch (Djurgårdsbrunnsviken) and separates from the mainland an island about 2 m. in length by $\frac{3}{4}$ m. broad. This is mainly occupied by Djurgården (the deer-park), a beautiful park containing the buildings of the northern museum, a collection of Scandinavian costumes and domestic and agricultural utensils, and a biological museum housed in a wooden building imitating the early Norwegian timber churches (*stavekirke*). Here also is Skansen, an ingenious reproduction in miniature of the salient physical features of Sweden with its flora, fauna and characteristic dwellings inhabited by peasants in the picturesque costumes of the various districts. Both the northern museum and Skansen were founded by Dr. Arthur Hazelius (1833–1901). There is a bust of the poet K. M. Bellman, whose festival is held on the 26th of July. Södermalm, the southern quarter, is principally residential.

The beautiful environment of sea and lake is fully appreciated by the inhabitants. To the north of the city, accessible by rail and water, are the residential suburbs of Haga and Ulriksdal, with royal *chateaux*, and Djursholm. Saltsjöbaden, 9 m. east of Stockholm, on Baggensfjörd, is the nearest and most favoured seaside resort, but Dalarö (20 m. south-east) and Nynäshamn (39 m. south) are much frequented. Vaxholm, 12 m. north-east by water, is a pleasant fishing-village where numerous villas have been built.

Institutions.—Stockholm is the centre of government and the usual residence of the king; in summer he usually occupies one of the neighbouring country palaces. The city is the seat of the high court of justice (*Högsta Domstolen*) and of the court of appeal for the northern and midland districts (*Svea Hofrätt*). As regards local government, Stockholm is a *län* (administrative district) in itself, distinct from the rural *län* of the same name, under a high governor (*öfverståthållare*) and deputy, with departments for secretarial work, taxation and police. The city is in the diocese of Uppsala, but has a separate consistory, composed of the rectors of the city parishes, the president of which is the rector of St. Nicholas (*Storkyrka*). Stockholm has no state university. A private university (*Högskola*) was founded in 1878, and was brought under state control in 1904. The president of the governing body is appointed by the government, while the appointment of the remaining members is shared by the Swedish Academy, the Academy of Sciences, and the City Council. The faculties are four—philosophy and history, philology, mathematics and natural sciences and jurisprudence. The Caroline Institute (*Karolinska Mediko-Kirurgiska Institut*) is a medical foundation dating from 1815, which ranks since 1874 with the state universities of Uppsala and Lund in the right to hold examinations and confer degrees in its special faculty. Special and secondary education is highly developed; there are schools of agriculture, min-



BY COURTESY OF SWEDISH STATE RAILWAYS

THE CITY HALL AT STOCKHOLM, COMPLETED IN 1922 ing and forestry, technical schools, a veterinary school, a school of pharmacy, etc. Among the public colleges under state control, one, the Nya Elementarskolan, was founded experimentally in 1828, after the Education Committee of 1825–1828, among the members of which were Tegner and Berzelius, had reported on the want of such schools. This school retains its separate governing board; whereas others of the class are under a central board. The control of the primary schools in the parishes is similarly centralized; whereas in Sweden generally each parish has its school-board.

Stockholm is the seat of the principal learned societies and royal academies. (*See* SWEDEN.) There are schools of painting, sculpture and architecture under the direction of the Royal Academy of Arts; a conservatory of music under that of the Royal Academy of Music; and experimental gardens and laboratories under the Royal Society of Agriculture. The Natural History Museum, the observatory and meteorological office, and the botanical gardens are under the supervision of the royal academy of sciences. Minor collections deserving mention are the museums of the geological survey and the Caroline Medical Institute, and the archives in the record office (*Riksarkivet*).

Among places of entertainment, the royal theatre is managed by a company receiving a state subsidy. The Dramatic Theatre (*Dramatiska Teatern*), in Kungsträdgårds-Gatan, the Swedish (*Svenska*) theatre in Blasieholms-Gatan, and the Vasa theatre in Vasa-Gatan may also be mentioned. The Djürgård is the principal place for variety entertainments in summer. Several of the leading sporting clubs have their headquarters in Stockholm. An annual regatta is held early in August by the Royal Swedish Yacht Club (*Svenska Segalsällskapet*). A harbour much frequented by yachts is Sandhamn in the outer *skärgård*. The Stockholm General Skating Club (*Almänna Skridskoklubb*) is the leading institution for the most favoured winter sport. A characteristic spectacle in winter is the tobogganing in the Humlegård on holidays. The principal athletic ground is the Idrottspark (Sports Park), on the north side of Östermalm, with tennis courts and a cycling track, which may be changed into a skating-rink in winter. There is a similar park at Djursholm. A stadium in Swedish mediaeval style, seating 15,000, was opened for the Olympic Games in 1912.

Commerce.—The industries of Stockholm are miscellaneous. The value of the output of these is nearly thrice that of Malmö or Gothenburg, the next most important manufacturing towns, and the industries of Stockholm exceed those of every *län* (administrative division) except Malmöhus. The iron and steel industries are very important, including engineering in every branch, and shipbuilding. Factories for articles of human consumption (*e.g.*, breweries and tobacco works) are numerous; and cork, wood, silk, chemical and leather works may also be mentioned. Fine ware is produced by the Rörstrand and Gustafsberg porcelain works. In addition there are various government works, as the mint and printing works. Stockholm is the first port in Sweden for import trade, but as regards exports ranks about level with Malmö and is exceeded by Gothenburg, Stockholm having proportionately little share in the vast timber export trade. Over 50% of the tonnage using the port is Swedish. Vessels of 23 ft. draught can go up to the city (Skeppsbro and Blasieholm quays), and there is an outport at Värtan on the Lilla Värtan channel to the north-east. The port accommodation was enlarged in 1925, and the new Hammarby channel, for vessels up to 3,500 tons, was completed. A new dock for large vessels was constructed in 1926, and further harbour works on Lake Mälar are projected. In 1924 the railway station was rebuilt.

See P. R. Ferlin, *Stockholms Stad* (Stockholm, 1854–58); C. Lundin and A. Strindberg, *Gamla Stockholm* (Stockholm, 1882); C. Lundin, *Nya Stockholm* (Stockholm, 1890); G. Nordensvan, *Mälardrottningen* ["the queen of Mälar"] (Stockholm, 1896); E. W. Dahlgren, *Stockholm, Sveriges hufvustad skildrad* (Stockholm, 1897, issued by the municipal council on the occasion of the Stockholm Exhibition, 1897).

STOCKINETTE. A term strictly denoting a particular variety of knitted or hosiery fabric composed of wool, cotton, silk or artificial silk, and produced as a tubular fabric and in a continuous piece of indefinite length on a knitting machine of the circular type. The fabric may be used in its tubular form, or may be cut lengthwise and opened out into single width, to be made up into the numerous garments for clothing and other articles for domestic use.

STOCKJOBBER: *see* JOBBER, STOCK EXCHANGE.

STOCKMAR, CHRISTIAN FRIEDRICH, BARON VON (1787–1863), Anglo-Belgian statesman, who came of a Swedish family, was born at Coburg on Aug. 22, 1787. He was educated as a physician, and became attached in 1816 to Prince Leopold of Saxe-Coburg-Gotha on his marriage to Princess Charlotte of England. When she died next year he remained Leopold's private secretary, controller of the household and political agent, until the prince became in 1831 king of the Belgians. His disinterestedness and profound acquaintance with English and European social and political questions impressed themselves on all who were associated with him. In 1831 he retired to Coburg, in order not to excite Belgian jealousies by residing at court as confidential adviser, but he continued to be Leopold's right-hand man. In 1837 Leopold sent him to England as adviser to the young Queen Victoria, and in the next year he accompanied Prince Albert (afterwards Prince Consort) on his tour in Italy. He won the complete confidence of the prince as well as of the queen, and on their marriage in 1840 he became their trusted though unofficial counsellor, dividing his time between England and the Continent. He died at Coburg on July 9, 1863.

See the articles on VICTORIA, QUEEN; and ALBERT, PRINCE CONSORT. Selections from Stockmar's papers were published by his son Ernest in 1872, and a biography by Juste appeared at Brussels in 1873; *see* also *The Letters of Queen Victoria* (1907).

STOCKPORT, a municipal, county and parliamentary borough of Lancashire (in part) and Cheshire (in part), England, 6 m. S.E. of Manchester. Pop. (1921) 123,309. The boundaries of Manchester and Stockport meet in Levenshulme. The ancient town stood on the slopes of a narrow gorge where the rivers Tame and Goyt join to form the Mersey, but the modern town has extended on to the more level land above. There are many river bridges and a lofty railway viaduct bestrides the gorge. Stockport is served by the L.M.S., L.N.E. and Cheshire Lines railways. Electric tramways connect it with Manchester. The town is an important industrial and railway centre. Its industries include cotton and felt hat manufactures, the construction of machinery for the cotton trade, motor and electrical engineering, bleaching and dyeing, and the manufacture of leather and of foodstuffs. The public buildings include the church of St. Mary (built about 1817) with portions of earlier date and a Decorated east window; St. George's church (1897); St. Mark's church (1921); the town hall (1908), designed by Sir Brunwell Thomas; the central library (1913), the grammar school (1916) and the Hall of Memory. In all there are 214 ac. of parks. The Kinder waterworks (1912) have a reservoir covering 44 acres. The old Stockport grammar school was founded in 1847 and the Stockport Sunday school (founded 1784) is one of the largest in the kingdom. Stockport returns two members to parliament. It was enfranchised in 1832, incorporated 1835, and became a county borough in 1888. Richard Cobden represented Stockport in parliament from 1841 to 1847.

During the Roman occupation there was a small military station on the site of Stockport, at the junction of two Roman roads. The etymology of the name may be Saxon, but there is no evidence of a Saxon settlement, and the place is not mentioned in Domesday. A castle was in existence in the 12th century, but is not mentioned after 1327. Stockport (Stokeporte, Stopport, Stopford) was made a free borough by a charter of Robert de Stokeport about 1220. Thus Stockport was not a true municipal borough until formally incorporated under the Municipal Corporations Act of 1835.

STOCKS, a wooden structure formerly in use both on the continent of Europe and in Great Britain as a method of punishment for petty offences. The culprit sat on a wooden bench with his ankles, and sometimes his wrists or even neck, thrust through holes in movable boards, generally for at least several hours. That stocks were used by the Anglo-Saxons is proved by their often figuring in drawings of the time (*see* Harleian mss.

No. 65). The second Statute of Labourers (1350) ordered the punishment for unruly artisans. It further enjoined that stocks (ceppes) should be made in every town between the passing of the act and the following Pentecost. The act appears to have been ill observed, for in 1376 the Commons prayed Edward III. that stocks should be set up in every village. Though never expressly abolished, the punishment of the stocks began to die out in England during the early part of the 19th century, though there is a recorded case of its use so late as 1865 at Rugby. In many villages may still be seen well-preserved examples of stocks, in some cases with whipping posts attached. In the United States stocks were of frequent use in the 18th century, more particularly in the New England States; while in the Southern States they were employed for punishing slaves (*see* PILLORY).

STOCK-TAKING. To prepare a balance sheet (*q.v.*) it is necessary for a trader to arrive at a valuation of his stock-in-trade; this process is called stock-taking or, in America, inventory-taking. When proper stock records are available, they are of course an invaluable check upon the accuracy of the stock-taking; but in their absence it is essential that the process of stock-taking should be performed with the utmost care. If a wrong value be placed upon stock, the accounts embodying that valuation will to a corresponding extent mis-state the profits of the undertaking and its current financial position, and to a corresponding extent the accounts of the ensuing period will be affected in the opposite direction. The lower the rate of turnover the more serious will be any error in the periodical stock-taking. In many cases, the only independent check that the trader has upon the accuracy of his stock-taking is the inherent probability of the percentage of profit shown by the trading account.

The generally accepted basis for the correct valuation of stock-in-trade, assuming the goods to be in a readily saleable condition, is either the price they actually cost or the price at which they could then be bought in the open market, whichever of the two be the lower.

But although it is unsound to take into account any rise that there may have been in market values since the goods were bought, it would be equally unwise for a trader to dispose of his stock upon a rising market at normal prices, when he can only replace the goods sold at a greatly enhanced figure. Usually, therefore, although rising market prices are ignored for stock-taking purposes, selling prices are advanced as buying prices increase; and this is equalized by the fact that as buying prices fall, it commonly becomes necessary for the trader to reduce his selling prices, though he still has stock purchased at the higher rate.

Responsibility.—In most businesses it is usual to make the general manager responsible for the general accuracy of the stock-taking. The managers of departments are responsible to him, and the actual work is split up among the various employees, each of whom is held responsible for his section of the work. Those employed in counting, measuring or weighing goods are usually those familiar with the handling of these goods, and thus able to identify them as being correctly described. The cost prices are then entered on the list by clerks from actual invoices. The managers decide what (if any) percentage is to be deducted from goods that are old-fashioned, or otherwise out of condition, and the remaining calculations are then completed in the office, after which the summary is certified by the general manager.

The actual process of taking stock is often rendered more difficult and uncertain because it has to go on while trading operations are in full swing, and goods are accordingly constantly coming in and going out. It is very necessary to take precautions to ensure that no errors arise from this cause. For this reason some business houses prefer to close their premises during stock-taking, even although it means a corresponding loss of trade. Further, it is important to see that the invoices relating to all goods which have in fact been included in stock are also included in the books as purchases, even although (as is sometimes the case) the actual invoices do not come to hand until later; conversely, invoices already to hand relating to goods in transit may, of course, be excluded from purchases.

When the trade is a seasonal one, it is usual to fix a date for stock-taking that comes between the two seasons, as it is naturally more convenient to take stock when the stock is at its lowest. In such cases it sometimes happens that deliveries of new season's goods have already been accepted, the invoices for which are "dated forward," *i.e.*, into the new accounting period. In such cases it seems admissible to exclude the value of these goods both from the purchases of the past period and also from the stock-taking. (L. R. D.)

STOCKTON, FRANCIS RICHARD (1834–1902), American writer, was born in Philadelphia (Pa.), April 5, 1834. On the completion of his high-school course Stockton studied wood engraving, but his tastes were so definitely literary that he soon turned to journalism. He contributed to various magazines and was on the editorial staff of *Hearth and Home*, the *Century Magazine* and *St. Nicholas*, of which he became assistant editor in 1873. About 1880 he gave up editorial work for independent authorship. He died in Washington (D.C.), April 20, 1902.

Stockton's first published books were fanciful stories for children—*Ting-a-Ling-Stories* (1870), *Roundabout Rambles in Lands of Fact and Fancy* (1872), etc. In 1879 his reputation with older readers was established by his amusing and original *Rudder Grange* (1879), his best long work, although a series of sketches rather than a novel. His peculiar talent was for the short story; some of the best examples are the title-stories of the volumes *The Lady or the Tiger?* (1884), *The Christmas Wreck* (1886) and *The Bee Man of Orn* (1887). Effective also are the novelettes *The Casting Away of Mrs. Lecks and Mrs. Aleshine* (1886), and its sequel, *The Dusantes* (1888).

STOCKTON, a city of central California, U.S.A., at the head of tidewater on the San Joaquin river, 80 m. E. of San Francisco; the county seat of San Joaquin county. It is on the Pacific highway; has a municipal airport; and is served by the Santa Fe, the Southern Pacific, the Western Pacific, electric and beltline railways, by motor-coach and truck lines in all directions, and by river boats to San Francisco. Pop. (1920) 40,296 (77% native white); 1928 local estimate, 58,000. Stockton has a level site, not much above sea-level, surrounded by the fertile lands of the San Joaquin valley, which produce great crops of potatoes, onions, beans, corn, asparagus, grain, Tokay grapes and other fruits. Over 50 commercial crops are grown in the county, valued in 1927 at $52,000,000. Dredging of a deep-water channel which will make the port accessible to 90% of all ocean-going vessels was under way in 1928. The aggregate factory output of Stockton in 1927 was valued at $38,000,000; bank debits in 1926 totalled $324,934,000; and the assessed valuation of property for 1927 was $65,563,796. Stockton is the seat of the College of the Pacific (Methodist Episcopal), the oldest incorporated educational institution of the State, chartered in 1851, located in Santa Clara until 1871, and in San Jose from 1871 to 1922.

There was a small settlement here (called Tuleberg, and later New Albany) before the discovery of gold. With the coming of the first gold-seekers the importance of the site as an outfitting point for the mining country immediately became apparent. A town was laid out in the spring of 1849 and named after Robert Field Stockton, who had been prominent in the events which secured California for the United States. In 1850 Stockton became the county seat and was chartered as a city.

STOCKTON-ON-TEES, town and port in County Durham, England, on the Tees, 5½ m. above its mouth, and on the L.N.E.R., 236 m. N. from London. Pop. (1921) 64,126. At Norton, 1 m. N. St. Mary's church, once collegiate, shows fine Norman work. The chief buildings are a town hall, borough-hall, exchange and public library. The quays are accessible to vessels drawing 22½ ft. at high water spring tides. Stockton grew up round the castle of the bishops of Durham, to whom the town belonged even before their purchase of the earldom of Sadberge. The castle was probably built between 1183 and 1214, and it is said that King John granted a charter in 1214 but of this, no traces remain. Stockton was divided into two parts: the "town," governed by the bailiff of the bishop, and the borough, under a mayor and aldermen. The bishop's bailiff was also the keeper of the castle. The borough is first mentioned in 1283. It occurs again in a record of 1328, and in 1344. Bishop Hatfield's survey (1377–82) gives a list of tenants within the borough. In 1644 the parliamentary troops besieged and captured the castle, which was dismantled in 1652.

STOCKYARDS are located at meat-packing centres for the purpose of receiving live stock which are to be used in a packing plant or sold to farmers for further feeding. At most points where there are two or more packing companies, there are stockyards known as public stockyards. Many packing companies, especially those which are located at country points, have private stockyards for their own use. The U.S. Department of Agriculture compiles and publishes records of live stock receipts, shipments, etc., at 67 public stockyards in all sections of the country. The largest of these stockyards are located at Chicago, Kansas City, Omaha, St. Louis and St. Paul. Any farmer who wishes to sell live stock may ship his animals to one of these markets, usually consigning his animals to a commission firm whose function it is to sell to a packer or a live stock feeder, when animals require further feeding to improve their quality. When the animals arrive at the stockyards, they are unloaded into pens where they are watered and fed and held until they are sold. The costs of feeding and handling and the fees to the commission firm are paid by the farmer. At public stockyards, these charges are prescribed by the U.S. Department of Agriculture. The packers located near the stockyards send live stock buyers each day to the stockyards to buy their day's requirements. The buyers ride among the pens, accompanied by representatives of the commission firms, and make their offers for the animals they want. In practice, every animal sent to market is purchased by someone a few hours or days after its arrival. Moreover, live stock are sold on a cash basis, so that the farmer receives his money almost immediately after the animals have been sold. Approximately 60,000,000 to 80,000,000 hogs, 14,000,000 cattle and 16,000,000 sheep and lambs are marketed in the average year by U.S. farmers. (E. B. W.)

STODDARD, RICHARD HENRY (1825–1903), American writer, was born in Hingham (Mass.), July 2, 1825. As a boy Henry Stoddard read whatever he could find, and wrote and revised conscientiously and continuously. The literati of New York were kind; and soon Stoddard was contributing frequently to magazines and saving up money enough to have his first book *Footprints* (1848) published. Nathaniel Hawthorne helped him to secure a position in the New York custom-house (1853–70). Later he was private secretary to Gen. George B. McClellan in the New York dock department (1870–73); city librarian of New York (1874–75); literary editor of the New York *World* (1860–70) and the *Mail and Express* (1880–1903); and editor of the *Aldine* (1869–74). He died in New York, May 12, 1903. Stoddard's poems are sincere, original and felicitous in form.

STOESSEL, ALBERT FREDERIC (1894–), American musician, was born at St. Louis (Mo.), on Oct. 11, 1894. He was educated at the Berlin Hochschule, making his début as violinist in that city with the Blüthner Orchestra. During the World War he took over the directorship of the A.E.F. bandmasters' school from its founder, Walter Damrosch and later (1921) succeeded Mr. Damrosch as conductor of the New York Oratorio Society. The same year he was made conductor of the New York Symphony Concerts at Chautauqua, New York. When the department of music of New York university was created (1923) Stoessel was appointed its head.

STOFFLET, JEAN NICOLAS (1751–1796), Vendéan general, was born at Lunéville, the son of a miller. Long a private soldier in a Swiss regiment in France, and afterwards game-keeper to the comte de Colbert-Maulevrier, he joined the Vendéans when they rose against the Revolution. He was appointed major-general of the royalist army, and in 1794 succeeded La Rochejaquelein as commander-in-chief. He accepted the treaty of La Jaunaie (May 2, 1795). But he again took arms in December 1795 on behalf of the count of Provence (the future Louis XVIII.), from whom he had received the rank of *maréchal-de-camp*. He was taken prisoner, condemned to death by a military commission, and shot at Angers on Feb. 23, 1796.

See General d'Andigné, *Mémoires*, edited by E. Biré (1900–01); C. Loyer, "Cholet sous la domination de Stofflet," in *L'Anjou historique*, vol. iii. (1902–03).

STOICHEIOMETRY, in chemistry, is a term which, strictly, denotes the determination of the proportions in which elements or compounds react with one another, and may be extended to include the determination of atomic and molecular weights (Gr. *τοιχεῖα,* fundamental parts or elements; *μέτρον*, measure). Actually, however, it is often used in the still broader sense covering the study of the physical properties of gases, liquids and solids; this aspect of the subject is dealt with in the article CHEMISTRY, *Physical*. The present article deals with the determination of molecular weights, the fundamental atomic weights being dealt with under that heading.

It is possible to determine with accuracy only the molecular weights of gases or vapours and of solids in solution. No method is known of determining the molecular weights of solids as such, although modern work on crystal structure (*see* CRYSTALLOGRAPHY) enables one to say how many simple molecules are packed together in one unit cell of the crystal. Similarly, no method is available for finding the molecular complexity of liquids with certainty, although several criteria are used for judging whether a liquid consists of simple or of complex molecules. Thus most of these criteria agree in assigning a complex structure, possibly $(H_2O)_2$ or $(H_2O)_3$, to liquid water, but none is capable of precisely fixing the degree of complexity; and most of them agree in giving the simple formula C_6H_6 to liquid benzene, *i.e.*, it has the same molecular weight as its vapour. On the other hand, some recent views on this question regard water as having a considerable *but variable* degree of complexity, and benzene as having a similar *but constant* degree. (For fuller discussion of the molecular weights of liquids, *see* the article ASSOCIATION.) The two more precise cases are now dealt with, namely, (1) gases and (2) dissolved solids.

Gases.—The generalization due to Avogadro—that equal volumes of gases under the same conditions of temperature and pressure contain equal numbers of molecules—may be stated in the form that the densities of gases are proportional to their molecular weights. If therefore the density of a gas relative to hydrogen or oxygen is determined, the molecular weight of the gas should follow by simple proportion, since that of oxygen is 32 (taken as standard) and that of hydrogen 2·0154. Avogadro's law, however, is not rigorously true, except under extremely low pressures, and it is necessary to correct the observed densities to what they would be if the gases were *ideal*, *i.e.*, if they showed no departure from Boyle's law. The principles underlying such corrections are briefly as follows.

P. A. Guye's Method.—According to Boyle's law, the product of the pressure and the volume of a gas is constant at any definite temperature, and, further, according to Gay Lussac's (or Charles's) law, this constant is directly proportional to the absolute temperature. Hence, $pv=RT$, where R is the so-called *gas constant*. J. D. van der Waals showed that, for representation of the actual behaviour of a gas, this ideal equation must be replaced by

$$\left(p+\frac{a}{v^2}\right)(v-b)=RT,$$

where a and b are constants for any one gas, but differ for different gases. Now a study of the behaviours of gases over a wide range of pressures has led to the assignment of appropriate values of a and b to each gas; hence, if v is the volume actually occupied by one gram-molecule of a gas at a pressure of 1 atmosphere and at a temperature $T°$ (usually 0° C is taken), and V is the volume which it would occupy under ideal conditions at the same temperature and pressure, then we have

$$1\times V=RT=\left(1+\frac{a}{v^2}\right)(v-b)$$

or

$$V=v\left(1-\frac{b}{v}+\frac{a}{v^2}\right)\text{ (approx.)},$$

so that the necessary correction can be applied from the known values of a and b.

D. Berthelot's Method.—It is known that the product pv for a gas (except hydrogen) decreases slightly with increasing pressure until a pressure of several hundred atmospheres is reached. From a study of this decrease at low pressures it is possible to find what the relative densities of two gases would be at an infinitesimally low pressure, p_0. If v_1 and v_0 are the volumes of a gas at pressures of about 1 atmos. (p_1) and p_0 respectively; if

$$1 - \frac{p_1 v_1}{p_0 v_0} = \alpha;$$

and if α' and v' are the corresponding values for the reference gas which has the same volume v_0 at p_0; then, assuming that Avogadro's law holds rigidly for the very low pressure p_0, we have

$$p_1 v_1 = (1-\alpha)\, p_0 v_0 = (1-\alpha)\, RT$$

and $$p_1 v_1' = (1-\alpha')\, p_0 v_0 = (1-\alpha')RT$$

whence $$\frac{v_1}{v_1'} = \frac{1-\alpha}{1-\alpha'},$$

i.e., the ratio of the vapour densities at atmospheric pressure can be corrected to the ideal ratio.

Lord Rayleigh and D. Berthelot applied corrections in the latter way to many gases. Thus, E. W. Morley had found the density of oxygen relative to hydrogen to be 15·90 at ordinary pressures; since the value of α for oxygen is 0·0009 and for hydrogen −0·0005, the corrected density becomes 15·88 (H=1), or 16·00 (H=1·0077) in the units now adopted. (*See* Atomic Weights.) Compound gases are dealt with similarly; thus T. Batuecas (1925) corrected the densities of ethylene, nitrous oxide and nitric oxide by examination of their compressibilities (alteration of v, and hence of pv, with change in p), and hence obtained $C_2H_4 = 24·015$; $N_2O = 44·003$; $NO = 30·006$. P. A. Guye and E. Moles, among others, have determined many molecular and atomic weights by similar methods.

The principle indicated here is applicable to the determination of the molecular weight of any vaporizable substance, and it is not necessary to compare the vapour density directly with that of oxygen, for, from the "ideal" vapour density, it is only necessary to calculate the weight (in grams) which would occupy 22·41 litres (corresponding to 32 grams of oxygen) at 0° C and 760 mm. pressure in order to determine the molecular weight.

The theory of solution permits the investigation of the molecular weights of substances which dissolve in water or some other solvent. It is shown in Solution that a solute lowers the freezing point and raises the boiling point of the solvent in a regular manner as long as dilute solutions are dealt with. It has been shown that if one gram-molecule of a solute be dissolved in 100 grams of solvent then the boiling point is raised by $0·02T^2/w$ (say D) degrees, where T is the absolute boiling point and w the latent heat of vaporization of the solvent; this constant is known as the *molecular rise of the boiling point*, and varies from solvent to solvent. If we dissolve, say, m grams of a substance of molecular weight M in 100 grams of the solvent and observe the elevation in the boiling point, d, then M is given by $M = mD/d$. Similar considerations apply to the freezing points of solutions. In this case $D = 0·02T^2/w$, where T is the absolute freezing point of the pure solvent and w the latent heat of solidification. To apply these principles it is only necessary therefore to determine the freezing (or boiling) point of the solvent (of which a known weight is taken), add a known weight of the solute, allow it to dissolve and then notice the fall (or rise) in the freezing (or boiling) point, from which values, if the molecular depression (or elevation) be known, the molecular weight of the dissolved substance is readily calculated. The following are the molecular depressions and elevations (with, respectively, the freezing and boiling points in brackets) of the commoner solvents.

Molecular depressions: aniline (6°), 58·7; benzene (5·4°), 50·0; acetic acid (17·0°), 39·0; nitrobenzene (5·3°), 70·0; phenol (40°), 72; water (0°), 18·5.

Molecular elevations: acetic acid (118·1°), 25·3; acetone (56°), 17·1; alcohol (78°), 11·7; ether (35°), 21·7; benzene (80°), 26·7; chloroform (61°), 35·9; pyridine (115°), 29·5; water (100°), 5·1.

Other methods are available for dissolved substances, *e.g.*, determination of osmotic pressure, lowering of vapour pressure, and diminution of solubility, but these are little used. It must be remembered, however, that the molecular weight of a solid in solution is only apparent, for it may be affected by a great variety of factors. Thus, electrolytic dissociation of the solid if a salt will give an abnormally low value; separation as mixed crystals (*see* Chemistry, Physical) with the solvent will cause errors; any interaction with the solvent, such as formation of hydrates or "solvates," will affect the result; and equally important is the circumstance that the "ebullioscopic" and "cryoscopic" (boiling point and freezing point) methods just described become increasingly inexact with increasing concentration of the solute. (*See* Solution.) (A. D. M.)

STOICS, a school of philosophers founded at the close of the 4th century B.C. by Zeno of Citium, and so called from the Stoa or painted corridor (στοὰ ποικίλη) on the north side of the market-place at Athens, which, after its restoration by Cimon, the celebrated painter Polygnotus had adorned with frescoes representing scenes from the Trojan War. But, though it arose on Hellenic soil, from lectures delivered in a public place at Athens, the school is scarcely to be considered a product of purely Greek intellect, but rather as the firstfruits of that interaction between West and East which followed the conquests of Alexander. Hardly a single Stoic of eminence was a citizen of any city in the heart of Greece, unless we make Aristo of Chios, Cleanthes of Assus and Panaetius of Rhodes exceptions. Such lands as Cyprus, Cilicia and Syria, such cities as Citium, Soli, Heraclea in Pontus, Sidon, Carthage, Seleucia on the Tigris, Apamea by the Orontes, furnished the school with its scholars and presidents; Tarsus, Rhodes and Alexandria became famous as its university towns. As the first founder was of Phoenician descent, so he drew most of his adherents from the countries which were the seat of Hellenistic (as distinct from Hellenic) civilization; nor did Stoicism achieve its crowning triumph until it was brought to Rome, where the grave earnestness of the national character could appreciate its doctrine, and where for two centuries or more it was the creed, if not the philosophy, of all the best Romans. Properly therefore it stands in marked antithesis to that fairest growth of old Hellas, the Academy, which saw the Stoa rise and fall—the one the typical school of Greece and Greek intellect, the other of the Hellenized East, and, under the early Roman Empire, of the whole civilized world. The transcendent genius of its author, the vitality and romantic fortunes of his doctrine, claim our warmest sympathies for Platonism. But it should not be forgotten that for more than four centuries the tide ran all the other way. It was Stoicism, not Platonism, that filled men's imaginations and exerted the wider and more active influence upon the ancient world at some of the busiest and most important times in all history.

The history of the Stoic school may conveniently be divided in the usual threefold manner: the old Stoa, the middle or transition period (Diogenes of Seleucia, Boethus of Sidon, Panaetius, Posidonius), and the later Stoicism of Roman times. By the old Stoa is meant the period (*c.* 304–205 B.C.) down to the death of Chrysippus, the second founder; then was laid the foundation of theory, to which hardly anything of importance was afterwards added. Confined almost to Athens, the school made its way slowly among many rivals. Aristo of Chios and Herillus of Carthage, Zeno's heterodox pupils, Persaeus, his favourite disciple and housemate, the poet Aratus, and Sphaerus, the adviser of the Spartan king Cleomenes, are noteworthy minor names; but the chief interest centres about Zeno, Cleanthes, Chrysippus, who in succession built up the wondrous system.

Zeno.—Zeno's residence at Athens fell at a time when the great movement which Socrates originated had spent itself in the second generation of his spiritual descendants. Neither Theophrastus at the Lyceum, nor Xenocrates and Polemo at the Academy, nor Stilpo, who was drawing crowds to hear him at Megara, could be said to have inherited much of the great reformer's intellectual vigour, to say nothing of his moral earnestness. Zeno visited all the schools in turn, but seems to have attached himself definitely to the Cynics; as a Cynic he composed at least one of his more important works, "the much admired *Republic*," which we know to have been later on a stumbling-block to the school. In the Cynic school he found the practical spirit which he divined to be the great need of that stirring troublous age. For a while his motto must have been "back to Socrates," or at least "back to Antisthenes." The Stoics always counted themselves amongst the Socratic schools, and canonized Antisthenes and Diogenes; while reverence for Socrates was the tie which united to them such an accomplished writer upon lighter ethical topics as the versatile Persaeus, who, at the capital of Antigonus Gonatas, with hardly anything of the professional philosopher about him, reminds us of Xenophon, or even Prodicus. Zeno commenced, then, as a Cynic; and in the developed system we can point to a kernel of Cynic doctrine to which various philosophemes of other thinkers (more especially Heraclitus and Aristotle, but also Diogenes of Apollonia, the Pythagoreans, and the medical school of Hippocrates in a lesser degree) were added. Thus, quite apart from the general similarity of their ethical doctrine, the Cynics were materialists; they were also nominalists, and combated the Platonic ideas; in their theory of knowledge they made use of "reason" (λόγος), which was also one of their leading ethical conceptions. In all these particulars Zeno followed them, and the last is the more important, because, Chrysippus having adopted a new criterion of truth—a clear and distinct perception of sense—it is only from casual notices we learn that the elder Stoics had approximated to Cynicism in making right reason the standard. At the same time, it is certain that the main outlines of the characteristic physical doctrine, which is after all the foundation of their ethics and logic, were the work of Zeno. The Logos, which had been an ethical or psychological principle to the Cynics, received at his hands an extension throughout the natural world, in which Heraclitean influence is unmistakable.

Cleanthes.—If the recognition of physics and logic as two studies co-ordinate with ethics is sufficient to differentiate the mature Zeno from the Cynic author of the *Republic*, no less than from his own heterodox disciple Aristo, the elaboration on all sides of Stoic natural philosophy belongs to Cleanthes, who certainly was not the merely docile and receptive intelligence he is sometimes represented as being. He carried on and completed the assimilation of Heraclitean doctrine; but his own contributions were more distinctive and original than those of any other Stoic. He was able to transform Zeno's seeming dualism of God (or force) and formless matter into the lofty pantheism which breathes in every line of the famous hymn to Zeus. Heraclitus had indeed declared all to be in flux, but we ask in vain what is the cause for the unceasing process of his ever-living fire. It was left for Cleanthes to discover this motive cause in a conception familiar to Zeno, as to the Cynics before him, but restricted to the region of ethics—the conception of tension or effort. The soul of the sage, thought the Cynics, should be strained and braced for judgment and action; his first need is firmness (εὐτονία) and Socratic strength. But the mind is a corporeal thing. Then followed the flash of genius: this varying tension of the one substance everywhere present, a purely physical fact, accounts for the diverse destinies of all innumerable particular things; it is the veritable cause of the flux and process of the universe. Herein lies the key to the entire system of the Stoics, as Cleanthes's epoch-making discovery continually received fresh applications to physics, ethics and epistemology.

Chrysippus.—Zeno had caught the practical spirit of his age—the desire for a popular philosophy to meet individual needs. But there was another tendency in post-Aristotelian thought—to lean upon authority and substitute learning for independent research—which grew stronger just in proportion as the fresh interest in the problems of the universe and the zeal for discovery declined—a shadow, we may call it, of the coming Scholasticism thrown a thousand years in advance. The representative of this tendency, Chrysippus, addressed himself to the congenial task of assimilating, developing, systematizing the doctrines bequeathed to him, and, above all, securing them in their stereotyped and final form, not simply from the assaults of the past, but, as after a long and successful career of controversy and polemical authorship he fondly hoped, from all possible attack in the future. To his personal characteristics can be traced the hair-splitting and formal pedantry which ever afterwards marked the activity of the school, the dry repellent technical procedure of the Dialecticians *par excellence*, as they were called. He created their formal logic and contributed much that was of value to their psychology and epistemology; but in the main his work was to new-label and new-arrange in every department, and to lavish most care and attention on the least important parts—the logical terminology and the refutation of fallacies, or, as his opponents declared, the excogitation of fallacies which even he could not refute.

Stoic Conception of Philosophy.—What is philosophy? No idle gratification of curiosity, no theory divorced from practice, no pursuit of science for its own sake, but knowledge so far forth as it can be realized in virtuous action, the learning of virtue by exercise and effort and training. So absolutely is the "rare and priceless wisdom" identical with virtue itself that the three main divisions of philosophy current at the time and accepted by Zeno—logic, physics and ethics—are defined as the most generic or comprehensive *virtues*. Accordingly Aristo rejected two of these parts of philosophy as useless and out of reach—a divergence which excluded him from the school, but strictly consistent with his view that ethics alone is scientific knowledge. Of the three divisions logic is the least important; ethics is the outcome of the whole, and historically the all-important vital element; but the foundations of the whole system are best discerned in the science of nature, which deals pre-eminently with the macrocosm and the microcosm, the universe and man, including natural theology and anthropology or psychology, the latter forming the direct introduction to ethics.

Physics.—The Stoic system is in brief: (*a*) materialism, (*b*) dynamic materialism, lastly (*c*) monism or pantheism. (*a*) The first of these characters is described by anticipation in Plato's *Sophist* (246 C *seq.*), where, arguing with those "who drag everything down to the corporeal" (σῶμα), the Eleatic stranger would fain prove to them the existence of something incorporeal, as follows. "They admit the existence of an animate body. Is soul then something existent (οὐσία)? Yes. And the qualities of soul, as justice and wisdom—are they visible and tangible? No. Do they then exist? They are in a dilemma." Now, however effective against Plato's contemporary Cynics or Atomists, the reasoning is thrown away upon the Stoics, who take boldly the one horn of this dilemma. That qualities of bodies (and therefore of the corporeal soul) exist they do not deny; but they assert most uncompromisingly that they are one and all (wisdom, justice, etc.) corporeal. And they strengthen their position by taking Plato's own definition (247 D), namely "being is that which has the power to act or be acted upon," and turning it against him. For this is only true of Body; action, except by contact, is inconceivable; and they reduce every form of causation to the efficient cause, which implies the communication of motion from one body to another. Again and again, therefore, only Body exists. The most real realities to Plato and Aristotle had been thought and the objects of thought, νοῦς and νοητά, whether abstracted from sensibles or inherent in "matter," as the incognizable basis of all concrete existence. But this was too great an effort to last long. Such spiritualistic theories were nowhere really maintained after Aristotle and outside the circle of his immediate followers. The reaction came and left nothing of it all; for five centuries the dominant tone of the older and the newer schools alike was frankly materialistic. "If," says Aristotle, "there is no other substance but the organic substances of nature, physics will be the highest of the sciences," a conclusion which passed for axiomatic until the rise of Neoplatonism. The analogues therefore of metaphysical problems must be sought in physics; particularly that problem of the causes of things for which the Platonic idea and the Peripatetic "constitutive form" had been, each in its turn, received solutions. (*b*) But the doctrine that all existence is confined within the limits of the sensible universe—that there is no being save corporeal being or body—does not suffice to characterize the Stoic system; it is no less a doctrine of the Epicureans. It is the idea of tension or tonicity as the essential attribute of body, in contradistinction to passive inert matter, which is distinctively Stoic. The Epicureans leave unexplained the primary constitution and first movements of their atoms or elemental solids; chance or declination may account for them. Now, to the Stoics nothing passes unexplained; there is a reason (λόγος) for everything in nature. Everything which exists is at once capable of acting and being acted upon. In everything that exists, therefore, even the smallest particle, there are these two principles. By virtue of the passive principle the thing is susceptible of motion and modification; it is matter which determines substance (*οὐσία*). The active principle makes the matter a given determinate thing, characterizing and qualifying it, whence it is termed quality (*ποιότης*). For all that is or happens there is an immediate cause or antecedent; and as "cause" means "cause of motion," and only body can act upon body, it follows that this antecedent cause is itself as truly corporeal as the matter upon which it acts. Thus we are led to regard the active principle "force" as everywhere coextensive with "matter," as pervading and permeating it, and together with it occupying and filling space. This is that famous doctrine of universal permeation (*κρᾶσις δἰ ὅλου*), by which the axiom that two bodies cannot occupy the same space is practically denied. Thus that harmony of separate doctrines which contributes to the impressive simplicity of the Stoic physics is only attained at the cost of offending healthy common sense, for Body itself is robbed of a characteristic attribute. A thing is no longer, as Plato once thought, hot or hard or bright by partaking in abstract heat or hardness or brightness, but by containing within its own substance the material of these qualities, conceived as air-currents in various degrees of tension. We hear, too, of corporeal days and years, corporeal virtues, and actions (like walking) which are bodies (*σώματα*). Obviously, again, the Stoic quality corresponds to Aristotle's essential form; in both systems the active principle, "the cause of all that matter becomes," is that which accounts for the existence of a given concrete thing (λόγος *τῆς οὐσίας*). Only here, instead of assuming something immaterial (and therefore unverifiable), we fall back upon a current of air or gas (*πνεῦμα*); the essential reason of the thing is itself material, standing to it in the relation of a gaseous to a solid body. Here, too, the reason of things—that which accounts for them—is no longer some external end to which they are tending; it is something acting within them, "a spirit deeply interfused," germinating and developing as from a seed in the heart of each separate thing that exists (λόγος *σπερματικός*). By its prompting the thing grows, develops and decays, while this "germinal reason," the element of quality in the thing, remains constant through all its changes.

Psychology and Theory of Knowledge.—If, however, in the science of nature the Stoics can lay claim to no striking originality, the case is different when we come to the science of man. In the rational creatures—man and the gods—Pneuma is manifested in a high degree of purity and intensity as an emanation from the world-soul, itself an emanation from the primary substance of purest ether—a spark of the celestial fire, or, more accurately, fiery breath, which is a mean between fire and air, characterized by vital warmth more than by dryness. The physical basis of Stoic psychology deserves the closest attention. On the one hand, soul is corporeal, else it would have no real existence, would be incapable of extension in three dimensions (and therefore of equable diffusion all over the body), incapable of holding the body together, as the Stoics contended that it does, herein presenting a sharp contrast to the Epicurean tenet that it is the body which confines and shelters the light vagrant atoms of soul. On the other hand, this corporeal thing is veritably and identically reason, mind, and ruling principle (*λόγος, νους, ἡγεμονικόν*); in virtue of its divine origin Cleanthes can say to Zeus, "We too are thy offspring," and a Seneca can calmly insist that, if man and God are not on perfect equality, the superiority rests rather on our side. What God is for the world that the soul is for man. The Cosmos must be conceived as a single whole, its variety being referred to varying stages of condensation in Pneuma. So, too, the human soul must possess absolute simplicity, its varying functions being conditioned by the degrees or species of its tension. It follows that of "parts" of the soul, as previous thinkers imagined, there can be no question; all that can consistently be maintained is that from the centre of the body—the heart—seven distinct air-currents are discharged to various organs, which are so many modes of the one soul's activity. The ethical consequences of this position will be seen at a later stage. With this psychology is intimately connected the Stoic theory of knowledge. From the unity of soul it follows that all psychical processes—sensation, assent, impulse—proceed from reason, the ruling part; that is to say, there is no strife or division: the one rational soul alone has sensations, assents to judgments, is impelled towards objects of desire just as much as it thinks or reasons.

Cosmopolitanism.—In their view of man's social relations the Stoics are greatly in advance of preceding schools. We saw that virtue is a law which governs the universe: that which Reason and God ordain must be accepted as binding upon the particle of reason which is in each one of us. Human law comes into existence when men recognize this obligation; justice is therefore natural and not something merely conventional. The opposite tendencies, to allow to the individual responsibility and freedom, and to demand of him obedience to law, are both features of the system; but in virtue even of the freedom which belongs to him *qua* rational, he must recognize the society of rational beings of which he is a member, and subordinate his own ends to the ends and needs of this society. Those who own one law are citizens of one state, the city of Zeus, in which men and gods have their dwelling. In that city all is ordained by reason working intelligently, and the members exist for the sake of one another; there is an intimate connection (*συμπάθεια*) between them which makes all the wise and virtuous friends, even if personally unknown, and leads them to contribute to one another's good. Their intercourse should find expression in justice, in friendship, in family and political life. But practically the Stoic philosopher always had some good excuse for withdrawing from the narrow political life of the city in which he found himself. The circumstances of the time, such as the decay of Greek city-life, the foundation of large territorial states under absolute Greek rulers which followed upon Alexander's conquests, and afterwards the rise of the world-empire of Rome, aided to develop the leading idea of Zeno's *Republic*. There he had anticipated a state without family life, without law courts or coins, without schools or temples, in which all differences of nationality would be merged in the common brotherhood of man. This cosmopolitan citizenship remained all through a distinctive Stoic dogma; when first announced it must have had a powerful influence upon the minds of men, diverting them from the distractions of almost parochial politics to a boundless vista. There was, then, no longer any difference between Greek and barbarian, between male and female, bond and free.

Religion.—The religious problem had peculiar interest for the school which discerned God everywhere as the ruler and upholder, and at the same time the law, of the world that He had evolved from Himself. The physical ground-work lends a religious sanction to all moral duties, and Cleanthes's noble hymn is evidence how far a system of natural religion could go in providing satisfaction for the cravings of the religious temper:—

> "Most glorious of immortals, O Zeus of many names, almighty and everlasting, sovereign of nature, directing all in accordance with law, thee it is fitting that all mortals should address. . . . Thee all this universe, as it rolls circling round the earth, obeys wheresoever thou dost guide, and gladly owns thy sway. Such a minister thou holdest in thy invincible hands—the two-edged, fiery, everliving thunderbolt, under whose stroke all nature shudders. No work upon earth is wrought apart from thee, lord, nor through the divine ethereal sphere, nor upon the sea; save only whatsoever deeds wicked men do in their own foolishness. Nay, thou knowest how to make even the rough smooth, and to bring order out of disorder; and things not friendly are friendly in thy sight. For so hast thou fitted all things together, the good with the evil, that there might be one eternal law over all. . . . Deliver men from fell ignorance. Banish it, father, from their soul, and grant them to obtain wisdom, whereon relying thou rulest all things with justice."

To the orthodox theology of Greece and Rome the system stood in a twofold relation, as criticism and rationalism. That the popular religion contained gross errors hardly needed to be pointed out. The forms of worship were known to be trivial or mischievous, the myths unworthy or immoral. But Zeno declared images, shrines, temples, sacrifices, prayers and worship to be of no avail. A really acceptable prayer, he taught, can only have reference to a virtuous and devout mind: God is best worshipped in the shrine of the heart by the desire to know and obey Him. At the same time the Stoics felt at liberty to defend and uphold the truth in polytheism. Not only is the primitive substance God, the one supreme being, but divinity must be ascribed to His manifestations—to the heavenly bodies, which are conceived, like Plato's created gods, as the highest of rational beings, to the forces of nature, even to deified men; and thus the world was peopled with divine agencies. Moreover, the myths were rationalized and allegorized, which was not in either case an original procedure. The search for a deeper hidden meaning beside the literal one had been begun by Democritus, Empedocles, the Sophists and the Cynics. It remained for Zeno to carry this to a much greater extent and to seek out or invent "natural principles" (λόγοι φυσικοί) and moral ideas in all the legends and in the poetry of Homer and Hesiod. In this sense he was the pattern if not the "father" of all such as allegorize and reconcile.

Stoicism in Rome.—The introduction of Stoicism at Rome was the most momentous of the many changes that it saw. After the first sharp collision with the jealousy of the national authorities it found a ready acceptance, and made rapid progress amongst the noblest families. It has been well said that the old heroes of the republic were unconscious Stoics, fitted by their narrowness, their stern simplicity and devotion to duty for the almost Semitic earnestness of the new doctrine. In Greece its insensibility to art and the cultivation of life was a fatal defect; not so with the shrewd men of the world, desirous of qualifying as advocates or jurists. It supplied them with an incentive to scientific research in archaeology and grammar; it penetrated jurisprudence until the belief in the ultimate identity of the *jus gentium* with the law of nature modified the praetor's edicts for centuries. Even to the prosaic religion of old Rome, with its narrow original conception and multitude of burdensome rites, it became in some sort a support. Scaevola, following Panaetius, explained that the prudence of statesmen had established this public institution in the service of order midway between the errors of popular superstition and the barren truths of enlightened philosophy. Soon the influence of the pupils reacted upon the doctrines taught. Of speculative interest the ordinary Roman had as little as may be; for abstract discussion and controversy he cared nothing. Indifferent to the scientific basis or logical development of doctrines, he selected from various writers and from different schools what he found most serviceable. All had to be simplified and disengaged from technical subtleties. To attract his Roman pupils Panaetius would naturally choose simple topics susceptible of rhetorical treatment or of application to individual details. He was the representative, not merely of Stoicism, but of Greece and Greek literature, and would feel pride in introducing its greatest masterpieces: amongst all that he studied, he valued most the writings of Plato. He admired the classic style, the exquisite purity of language, the flights of imagination, but he admired above all the philosophy. He marks a reaction of the genuine Hellenic spirit against the austerity of the first Stoics.

The Later Stoics.—The writings of the later Stoics have come down to us, if not entire, in great part, so that Seneca, Cornutus, Persius, Lucan, Epictetus, Marcus Aurelius are known at first hand. They do not profess to give a scientific exposition of doctrine, and may therefore be dismissed somewhat briefly (*see* Epictetus and Marcus Aurelius). We learn much more about the Stoic system from the scanty fragments of the first founders, or even from the epitomes of Diogenes Laërtius and Stobaeus, than from these writers. They testify to the restriction of philosophy to the practical side, and to the increasing tendency, ever since Panaetius, towards a relaxation of the rigorous ethical doctrine and its approximation to the form of religious conviction. This finds most marked expression in the doctrines of submission to Providence and universal philanthropy. Only in this way could they hold their ground, however insecurely, in face of the religious reaction of the 1st century. In passing to Rome, Stoicism quitted the school for actual life. The fall of the republic was a gain, for it released so much intellectual activity from civic duties. The life and death of Cato fired the imagination of a degenerate age in which he stood out both as a Roman and a Stoic. To a long line of illustrious successors, men like Thrasea Paetus and Helvidius Priscus, Cato bequeathed his resolute opposition to the dominant power of the times; unsympathetic, impracticable, but fearless in demeanour, they were a standing reproach to the corruption and tyranny of their age. But when at first, under Augustus, the empire restored order, philosophy became bolder and addressed every class in society, public lectures and spiritual direction being the two forms in which it mainly showed activity. Books of direction were written by Sextius in Greek (as afterwards by Seneca in Latin), almost the only Roman who had the ambition to found a sect, though in ethics he mainly followed Stoicism. His contemporary Papirius Fabianus was the popular lecturer of that day, producing a powerful effect by his denunciations of the manners of the time. Under Tiberius, Sotion and Attalus were attended by crowds of hearers.

Seneca.—Seneca is the most prominent leader in the direction which Roman Stoicism now took. His penetrating intellect had mastered the subtleties of the system of Chrysippus, but they seldom appear in his works, at least without apology. Incidentally we meet there with the doctrines of Pneuma and of tension, of the corporeal nature of the virtues and the affections, and much more to the same effect. But his attention is claimed for physics chiefly as a means of elevating the mind, and as making known the wisdom of Providence and the moral government of the world. To reconcile the ways of God to man had been the ambition of Chrysippus, as we know from Plutarch's criticisms. He argued plausibly that natural evil was a thing indifferent—that even moral evil was required in the divine economy as a foil to set off good. The really difficult problem why the prosperity of the wicked and the calamity of the just were permitted under the divine government he met in various ways: sometimes he alleged the forgetfulness of higher powers; sometimes he fell back upon the necessity of these contrasts and grotesque passages in the comedy of human life. Seneca gives the true Stoic answer in his treatise *On Providence:* the wise man cannot really meet with misfortune; all outward calamity is a divine instrument of training, designed to exercise his powers and teach the world the indifference of external conditions. In the soul Seneca recognizes an effluence of the divine spirit, a god in the human frame; in virtue of this he maintains the essential dignity and internal freedom of man in every human being. Yet, in striking contrast to this orthodox tenet is his vivid conception of the weakness and misery of men, the hopelessness of the struggle with evil, whether in society or in the individual. Thus he describes the body (which, after Epicurus, he calls the flesh) as a mere husk or fetter or prison of the soul; with its departure begins the soul's true life. Sometimes, too, he writes as if he accepted an irrational as well as a rational part of the soul. In ethics, if there is no novelty of doctrine, there is a surprising change in the mode of its application. The ideal sage has receded; philosophy comes as a physician, not to the whole but to the sick. We learn that there are various classes of patients in "progress" (προκοπή), *i.e.*, on their way to virtue, making painful efforts towards it. The first stage is the eradication of vicious habits: evil tendencies are to be corrected, and a guard kept on the corrupt propensities of the reason. Suppose this achieved, we have yet to struggle with single attacks of the passions: irascibility may be cured, but we may succumb to a fit of rage. To achieve this second stage the impulses must be trained in such a way that the fitness of things indifferent may be the guide of conduct. Even then it remains to give the will that property of rigid infallibility without which we are always liable to err, and this must be effected by the training of the judgment. Other peculiarities of the later Stoic ethics are due to the condition of the times. In a time of moral corruption and oppressive rule, as the early empire repeatedly became to the privileged classes of Roman society, a general feeling of insecurity led the student of philosophy to seek in it a refuge against the vicissitudes of fortune which he daily beheld.

Musonius.—From Seneca we turn, not without satisfaction, to men of sterner mould, such as Musonius Rufus, who certainly deserves a place beside his more illustrious disciple, Epictetus. As a teacher he commanded universal respect, and wherever we catch a glimpse of his activity he appears to advantage. His philosophy, however, is yet more concentrated upon practice than Seneca's, and in ethics he is almost at the position of Aristo. Epictetus testifies to the powerful hold he acquired upon his pupils, each of whom felt that Musonius spoke to his heart.

Epictetus.—In the life and teaching of Epictetus this thought bore abundant fruit. The beautiful character which rose superior to weakness, poverty and slave's estate is also presented to us in the *Discourses* of his disciple Arrian as a model of religious resignation, of forbearance and love towards our brethren, that is, towards all men, since God is our common father. With him even the "physical basis" of ethics takes the form of a religious dogma—the providence of God and the perfection of the world. We learn that he regards the *δαίμων* or "guardian angel" as the divine part in each man; sometimes it is more nearly conscience, at other times reason. His ethics, too, have a religious character. He begins with human weakness and man's need of God: whoso would become good must first be convinced that he is evil. Submission is enforced by an argument which almost amounts to a retractation of the difference between things natural and things contrary to nature, as understood by Zeno. Would you be cut off from the universe? he asks. Go to, grow healthy and rich. But if not, if you are a part of it, then be resigned to your lot.

Aurelius.—Epictetus is marked out amongst Stoics by his renunciation of the world. He is followed by a Stoic emperor, M. Aurelius Antoninus, who, though in the world, was not of it. The *Meditations* give no systematic exposition of belief, but there are many indications of the religious spirit we have already observed, together with an almost Platonic psychology. Following Epictetus, he speaks of man as a corpse bearing about a soul; at another time he has a threefold division—(1) body, (2) soul, the seat of impulse (*πνευματίον*), and (3) *νοῦς* or intelligence, the proper *ego*. In all he writes there is a vein of sadness: the flux of all things, the vanity of life, are thoughts which perpetually recur, along with resignation to the will of God and forbearance towards others, and the religious longing to be rid of the burden and to depart to God. These peculiarities in M. Antoninus may perhaps be explained in harmony with the older Stoic teaching; but, when taken in connection with the rise of Neoplatonism and the revival of superstition, they are certainly significant. None of the ancient systems fell so rapidly as the Stoa. It had just touched the highest point of practical morality, and in a generation after M. Antoninus there is hardly a professor to be named. Its most valuable lessons to the world were preserved in Christianity; but the grand simplicity of its monism slumbered for fifteen centuries before it was revived by Spinoza.

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STOKE NEWINGTON, a borough of London, England. Pop. (1921) 52,172; area 863 acres. In Church Street is the ancient parish church of St. Mary, largely restored. The borough returns one member to Parliament.

STOKE-ON-TRENT, a city in Staffordshire, England, in the heart of the Potteries. Pop. (1921) 240,428. Stoke-upon-Trent, Burslem, Fenton, Hanley, Longton and Tunstall were amalgamated on March 31, 1910. In 1925 the borough became a city. The principal public buildings are the town hall (enlarged 1910–12), the county court offices, the market hall, the Minton memorial building, the Victoria institute (Tunstall), the central library and branch libraries, the central school of science and technology, secondary schools, etc. There are several large parks within the city boundaries. In addition to the potteries, there are coal-mines, as well as deposits of coarse clay, but the finer china-clay comes from Cornwall and elsewhere. New industries, *e.g.*, electrical accessories, rubber tyre manufacture, dyeing, etc., are also prosperous. The district is well served by railways and also by the Grand Trunk (Trent and Mersey) canal. There is a statue to Josiah Wedgwood (b. 1730) in Burslem. Other names made famous by the pottery industry here are, Josiah Spode (b. 1754), Herbert Minton (b. 1793) and the Copelands.

In the Domesday Survey of 1086 half the church of Stoke and lands in Stoca are said to have belonged to Robert of Stafford. Market rights were not acquired until 1845. By the Reform Bill (1832) Stoke sent two members to parliament, and since 1918, three members. It was first incorporated in 1874.

STOKE POGES, a village in Buckinghamshire, England. The church of St. Giles has portions of Norman, Early English, and later dates, and Thomas Gray is buried in the churchyard, held to be the original of his *Elegy*. The manor-house finds mention in his *Long Story*. West End Cottage, where he often stayed, remains in altered form as Stoke Court. Burnham Beeches, a favourite haunt of Gray's, is about 3 mi. away.

STOKES, ADRIAN (1887–1927), English bacteriologist, was born at Lausanne, and educated at Trinity college, Dublin, becoming demonstrator in anatomy, and assistant professor of pathology. During the World War, he established a mobile laboratory for the prevention of epidemic outbreaks, including typhoid. His inoculation of the Belgian civil population helped to suppress enteric. He was awarded the Belgian order of the Crown, and in 1918 received the D.S.O. After the war (1919) he became professor at Dublin and in 1922 he was appointed to the Sir William Dunn chair of pathology. In 1920 the Rockefeller Commission on Yellow Fever in West Africa included Stokes among its members, and in 1927 asked him to go out to West Africa. He collaborated with Hideyo Noguchi (*q.v.*) and William Young, and their discovery of a monkey susceptible to the disease enabled them to prepare a preventive vaccine. Stokes became infected with the disease, and died on Sept. 19, 1927. He published papers, particularly on infectious jaundice, typhoid carriers and dysentery.

STOKES, SIR (FREDERICK) WILFRID SCOTT K.B.E. (1860–1927), engineer and inventor, son of Scott Nasmyth Stokes, was born in 1860 at Liverpool. After some years in railway work he joined Ransomes and Rapier of Ipswich, becoming managing director and chairman. He was distinguished in many branches of engineering. His inventions, for which some fifty patents were granted, included improvements in sluice gates, breakdown cranes, railway, hydraulic, refrigerating and cement making machinery, ordnance and projectiles. He had a share in many notable engineering achievements at home and abroad, including the Manchester ship canal and the irrigation works in India, Egypt and the Sudan. He was responsible for the design of the sluice and lock gates, and he was present both at the opening of the Assuan dam 1901 and of the Sennar dam 1926.

From 1915 until 1918 Stokes served on Ministry of Munitions inventions committees, and he was also chairman of the East Anglian and other munitions committees. In 1915 he acquired fame by the timely invention of the Stokes trench mortar and ammunition.

At great personal risk, without previous technical knowledge of explosives he perfected the shells of which more than twenty million rounds were used with deadly effect in the trenches and at Zeebrugge and elsewhere. He also promoted the invention of effective anti-aircraft shells. For his public services he was created K.B.E. in 1917. Stokes was president of the British Engineers' Association 1916–1918.

See *Handbook of Stokes' Trench Mortar Equipment* (1920); *History of the Ministry of Munitions* (1922); T. E. Lawrence, *Revolt in the*

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STOKES, SIR GEORGE GABRIEL, BART. (1819–1903), British mathematician and physicist, son of the rector of Skreen, Co. Sligo, Ireland, was born on Aug. 13, 1819. In 1837 he entered Pembroke college, Cambridge, where he became a fellow in 1841. He lost his fellowship when he married in 1857, but twelve years later, under new statutes, he was re-elected. In 1902, he was elected Master. As Lucasian professor, secretary and president of the Royal Society, he held three offices, which had only once before been held by one man, Sir Isaac Newton. He was member of parliament for the University from 1887 to 1892, was created baronet in 1889 and died on Feb. 1, 1903.

Stokes was the oldest of the trio of physicists, Clerk Maxwell and Lord Kelvin being the other two, who especially contributed to the fame of the Cambridge school of mathematical physics in the middle of the 19th century. The Royal Society's catalogue of scientific papers gives the titles of over a hundred memoirs by him published down to 1883. The greater part of his work was concerned with waves and the transformations imposed on them during their passage through various media. His first published papers, which appeared in 1842 and 1843, were on the steady motion of incompressible fluids and some cases of fluid motion; these were followed in 1845 by one on the friction of fluids in motion and the equilibrium and motion of elastic solids, and in 1850 by another on the effects of the internal friction of fluids on the motion of pendulums. To the theory of sound he made several contributions, including a discussion of the effect of wind on the intensity of sound and an explanation of how the intensity is influenced by the nature of the gas in which the sound is produced. These inquiries together put the science of hydrodynamics on a new footing, and provided a key not only to the explanation of many natural phenomena, such as the suspension of clouds in air, and the subsidence of ripples and waves in water, but also to the solution of practical problems, such as the flow of water in rivers and channels, and the skin resistance of ships.

His best-known researches are perhaps those on the undulatory theory of light. His first papers on the aberration of light appeared in 1845 and 1846, and were followed in 1848 by one on the theory of certain bands seen in the spectrum. In 1849 his paper on the dynamical theory of diffraction showed that the plane of polarization must be perpendicular to the direction of vibration. Two years later he discussed the colours of thick plates; and in 1852, in his famous paper on the change of refrangibility of light, he described the phenomenon of fluorescence, as exhibited by fluorspar and uranium glass, materials which he viewed as having the power to convert invisible ultra-violet rays into rays of wave lengths which are visible. A mechanical model, illustrating the dynamical principle of Stokes's explanation was shown in 1883, during a lecture at the Royal Institution, by Lord Kelvin, who said he had heard an account of it from Stokes many years before, and had repeatedly but vainly begged him to publish it. In the same year, 1852, there appeared the paper on the composition and resolution of streams of polarized light from different sources, and in 1853 an investigation of the metallic reflection exhibited by certain non-metallic substances. About 1860 he was engaged in an inquiry on the intensity of light reflected from, or transmitted through, a pile of plates; and in 1862 he prepared for the British Association a valuable report on double refraction, which marks a period in the history of the subject in England. A paper on the long spectrum of the electric light bears the same date, and was followed by an inquiry into the absorption spectrum of blood.

The discrimination of organic bodies by their optical properties was treated in 1864; and later, in conjunction with the Rev. W. Vernon Harcourt, he investigated the relation between the chemical constitution and the optical properties of various glasses, with reference to the conditions of transparency and the improvement of achromatic telescopes. A still later paper connected with the construction of optical instruments discussed the theoretical limits to the aperture of microscopical objectives. In other departments of physics may be mentioned his paper on the conduction of heat in crystals (1851) and his inquiries in connection with the radiometer; his explanation of the light border frequently noticed in photographs just outside the outline of a dark body seen against the sky (1883); and, still later, his theory of the Röntgen rays, which he suggested might be transverse waves travelling as innumerable solitary waves, not in regular trains. Two long papers published in 1849—one on attractions and Clairaut's theorem, and the other on the variation of gravity at the surface of the earth—also demand notice, as do his mathematical memoirs on the critical values of the sums of periodic series (1847) and on the numerical calculation of a class of definite integrals and infinite series (1850) and his valuable discussion of a differential equation relating to the strains, stresses and other factors involved in the breaking of railway bridges (1849).

Many of his discoveries were only touched upon in lectures. An instance is his work in the theory of spectrum analysis. Some of Stokes's friends and pupils claimed that he had anticipated Kirchhoff but Stokes maintained that he had failed to see an essential step in the argument and disclaimed priority. As Lucasian professor, Stokes announced that he wished to help any member of the university in his mathematical studies, and pupils were glad to consult him, even after they had become colleagues. During the thirty years of his secretaryship to the Royal Society he advanced the cause of mathematical and physical science, not only by his own investigations, but by suggesting problems for inquiry and inciting men to attack them.

He received the Rumford medal in 1852 and in 1893, the Copley medal. His numerous other honours included the Prussian Ordre pour le Mérite. In 1869 he presided over the Exeter meeting of the British Association.

Sir George Stokes's mathematical and physical papers were published in a collected form in five volumes; the first three (Cambridge, 1880, 1883, and 1901) under his own editorship, and the two last (Cambridge, 1904 and 1905) under that of Sir Joseph Larmor, who also selected and arranged the *Memoir and Scientific Correspondence* of Stokes published at Cambridge in 1907. Stokes was the author of *Light* (1884–87) and *Natural Theology* (1891).

STOKES, WHITLEY (1830–1909), British lawyer and Celtic scholar, was a son of William Stokes (1804–1878), and a grandson of Whitley Stokes (1763–1845), each of whom was regius professor of physic in the university of Dublin. Educated at Trinity college, Dublin, young Stokes became a barrister and in 1862 went out to India. In 1877 he became legal member of the viceroy's council, and he drafted the codes of civil and criminal procedure. After his return to England in 1882 he devoted himself to the Celtic studies which made him famous. He studied Irish, Breton and Cornish texts, and among his numerous works may be mentioned editions of *Three Irish Glossaries* (1862); *Three Middle-Irish Homilies* (1877); and *Old Irish Glosses at Würzburg and Carlsruhe* (1887). He was one of the editors of the *Irische Texte* published at Leipzig (1880–1900); and he edited and translated *Lives of Saints from the Book of Lismore* (1890). With Professor A. Bezzenberger he wrote *Urkeltischer Sprachschatz* (1894). His principal legal work was *The Anglo-Indian Codes* (1887). He died in London, April 13, 1909.

STOKESAY, a parish and hamlet in Shropshire, England, 6½ m. N.W. of Ludlow, with an interesting old church and one of the most remarkable moated manor houses surviving in Britain. Its north tower, of stone, belongs to the early 12th century, and a timber structure was placed on it about 1620–30, when a timbered building and a half-timbered gate-house were built. The banqueting hall and solar date from 1240 and the south tower from 1291. The solar was re-decorated in 1665. There have been modern repairs.

STOLBERG, FRIEDRICH LEOPOLD, GRAF ZU (1750–1819), German poet, the younger son of Count Christian Stolberg, was born at Bramstedt in Holstein on Nov. 7, 1750. He studied in Göttingen and was a member of the famous Göttinger *Hain* or *Dichterbund*. After leaving the university he made a journey to Switzerland with his brother Christian, in company with

Goethe. In 1777 he was appointed envoy of the prince bishop of Lübeck at the court of Copenhagen, but often stayed at Eutin, where he was the intimate associate of J. H. Voss. In 1782 he married Agnes von Witzleben, whom he celebrated in his poems. After her early death in 1788, he became Danish envoy at the court of Berlin, and contracted a second marriage with the countess Sophie von Redern in 1789. In 1791 he was appointed president of the Lübeck episcopal court at Eutin; he resigned this office in 1800, and retiring to Münster in Westphalia, there joined, with his whole family, the eldest daughter only excepted, the Roman Catholic Church. For this step he was severely attacked by his former friend Voss (*Wie ward Fritz Stolberg ein Unfreier?* 1819). After living for a while (from 1812) in the neighbourhood of Bielefeld, he removed to his estate of Sondermühlen near Osnabrück, where he died on Dec. 5, 1819. He wrote many odes, ballads, satires and dramas—among the last the tragedy *Timoleon* (1784), translations of the *Iliad* (1778), of Plato (1796–1797), Aeschylus (1802), and Ossian (1806); he published in 1815, a *Leben Alfreds des Grossen*, and a voluminous *Geschichte der Religion Jesu Christi* (17 vols., 1806–1818).

Stolberg's brother, CHRISTIAN, GRAF ZU STOLBERG (1748–1821), was also a poet. Born at Hamburg on Oct. 15, 1748, he became a magistrate at Tremsbüttel in Holstein in 1777, and died on Jan. 18, 1821. Of the two brothers Friedrich was undoubtedly the more talented, but Christian, though not a poet of high originality, excelled in the utterance of gentle sentiment. They published together a volume of poems, *Gedichte* (edited by H. C. Boie, 1779); *Schauspiele mit Chören* (1787), their object in the latter work being to revive a love for the Greek drama; and a collection of patriotic poems *Vaterländische Gedichte* (1815). Christian von Stolberg was the sole author of *Gedichte aus dem Griechischen* (1782), a translation of the works of Sophocles (1787), and of a poem in seven ballads, *Die weisse Frau* (1814), which last attained considerable popularity.

The Collected Works of Christian and Friedrich Leopold zu Stolberg were published in twenty volumes in 1820–25; 2nd ed. 1827. Friedrich's correspondence with F. H. Jacobi will be found in Jacobi's *Briefwechsel* (1825–27); that with Voss has been edited by O. Hellinghaus (1891). Selections from the poetry of the two brothers will be found in A. Sauer's *Der Göttinger Dichterbund*, iii. (Kürschner's *Deutsche Nationalliteratur*, vol. 50, 1896). *See* also T. Menge, *Der Graf F. L. Stolberg und seine Zeitgenossen* (2 vols., 1862); J. H. Hennes, *Aus F. L. von Stolbergs Jugendjahren* (1876); the same, *Stolberg in den zwei letzten Jahrzehnten seines Lebens* (1875); J. Janssen, *F. L. Graf zu Stolberg* (2 vols., 1877), 2nd ed. 1882; W. Keiper, *F. L. Stolbergs Jugendpoesie* (1893).

STOLBERG, a town in the Prussian Rhine province. Pop. (1925) 17,096. Its prosperity was founded in the 17th century by French refugees, who introduced brass-founding. A castle is on the site of a church said to have been used by Charlemagne. The leading industry is metal-working in zinc, brass and iron.

STOLE, a liturgical vestment of the Catholic Church, peculiar to the higher orders, *i.e.*, deacons, priests and bishops. It is a strip of stuff, usually silk, some 2½yds. long by 4in. broad; in the middle and at the ends, which are commonly broadened out, it is ornamented with a cross. Its colour varies with the liturgical colour of the day, or of the function at which it is worn.

The stole is worn immediately over the alb or surplice; by deacons, scarfwise over the left shoulder, across the breast and back to the right side; by priests and bishops, dependent from the neck, the two ends falling over the breast. In the case of bishops the stole always hangs straight down; while priests wear it crossed over the breast when vested in the alb. According to the Roman usage the stole is now only worn at Mass.

The origin of the stole is very obscure. It has been variously derived from the ancient *stola*, which was, however, a tunic, from the Jewish prayer-blanket (*tallith*), from the ancient *orarion* (neck-cloth) and, as regards the diaconal stole, from a napkin used in the liturgy. Father Braun, however, in his *Liturgische Gewandung*, gives good reasons for rejecting all these derivations and suggests that the stole was originally introduced as that which first appears in the 22nd canon of Laodicea, viz., a special mark of distinction for deacons, which was later extended to higher orders.

The stole was not one of the vestments prescribed by the rubrics of the first Prayer-book of Edward VI. (*see* VESTMENTS). It was replaced in the Church of England from the Reformation onwards by the scarf, a broad band of black silk, formerly part of the outdoor dress of the dignified clergy and without liturgical significance. This vestment has some resemblance to the stole, in that it is worn round the neck, hanging straight down in front over each shoulder. This resemblance facilitated the reintroduction of the stole by the "Ritualists" during the 19th century. The revised Prayer-book, adopted by Convocation and the Church Assembly in 1927, authorizes the use of the "stole or scarf."

STOLEN GOODS: *see* LARCENY.

STOLP, a town in Pomerania. Pop. (1925) 41,826. Stolp received town rights in 1273. From the 14th to the 16th century it was a member of the Hanseatic League. Until 1637, when it passed to Brandenburg, the town usually belonged to the dukes of Pomerania. The large church of St. Mary, with a 14th century tower, the 16th century Renaissance castle, now used as a prison, one of the ancient town-gates restored in 1872 and the church of St. John (13th century) are the oldest buildings.

STOLYPIN, PETER ARCADIEVICH (1863–1911), Russian statesman, was born at Baden-Baden in 1863. He was educated at St. Petersburg (Leningrad), and in 1902 he became governor of Grodno, and in 1903 of Saratov, where he was a firm administrator. In 1906 he was minister of internal affairs, and in July succeeded Goremykin as minister-president. (*See* RUSSIA.) His relentless policy led to attempts upon his life. In Aug. 1906 a bomb was exploded at his summer residence, injuring a daughter, and on Sept. 14, 1911, he was shot in a theatre at Kiev before the eyes of the Imperial family, by a Jew, Mordka Bogrov. He died on Sept. 18, 1911.

STOMACH, the bag-like digestive organ which in man is situated in the upper left part of the abdomen. For anatomical details *see* ALIMENTARY CANAL. For the diseases of the stomach in general *see* DIGESTIVE ORGANS; and for special forms, GASTRITIS, GASTRIC ULCER, DYSPEPSIA, etc.; also ABDOMEN.

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STONE, EDWARD JAMES (1831–1897), British astronomer, was born in London on Feb. 28, 1831. He was educated at the City of London School, King's College, London, and Queen's College, Cambridge. In 1860 he succeeded Main as chief assistant at the Royal Observatory, Greenwich. He deduced the solar parallax, first from observations of Mars, obtaining 8·932″ (*Mon. Not. R.A.S.* xxiii. 183), and 8·945″ (*Mem. of R.A.S.*, vol. xxxiii.), and secondly from the transit of Venus in 1769 which yielded 8·91″ (*Mon. Not. R.A.S.* xxviii. 255). From the Greenwich transit circle observations between 1851 and 1865 he found for the constant of lunar nutation the value 9·134″. He received the Royal Astronomical Society's gold medal in 1869, and in 1870 became astronomer at the Cape.

He produced a catalogue of 12,441 stars to the 7th magnitude between the South Pole and 25° S. declination, published as the *Cape Catalogue* for 1880. In 1878, he was appointed Radcliffe Observer at Oxford. At Oxford he extended the Cape observations of stars to the 7th magnitude from 25° S. declination to the equator, and collected the results in the *Radcliffe Catalogue* for 1890, which contains the places of 6,424 stars. Stone observed the transit of Venus of 1874 at the Cape, and organized similar expeditions in 1882. He was president of the Royal Astronomical Society (1882–1884), and drew attention to the old observations at the Radcliffe Observatory by Hornsby, Robertson and Rigaud (*Mon. Not. R.A.S.*, vol. lv.). He died at Oxford on May 9, 1897.

See *Proc. Roy. Society*, lxii. 10; *Month. Not. Roy. Ast. Soc.* lviii. 143; *The Times*, May 10, 1897; *Observatory*, xx. 234; *Astr. Nach.* No. 3426; *Roy. Soc. Cat. Scient. Papers.*

STONE, GEORGE (1708–1764), archbishop of Armagh, the son of a London banker, was educated at Westminster school and Christ Church, Oxford. He took holy orders, and advanced rapidly in the Church, mainly through the influence of his brother Andrew (1703–1773), who was under-secretary of State (1834) under George II. and treasurer to Queen Charlotte under George III. When the duke of Dorset became lord-lieutenant of Ireland (1731), George Stone went to Ireland as his chaplain. After holding various preferments in Ireland as dean and bishop, he became archbishop of Armagh in 1747. As archbishop he proved more a politician than an ecclesiastic. In 1758 Stone wrote a letter, preserved in the *Bedford Correspondence* (ii. 357), in which he speaks despondently of the distress of the people. He was one of the "undertakers" who controlled the Irish House of Commons, and took a prominent share in the administration of Ireland until his death in London on Dec. 19, 1764.

Although this "much-abused prelate," as Lecky calls him, was a firm supporter of the English Government in Ireland, he was not intolerant. It was due to him that the anti-tithe disturbances in Ulster in 1763 were suppressed with little bloodshed; he favoured conciliation towards the Roman Catholics, whose loyalty he defended.

STONE, LUCY (BLACKWELL) (1818–1893), American reformer, anti-slavery and woman's-rights leader, was born in West Brookfield, Mass., Aug. 13, 1818. Her father refused her the college education that she so eagerly desired, but she earned enough to carry her through Oberlin college, where she graduated in 1847. She immediately went on the lecture platform as an advocate of abolition and of woman's rights, and her remarkable voice and commanding eloquence often held in check the most disorderly audiences. In 1855 she married Dr. Henry B. Blackwell (1824–1909), a prominent abolitionist and advocate of woman's rights, who agreed that she should keep her maiden name; after 1870 he assisted his wife in the management of the *Woman's Journal* of Boston of which she became editor in 1872.

She allowed her New Jersey property to be sold for taxes, and then published a pamphlet on "taxation without representation." She campaigned for woman's suffrage amendments in Kansas (1867), Vermont (1870), Michigan (1874), Colorado (1877) and Nebraska (1892). She died in Dorchester, Oct. 18, 1893.

STONE, MELVILLE ELIJAH (1848–1929), American journalist, was born in Hudson (Ill.), Aug. 22, 1848. In 1860 his father was made pastor of a Methodist church in Chicago, and it was there that he got his schooling. In 1864 he began as a reporter for the Chicago *Tribune*, but he became proprietor in 1869 of an iron-foundry and machine shop. In the great Chicago fire of 1871 this was destroyed, and Stone then engaged in the administrative work of municipal relief and reconstruction. In 1872 he became one of the editors of the Chicago *Republican* (subsequently *Inter-Ocean*), and later of the *Post and Mail*, becoming for several years a political correspondent at Washington.

At the end of 1875, having returned to Chicago, Stone, with a colleague, started the evening *Daily News*, and two years later Victor F. Lawson became a partner. The venture was very prosperous. He and Lawson bought out the *Post and Mail*, and in 1881 they established the *Morning News* (later *Record* and *Record-Herald*). In 1888 he retired, and later founded the Globe National Bank, of which he became president in 1892. In 1893 he became general manager of the Associated Press, which received a new stimulus. He held this position until April 1921. During that 28 years the budget of the Associated Press had grown from $500,000 to $6,000,000, and it had come to furnish more than half the news printed in American papers. He died in New York city on Feb. 15, 1929.

See his autobiography, *Fifty Years a Journalist* (1921).

STONE, NICHOLAS (1587–1647), English sculptor and architect, was the son of a quarryman of Woodbury, near Exeter, and as a boy was apprenticed to Isaac James, a London mason. About 1603 he went to Holland and worked under the sculptor Hendrik de Keyser (1567–1621) and his son Pieter, and married his master's daughter. Stone is said to have made the portico to the Westerkerk at Amsterdam. Returning to London about 1613 with Bernard Janssens (*fl.* 1610–1630), a fellow pupil, he settled in Southwark and obtained a large practice; in 1619 he was appointed master-mason to James I., and in 1626 to Charles I. He died in London on Aug. 24, 1647. Stone, whose work is associated with Inigo Jones's introduction of Renaissance architecture into England, ranks as the great sculptor of his time and the rejuvenator of the art in England.

See an article by A. E. Bullock in the *Architectural Review*, 1907, and the same author's illustrated monograph *Some Sculptural Works of Nicholas Stone* (Batsford, London, 1908).

STONE, market town, urban district, Stone parliamentary division, Staffordshire, England. Pop. (1921) 5,552. There are remains of an abbey (670) here; the abbey church collapsed in 1749 and on the site, St. Michael's church was built (1750). Alleyne's grammar school is a foundation of 1558. There is an ancient earthwork at Bury Bank and others at Saxon Low.

STONE, a detached piece or fragment of rock. The word is thus applied to the small fragments scattered in the ground or on roads, to the water-worn pebbles of the sea-shore or river beds, and to the hewn, dressed or shaped rock used as building material, with which this article deals. A qualifying word generally accompanies "stone" when the term is applied to pieces of rock cut to a particular size and shape and used for a specific purpose, *e.g.*, "mill-stone," "hearth-stone," "grave-stone," etc. The term "precious stone" is used of those minerals which, from their beauty of colour, etc., their rarity and sometimes their hardness, are valued for their suitability for ornaments (*see* GEMS). The word is also often applied to many objects resembling a stone or pebble, such as the hard kernel of certain fruits, as of the cherry, plum, peach, etc., or the *calculi* or concretions sometimes formed in the gall or urinary bladder or the kidneys. (*See* BLADDER DISEASES and KIDNEY DISEASES.) The "stone" has been a common measure of weight in north-western Europe. In Germany the "Stein" was of 20 to 22 lbs. In the British system of weights the "legal" stone, or "horseman's" weight is of 14 lb. avoirdupois; in weighing wool it was also of 14 lb., but is now usually 16 lb. The "customary" stone for fish or butcher's meat is of eight pounds.

Building Stone.—Stone selected for building purposes must be strong enough to bear the load placed upon it, it must be durable and weather well in the atmosphere of the district, and its colour and appearance need to be studied. Available supply and price are factors. Where there is risk of fire, as in factories, the stone must be resistant to heat.

The disintegration of stone is caused by internal stresses. They may be set up, as in the case of granite, by heat, which causes the quartz or silica constituent to change its chemical form with an accompanying expansion. Similarly quartz or silica pebbles used as an aggregate in concrete cause its disintegration when subjected to extreme heat. Again the internal stresses may be set up by the solution and recrystallization of minerals, or chemical substances, in the pores of the stone, for all stone is more or less porous. In cold climates certain porous stones may be comparatively rapidly destroyed by alternate freezing and thawing—the mere expansion of the absorbed water in freezing being sufficient. Certain argillaceous limestones contain an earthy or clayey mineral now known as beidellite which has the property of absorbing or possibly chemically combining with water. This is accompanied by expansion, and causes apparently sound stone to rapidly disintegrate when exposed to the weather. Smoke and waste gases from heating and industrial plants are carried by rain into the pores of the stone. Marbles and limestone, being composed largely of the carbonates of lime and magnesia, are very susceptible to the solvent action of these acids. The mortar used to bed the stones has been held responsible for disintegration since the lime may be dissolved out by the action of rain water, to be recrystallized in the interior pores of the adjacent stone. The physical and chemical tests for stone are thus as follows:

(1) Resistance to crushing; (2) acid test; (3) absorption test; (4) microscopical examination; (5) freezing and thawing test or its equivalent.

The resistance to crushing varies to an enormous extent with the different kinds of stone, from a little over 60 tons per sq.ft., which is the limit for a weak limestone, up to a load of over 1,300 tons necessary to crush the hardest granites. In general practice the load placed upon stone should not exceed one-tenth of the crushing weight as found by testing. The effect produced by soaking pieces of stone for some days in a 1% solution of sulphuric and hydrochloric acids will decide roughly whether it will be durable in a city atmosphere. The microscope is the best means of determining the structure of a stone, and of recognizing the presence of matter likely to affect its usefulness adversely. Should iron pyrites be discovered in any quantity the stone should be rejected, as this impurity easily decomposes on exposure, and stains and splits the stone. The freezing and thawing test is slow and requires a rather elaborate refrigerating apparatus. The specimens of stone to be tested are alternately oven-dried, soaked in water and subjected to a freezing temperature, thawed at room temperature, dried, and the cycle repeated as often as desired. The accumulative loss in weight of the dried sample after each cycle is the measure of the stone's durability or resistance. This test may be simulated with some degree of accuracy by the sodium-sulphate test, in which the specimens of stone are oven-dried, soaked in a saturated solution of sodium sulphate and allowed to dry out at room temperature. In drying out the sodium sulphate crystallizes in the pores of the stone, in a manner similar to the freezing or crystallizing of water. This test is apparently more severe than the freezing and thawing test and requires little apparatus. Laboratory experts have not yet agreed upon the exact relation of these tests to the actual behaviour, or life, of stone in structures. Dolomites, known to be fairly durable as building stone, are not correspondingly resistant to these tests.

The hardest, least absorbent, and most compact and uniform stones are of ancient geological formation, and with time and increase of superimposed pressure have become dense and very hard. The softer stones are of later formation, and are usually lighter in weight and more porous. A good stone should ring clearly when struck with steel, and a fresh fracture should on examination be bright, clean and sharp in texture and free from loose grains. A dull earthy appearance indicates an inferior stone.

The most usual method adopted for preserving stonework is to paint the exposed surfaces with ordinary oil colour. The painting must be redone every four or five years. *Boiled linseed oil* is sometimes used on stonework, one or more coats being well brushed in after cleaning it. Its use deepens the colour of the stone, and unless very carefully done the work is apt to appear patchy. A large number of processes consist of coating the stonework with a solution of soluble silica. In *Kuhlmann's process* a solution of silicate of potash or soda is brushed into the stone and, aided by the carbonic acid in the air, acts upon some of the constituents of the stone and forms a hard surface which is not liable to decay. In *Ransome's process*, a solution of silicate of soda is applied until the surface of the stone has become saturated. This is allowed to dry and a solution of chloride of calcium is then applied in a similar manner. The two solutions act together, and by decomposition produce an insoluble silicate of lime which fills the pores of the stone and binds its particles together thereby checking decay. *Baryta water* will, when applied to limestone that has decayed owing to the action of sulphurous fumes, penetrate into and solidify the crumbling portions, with the result that the stone is reconstituted and becomes hard and quite solid. Prof. A. H. Church employed this method in arresting the decay of the frescoes in the Houses of Parliament and the stonework of the chapter house at Westminster was also treated by him in the same manner. *Fluate* is the name given to a siliceous preservative specially recommended for use upon the limestones from the Bath district. It may also be applied to other limestones, and to bricks, tiles, terra-cotta, etc. It does not materially change the appearance of the stone but enters the pores and prevents decay.

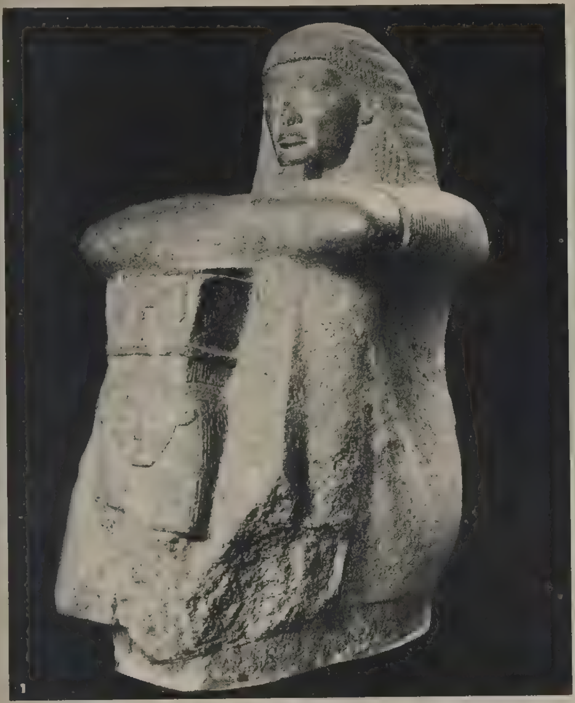
The natural bed of a stone is that surface on which it was originally deposited. But volcanic and other disturbances may have occurred since that time and completely altered its "lie"; and therefore it frequently happens that a horizontal line does not coincide with the natural bed of stone as it rests in the quarry. Care must be taken before using the stone to find the proper bed and to set all stones with their laminae quite level. Stone fresh from the quarry is found to contain a quantity of moisture called "quarry sap," on account of which all stones (even granite) are comparatively soft when first quarried. This water gradually evaporates, and after some months' exposure stones that were quite soft and weak when quarried acquire hardness and strength. For these reasons it is desirable from an economical point of view to "work" the stone to its desired shape and mould and carve it when soft and easily workable.

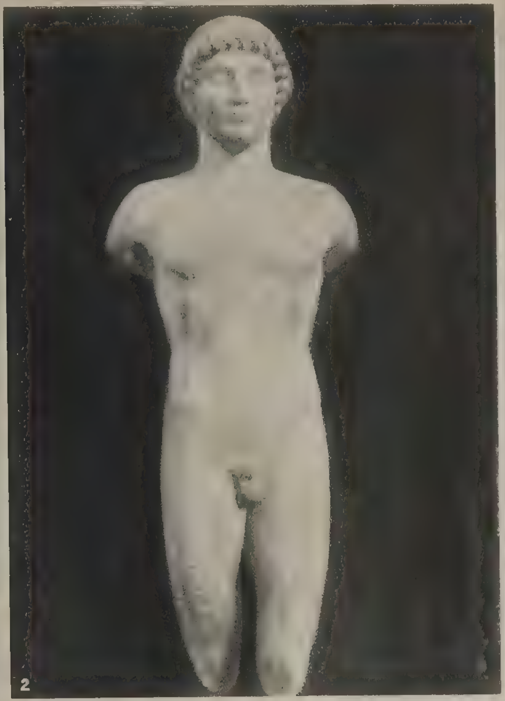
Varieties of Stone.—Building-stones are divided into several groups; limestones and sandstones are classified as aqueous or stratified rock granite being igneous or unstratified.

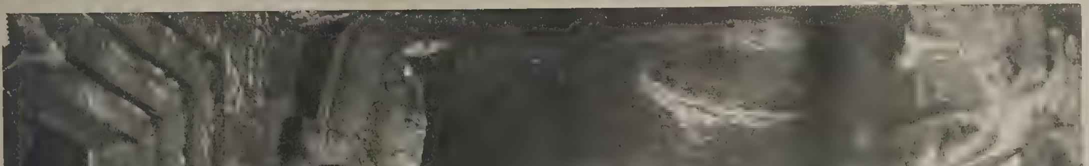
Limestones consist chiefly of calcium carbonate with small proportions of other substances. They are often classified under four heads: *Compact* limestones consist of carbonate of lime, either pure or in combination with clay and sand. *Granular* or *oolitic* limestones consist of grains of carbonate of lime cemented together by the same substance or mixed with sand and clay. The grains are egg-shaped (hence the name "oolite") and vary in size from tiny particles to grains as large as peas. *Shelly* limestones consist almost entirely of small shells, cemented together by carbonate of lime. *Magnesian* limestones are composed of carbonates of lime and magnesia in varying proportions, and usually also contain small quantities of silica, iron and alumina. Stones having less than 15% of magnesia are not classed under this head. *Dolomites* are limestones containing equal proportions of carbonate of lime and carbonate of magnesia. Many of the finest building-stones are limestones. In England typical examples are the Bath stones, Portland stone and Kentish ragstone, and in America those from the States of New York, Indiana (Bedford quarry, light brown stone), Illinois (Grafton and Chester quarries) and Kentucky (Bowling Green stone, light grey, similar to Portland). Notable French limestones are obtained from the quarries at Peuren (cream), Château-Gaillard (white), Abrots, Normandoux (white), and Villars (light brown). The hardest and closest grained of these are capable of taking a fine polish. Limestones should be used with care as they are uncertain in their behaviour and usually more difficult to work than sandstones, and as a general rule they do not stand the action of fire well. On being treated with a dilute acid, limestones will effervesce and by this test they can easily be identified. Limestones weigh between 130 lb. and 166 lb. per cu.ft. They vary in colour but most of them are cream or yellowish brown. *Marble* is a limestone which has been changed by the action of heat and pressure into a crystalline form. Many beautiful varieties are found which are suitable for interior decoration, such as for columns, wall lining, paving, etc., and in dry sunny climates they may be employed with great effect in external situations. They will take a high polish and the fine grained varieties are well adapted for intricate carving. The principal European supplies of marble are from Italy, Belgium and France, but the marbles from Ireland and those from Devonshire and Derbyshire possess a remarkable range of colour and variety of markings. America has few notable coloured marbles; most of the stones quarried are white or black. The States of Vermont (West Rutland and Sutherland Falls quarries), Tennessee and Georgia produce large quantities of marble. *Marezzo* and *scagliola* are plaster imitations of marbles (*see* PLASTERWORK).

Sandstones are composed of grains of sand held together by a cementing substance to form a compact rock. The cementing medium may be silica, alumina, carbonate of lime or an oxide of iron. Those stones that have a siliceous cement are the most durable. Sandstones vary more in colour than limestones, the colour being largely due to the presence of iron. Cream, brown, grey, pink, red, light and dark blue, and drab are common colours. Typical British sandstones are Corsehill (red) from Dumfriesshire, the Yorkshire sandstones (brown), Pennant stone and Forest of Dean (blue and grey) from Gloucestershire. In America sandstones are quarried in many States, principally Connecticut (brown stone), New York (Potsdam red stone), Ohio (Amherst, Berea and other quarries, light brown or grey stone) and Massachusetts (Longmeadow brown stone). The heaviest, densest, least porous and most lasting stones usually have a fine grain.

STONE CARVING







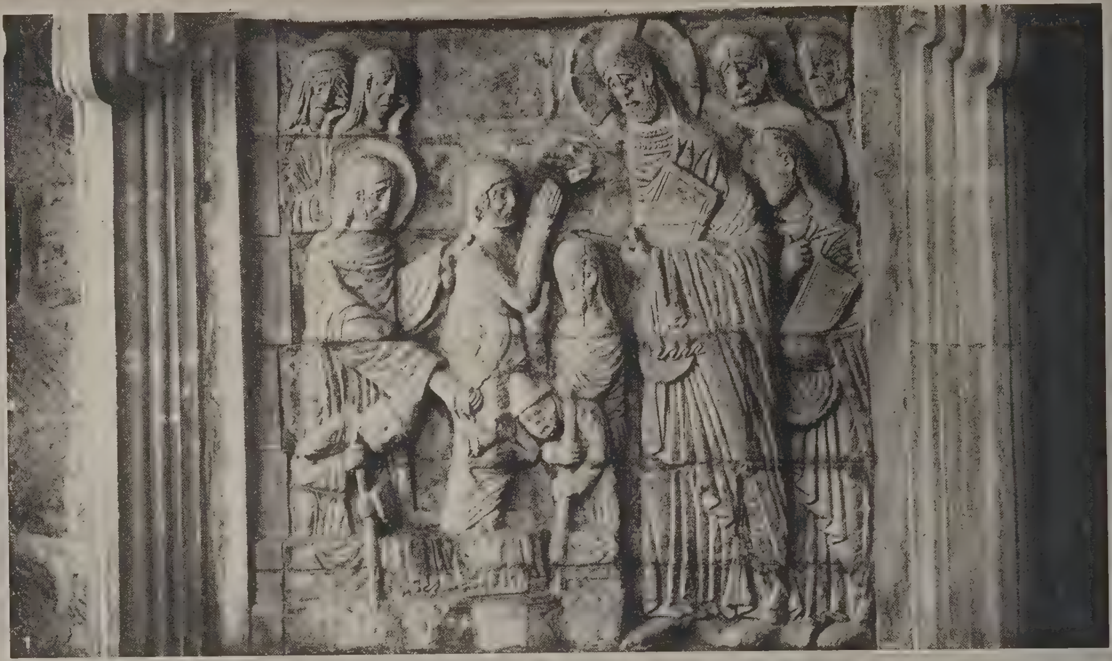
BY COURTESY OF (1, 2) THE TRUSTEES OF THE BRITISH MUSEUM, (3) THE INDIA OFFICE

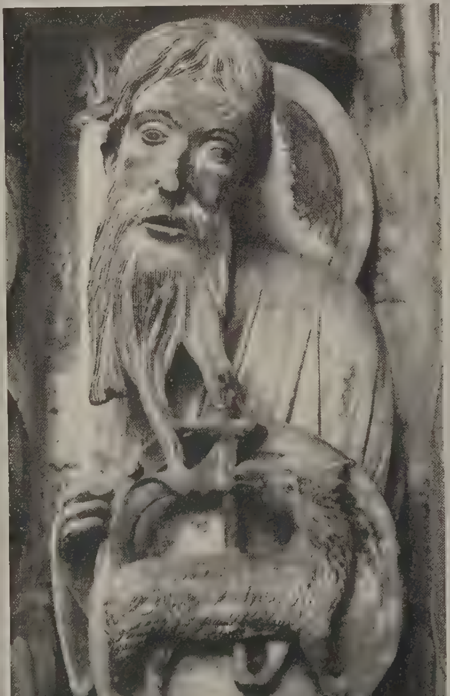
EXAMPLES OF ANCIENT CARVING

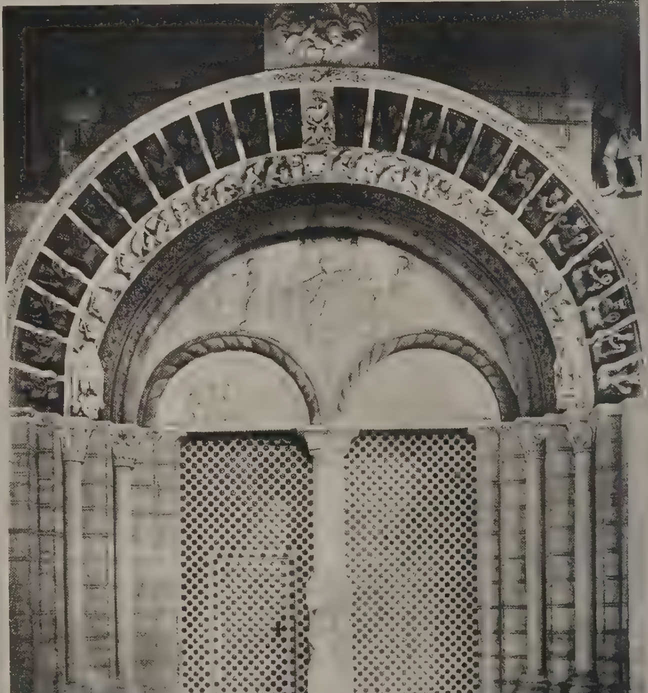
1. Seated granite figure of Rui, High Priest of Amen (about 2000 B.C.), 3 ft. high. Now in British Museum

2. The Strangford Apollo. 5th century B.C. Now in the British Museum

3. Carving depicting the marriage of Siva, a post-Vedic god of Hindu mythology styled the Bright or Happy One, and Pārvatī, a goddess in the Brahmanical system, daughter of Himavat. These carvings of the 8th–9th century B.C. are in the Caves of Elephanta, India



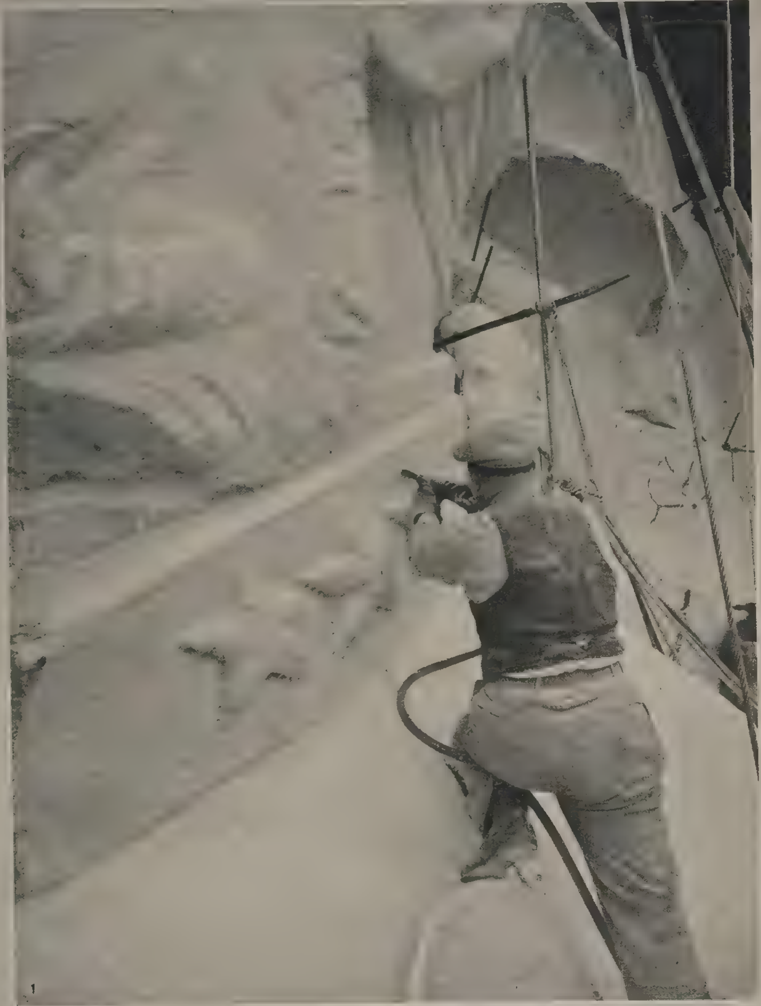




PHOTOGRAPHS, (1) VALENTINE, (2) E. HOUVET, (3) E.N.A.

STONE CARVING OF THE MIDDLE AGES

1. The Raising of Lazarus, an example of Romanesque sculpture in Chichester Cathedral, Sussex
2. Head of John the Baptist, in north porch of Chartres Cathedral, France; 13th century
3. "The Deposition," a low relief carving on the western porch of the Church of St. Mary at Oloron, southern France; about 12th century



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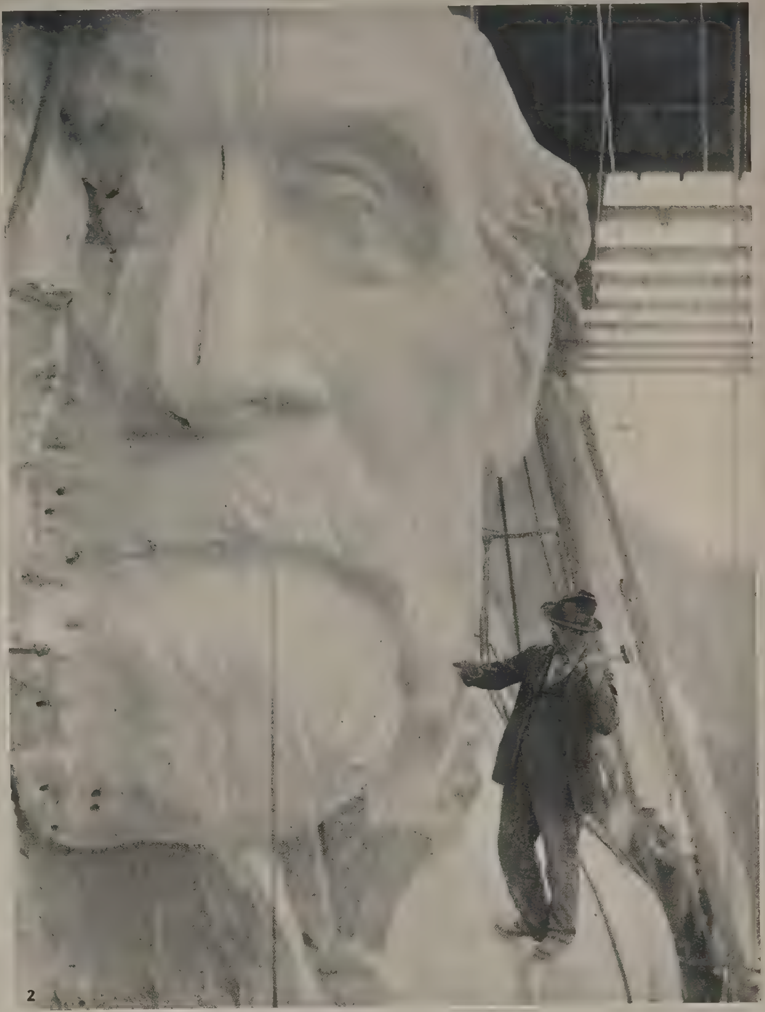

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PHOTOGRAPHS, EWING GALLOWAY

PRESENT-DAY STONE CARVING

1. A stone carver equipped with pneumatic chisel, finishing the stars on the collar of General Robert E. Lee, the leading figure in the heroic group designed by Augustus Lukeman for the Stone Mountain Memorial near Atlanta, Georgia

2. Carving with mallet and chisel a portion of the head of General Robert E. Lee, 400 feet up the side of Stone Mountain near Atlanta, Georgia. When completed, this group may be seen for several miles. It is larger and more elaborate than the colossal Ramessean figures of Abu Simbel hewn in the rock cliffs on the banks of the Nile

Granites are igneous rocks formed by volcanic action and are of all geological ages. Granite is composed of quartz, felspar and mica. Stones with a large proportion of quartz are hard and difficult to work. Earthy felspar is opaque and liable to decay; it should be almost transparent. The colour of the granite is generally due to this substance, but may be affected by the mica, whether light or dark. Granite is the hardest, strongest, and most durable of building-stones. When polished, many varieties present a beautiful and lasting surface. They are used for foundations, bases, columns, curbs and paving where strength is required.

The granites from Peterhead and Aberdeen in Scotland and from Cornwall and Devonshire in England are much used. In the United States good granites are quarried in Connecticut, Massachusetts and Minnesota. Canada, especially the eastern provinces, supplies excellent granite: So do Norway and Sweden. *Syenitic granite* contains hornblende in addition to quartz, felspar and mica. In true syenite hornblende takes the place of mica. It is named from a stone found at Syene in Egypt, but it has since been discovered that this stone actually contains more mica than hornblende. These rocks are very hard and are used more for paving and road-metalling than for building purposes.

Slate is composed of sandy clay metamorphosed by heat and pressure. Such rocks began as sediment by the sea or river. Owing to some sliding motion having taken place, slaty rocks can be split into thin sheets. A good slate will give out a metallic ring if struck, and when trimmed will not splinter. Slates range in colour from purple to grey and green. The best known British slates are those of the Welsh and Westmorland quarries. In America good slate is found in the States of New York, Pennsylvania and Maine. (*See* also ROOFS.)

There are several kinds of artificial stone on the market, consisting of fine cement concrete placed to set in wooden or iron moulds. Although from an artistic point of view it must be used with great discretion, it is prepared with such care that its cheapness, strength and uniform character have led to its wide employment. One of the best-known varieties is composed of finely crushed granite and Portland cement, carefully mixed by machinery in the proportions of three to one, and filled into moulds of the required shape. When the blocks are set hard the moulds are loosened and the blocks placed in a solution of silicate of soda for about two weeks for the purpose of indurating and hardening them. Many manufacturers turn out a material that is practically non-porous and is able effectually to resist the corroding influence of sea air or the impure atmosphere of large towns. Artificial stone is exceedingly useful for paving purposes, and blocks can readily be cast of any size or thickness to suit the pavements of streets or buildings; their regularity greatly reduces labour costs in laying.

See Rivington's *Notes on Building Construction* vol. iii.; also *Report on Building Stone for Extension of United States Capitol* (1849); J. L. Pearson, *Report of Select Committee on Westminster Hall* (Restoration) (1884–85); G. H. Blagrove, *Marble Decoration* (1888); F. E. Kidder, *Building Construction and Superintendence,* vol. i. (1896); G. P. Merril, *Stones for Building and Decoration* (1897). (J. BT.)

STONE AGE: *see* ARCHAEOLOGY.

STONE CARVING. Many as are the kinds, there is a character that properly belongs to all good stone carving, whether in relief (high relief or low) or in the round. The first constituent of this character is the quality called plasticity; it is the quality of solidity, of being in three dimensions. The beauty of stone carving is dependent upon this quality. Modelling in clay is a business wherein one starts from nothing, or perhaps a wire only (the "armature") and builds up a thing in three dimensions. But in a stone carving one does not start from nothing and build up; one starts from a solid thing and proceeds by subtraction instead of addition and, apart from the sensuous enjoyment which some people have in using tools and materials, the natural tendency in stone carving is to subtract as little as possible, as in modelling it is to add as little as possible. The result is that whereas a certain spareness and tensity of form is characteristic of modelling, the character most noticeable in stone carving is fullness and roundness of form—solidity, mass, weight. Moreover, by the use of wire or iron armatures it is possible to give a clay model any required freedom and detachment of parts—if it be an image of a man, the arms and legs may stand out freely from the body, fingers may be separate, and hair may even stand on end. In stone, on the other hand, freedom or detachment of parts is unnatural and difficult. The custom of many sculptors, ancient and modern, to work exclusively in clay and to leave the business of carving to hired mechanicians is responsible for the lack of the proper character of stone carving in their works. Trained mechanics are clever enough to do anything; whether the thing done be worth doing is not their affair.

In a stone carving done according to the natural character of stone, there is no detachment of parts; everything is solidly joined to everything else. If there be any separation between one thing and another the space between is in the nature of a hole—a piercing—as in the characteristic Byzantine foliage carving or in mediaeval window tracery. Stone is a brittle and very heavy material; it will stand enormous crushing strains but will hardly bend. These differing characters of materials render them suitable for different services—iron or wood for a girder subjected to a bending strain, stone for a pier or pillar, bronze for a gate, stone for a gate-post. And as each material renders its characteristic service, so each has its characteristic beauty. To imitate the characteristic beauty of flesh and blood in a material so different as stone is absurd in proportion to the success with which it is achieved; and it is as wasteful as it is ridiculous. The stick-beetle has excellent reasons for wishing to remain anonymous; that a stone carver should desire to produce illusions is folly. Moreover, it cannot be done, and the dust and dirt which collect in the veins and dimples of a realistic sculpture very soon betray it. The imitation of one material in another is wasteful because it is throwing away the special beauty of the material used. There is great beauty in the sculpture of Michelangelo, but it is not the beauty of stone.

The movement of the human mind which is called the Renaissance ushered in an entirely new attitude on the part of artists. Men who had formerly been part of the ordinary gang of builders, who made buildings or sculptures in stone or bronze as one makes boots or books in leather or skins, now ceased to be makers and became critics. They ceased to be, as they formerly were, men imitating nature by working as she works (*Ars imitetur naturam in sua operatione.* St. Thomas Aquinas, *Summa Theol. I.*, 9. 117, a. 1); they became men imitating nature by reproducing her appearance. The sculptor became a critic of nature, *pro* or *con*, and his works represented his view of the matter; they reflected nature and they reflected the artist and this not by accident, as hitherto, but of set purpose and to the applause of beholders. The results, admirable as we may think them and admirable as many of them are, have the characteristic beauty of human thought but not that of stone. The state of things which we call pre-Renaissance is the normal state of things in the world and is still the prevalent state in all places not affected by humanism. In mediaeval Europe, as in India or Japan, the idea of verisimilitude was either unknown or despised. Portraiture was nonexistent, drawing from nature was not done at all or was confined to the merest "studies." In fact, pre-Renaissance work was "natural" precisely as a tree is natural or as an unornamented electrical switch-board is natural. The only difference between a tree and a stone carving was that the tree was the immediate product of unconscious natural causes whereas the stone carving was the product of a conscious and deliberating mind. Neither in the one case nor the other was there any more criticism or imitation of nature than is displayed in an electrical switch-board. It is only in the paucity of language that a sculptor would speak of carving a man or a flower. The likeness to nature is an accident of such works, not the substance. A crucifix of the 12th century, for instance, or a Buddha of the same date in India is not substantively a life-like imitation of a man as seen in flesh and blood. The substance of such things is their philosophical or religious significance. That being so, the artist was free to use or exploit the aesthetic possibilities of the material used to the fullest extent. Thus it is that for the study of stone carvings as works of art we are compelled to look to the past or to foreign and distant countries.

There is no question whether modern European stone or marble carvings are good or bad things. The statue of Gladstone in Westminster Abbey is probably an excellent portrait; it would simply be wrong to judge it as stone carving. On the other hand, the sculptures of Egypt, India and China, like those of early mediaeval Europe, are primarily stone carvings; it would be wrong to judge them as portraits or as imitations of nature. After about 1350 the desire for verisimilitude became the ruling motive.

Generally, we may say a good stone carving is one which will not break (Michelangelo is said to have enunciated, but perhaps not followed, the dictum that the test of a good sculpture was that you could roll it down hill without breaking it); that stands firmly and well balanced; that is free from naturalistic modelling and undercutting; and in general we may say, paraphrasing the saying of Maurice Denis, "What we ask of stone carving is that it shall look like stone."

(*See* also SCULPTURE; ARTS AND CRAFTS; WOOD-CARVING; IVORY CARVING; BRONZE AND BRASS.)

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STONECHAT, a well-known British bird, *Saxicola torquata.* The black head, ruddy breast, and white collar and wing spot of the cock, render him a conspicuous object on almost every furze-grown common or heath in the British Isles. The stonechat is a small bird allied to the wheatear (*q.v.*) and whinchat (*q.v.*). It has a wide range in Europe and Asia; allied species inhabit Africa and Asia.

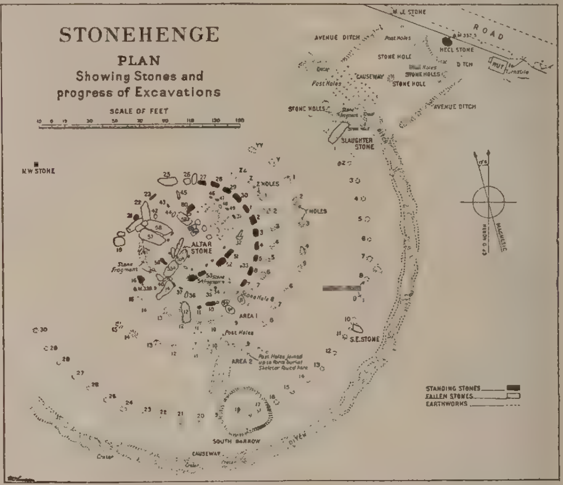
STONE-FLY, the name given to a small but well-defined group of insects forming the order Plecoptera (*q.v.*) or Perlaria. They are found only in the vicinity of fresh water.

STONEHAM, a town of Middlesex county, Massachusetts, U.S.A. Pop. (1920) 7,873 (82% native white), 1928 local estimate 10,000. Within its area of 6·6. sq.m. is Spot pond, a large lake which serves as a storage basin for the metropolitan water district; and 730 ac. of the Middlesex Fells Reservation. The manufactures include shoes, shoe stock, cutting dies, chemicals and druggists' supplies. Steam power was first applied to the manufacture of shoes here, by John Hill and Company, who introduced many labour-saving devices, notably the heeling machine (1862). Stoneham was settled about 1668. It was set off from Charlestown and incorporated as a town in 1725.

STONEHAVEN (locally *Stanehive*), seaport of Kincardineshire, Scotland. Pop. (1921), 4,856. The town is picturesquely situated on the Carron. On the decay of Kincardine, the original capital, Stonehaven became the county town in 1600, and suffered heavily during the covenanting troubles, Montrose setting it on fire in 1645.

STONEHENGE, a circular group of huge standing stones (*see* STONE MONUMENTS) situated on Salisbury Plain, Wiltshire, England, about 7 m. N. of Salisbury. The amenities of this, the most important antiquity in the British Isles, have recently been marred by the erection of bungalows, aerodromes and tea-houses. But now, thanks to the activities of The Stonehenge Preservation Committee (1927), an undertaking is near completion (1928) for purchasing and vesting in the National Trust the land for about a mile radius round Stonehenge, and the work of demolishing the buildings is in hand. In 1915 Sir Edmund Antrobus sold Stonehenge to Sir Cecil Chubb, who generously presented it to the nation, and since that date it has been under the charge of H.M. Office of Works. Professor Gowland in 1901 restored to a vertical position the leaning upright (No. 56) of the great inner trilithon, and in 1919 and 1920 H.M. Office of Works re-erected uprights 29, 30, 1 and 2 securing lintels.

Neither Roman historian nor Saxon chronicler makes mention of Stonehenge. Perhaps the earliest reference to it is in the writings of Henry of Huntingdon (died 1154), who cites Stonehenge as the second of the four wonders of England, but confesses ignorance of its origin. Geoffrey of Monmouth relates in his *Historia Britonum* (written before 1139) that Ambrosius Aurelianus, desirous of setting up a memorial to those slain in the battle with Hengist in 470, by the advice and with the aid of the magical powers of Merlin, removed the stones of The Giants' Dance from Kildare, Ireland, whither, according to Giraldus Cambrensis, they had been brought from Africa by giants, and re-erected them on the site of Stonehenge. This legend with slight alterations was current until Edmund Bolton in 1624 made the suggestion that Stonehenge was the tomb of Boudicca. Inigo Jones in his treatise on Stonehenge, written at the command of James I. and published in 1655, timidly puts forward the suggestion that Stonehenge was built by the Druids, but goes on to state with more emphasis that it is a Roman temple inscribed to Coelus. In opposition to this, Dr. Charleton, a court physician, propounded the theory in 1663 that Stonehenge was the work of Danes. It was John Aubrey (1626–1697) who first claimed Stonehenge as a Druidical temple, and this theory was elaborated by William Stukeley in 1742. Thus originated a belief which up to the present day has found favour with the public, although there is no evidence to support it. As late as 1872 James Fergusson contended that Stonehenge was a sepulchral monument of the Saxon period.



FROM THE ANTIQUARIES JOURNAL BY COURTESY OF THE SOCIETY OF ANTIQUARIES AND OF H.M. OFFICE OF WORKS

Stonehenge is approached by an ancient banked trackway, the so-called Avenue, on the north-east. As viewed to-day, it consists of an encircling earthwork and the remains of four series of stones, viz.: an outer circle of sarsens with lintels; an inner bluestone circle; a horse-shoe of five great sarsen trilithons; and an inner ovoid of bluestones. There are also two sarsen stones lying north-west and south-east of the circle close to the inner edge of the earthwork; a recumbent slab of sarsen, the so-called Slaughter Stone, near the south-east edge of the north-eastern causeway in the ditch; an upright sarsen, the Hele Stone, situated in the Avenue; and a recumbent block of micaceous sandstone, known as the Altar Stone, within the bluestone ovoid. The outer circle has a diameter of 100·75 ft., and consists of thirty large upright sarsens, carefully dressed into shape by pounding with stone mauls, of which sixteen remain standing. Their average height above ground is 13½ ft., depth below ground 4½ ft. and weight 26 tons. Their flat sides face inwards and they are secured by means of sarsen lintels, each lintel dovetailing with its fellow, and a mortice at each end of every lintel fitting over one of the two conical tenons on each upright. The inner circle of bluestones has a diameter of 76½ ft. To-day nine of the stones are standing, while eleven are overthrown. Recent excavations by the Society of Antiquaries of London have shown that the original number of stones in this circle exceeded the previously estimated number of forty. The five great sarsen trilithons are arranged in a horse-shoe with the opening to the north-east, and rise gradually in height towards the south-west. Only two are standing to-day. The height above ground of the great upright (No. 56), raised and made secure in 1901, is 22 ft. The inner ovoid consisted of dressed bluestones, of which twelve are visible now. The original number is uncertain, but excavation has proved that the series formed an ovoid and not a horse-shoe as was formerly supposed. The bluestones now remaining are of two varieties—diabase and rhyolite, but fragments of basic tuffs and agglomerates, grey wackes and argillaceous flagstones and slates may have belonged to stones now missing.

In the past Stonehenge has been a battleground on which archaeologists have fought with assumptions as their only weapons, but within recent years careful and systematic excavation, if it has not furnished definite evidence as to the purpose and date of construction of the monument, has at least added considerably to our knowledge.

The Avenue, first described in 1723 by Stukeley, approaches Stonehenge on the north-east, but its banks do not coincide with the sides of the causeway across the ditch which encircles Stonehenge. This suggests that it is a more recent structure. It consists of a broad road with lateral ditches and a slight bank between road and ditch. From Stonehenge it runs a straight course for 1,700 ft. in a north-easterly direction. Then, according to Stukeley, it branches, one arm curving westwards to meet the Cursus, the other "directly east, pointing to an ancient ford of the river Avon." In 1921, by the aid of photographs from the air, Crawford was able to trace the continuation of the Avenue from its furthest fixed point on the ridge between the Old and New King Barrows to the Stonehenge-Amesbury road opposite West Amesbury Farm. These photographs were verified by excavation, and excavation has since traced the Avenue across the road to the farm buildings, but there are no indications either on the surface or on air-photographs that it was continued across the river. The air-photographs also tend to disprove the existence of a western branch. At its Stonehenge end the Avenue measures 72 ft. from ditch to ditch, but as it progresses it varies in width, and measures 110½ ft. at West Amesbury.

Col. Hawley during his excavations for the Society of Antiquaries (1920–26) uncovered the eastern half of the ditch surrounding Stonehenge, and cleared the north-eastern causeway, which was found to be studded with postholes. He also discovered a smaller southern causeway (Inigo Jones mentioned three causeways, forming an equilateral triangle). The ditch is circular with a diameter of 300 ft., flat-bottomed, irregular, averages 5 ft. in depth, and has a bank on its inner side. The only objects found in its silting have been abundant red-deer antler picks, a few rough flint implements of Upper Palaeolithic facies, and two fragments of pottery. The chips of sarsen and bluestone struck off when the stones were dressed and set in place, are restricted to the lower level of the turf mould above the chalk silting.

In all, Col. Hawley cleared that half of the area inside the ditch which lies east of a north and south diameter. He discovered three important new features: a circle of holes parallel with and close inside the ditch and named by him Aubrey Holes, in honour of John Aubrey who recorded certain depressions along this line; and two new circles of holes, Z and Y, nearer to but still outside the outer sarsen circle. There are probably fifty-six Aubrey Holes, of which number thirty have been excavated. They are circular in plan, and average 3 ft. 8 in. in diameter and 2 ft. 8½ in. in depth. A small amount of cremated human bones was found in most of them, usually in a small pocket by the side of the hole. Sarsen and bluestone chips were present throughout their filling, but evidence is lacking as to whether stones or posts once stood in them. The Z and Y holes were wedge-shaped with rectangular bottoms. The Y holes averaged 2 ft. 11½ in. in depth and 5 ft. 6½ in. by 3 ft. 9 in. at the top. The Z holes averaged 3 ft. 6 in. in depth and 5 ft. 10½ in. by 3 ft. 8 in. at the top. They were constructed after the erection of the outer sarsen circle, but in all probability no stone or post ever stood in them. The Hele Stone was found to have an encircling ditch, with postholes to the west of it and three other stone holes between it and Stonehenge. The Slaughter Stone had been buried in its present position and no doubt once stood upright in a hole to the west of it. The isolated sarsen on the south-east just inside the ditch had no encircling ditch. The so-called "barrow" on the south in the line of the Aubrey Holes was not a barrow, but the site of an upright stone with encircling ditch. Between this "barrow" and the stone circles were numerous postholes, and within the circles the ground was honeycombed with others. Some were as old as, or older than, the erection of Stonehenge, but the date of most of them is as uncertain as is their purpose.

Stonehenge, as we see it to-day, is probably contemporary with the Avenue and is a reconstructed Stonehenge; an earlier and more simple circle of sarsens, contemporary with the ditch, having preceded it. The blocks of sarsen, Tertiary sandstone, were obtained from the Marlborough Downs; for sarsens in the immediate neighbourhood were scanty and small of size. The bluestones were brought from Prescelly in Pembrokeshire—a locality rich in stone circles. Two theories as to the purpose of Stonehenge exist to-day, the sun-worship theory and the sepulchral. The former was promulgated by Sir Norman Lockyer in 1901, but for many reasons, too many to recapitulate here, is probably erroneous, and the sepulchral theory is more likely to be the correct one. But all is surmise and analogy our only guide. Stonehenge is a stone circle, albeit an elaborate one, and most of those stone circles that have been carefully excavated have been proved to be sepulchral. With regard to the date of erection of the present Stonehenge, we have also to rely chiefly on analogy. Most stone circles and their contemporaries, long barrows, can be ascribed to the Aeneolithic period. We may here suggest a Bronze Age date. As regards the primary structure and the earthwork, the flints found in the ditch are no criterion, because they are implements roughly fashioned for rough work. The two pieces of pottery, however, found in the first silting of the ditch are almost certainly of the type called neolithic, and since the silting in the ditch must have been rapid we can speculate on a Stonehenge of the late Neolithic period superseded by an improved Stonehenge in the early Bronze Age.

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(R. C. C. C.)

STONE MONUMENTS, PRIMITIVE. The term primitive stone monument implies an ancient or rudimentary memorial or mark. Some represent men or things. Others are tabernacles, provided, either with pious or magical intent, that a power or a soul may be induced to dwell therein.

At first, they were memorial—to keep in memory the site of a certain event, or definite spot—perhaps to mark a route, perhaps to delimit the bourn of forbidden ground. They would be signposts, of a welcoming, funereal or warning character. Natural existing marks were doubtless first used; later, wooden posts where trees were plentiful. Stone heaps or boulders where available, would replace wood as less subject to decay and more difficult to remove treacherously. Such marks become sacred by natural evolution, so that men fear to remove them. This process varies according to the people's standard of magic or religion. Retribution is to be feared should a memorial be defaced or a boundary stone moved. During Woolley's excavation at Ur in 1924 there was found, in what appeared to be a museum or records department attached to a convent of the Kassite period (*c.* 1600 B.C.), such a bourn (now in the Baghdad Museum), photographs of which were exhibited in 1925 in the basement of the Assyrian Department at the British Museum. On this stone were graven the boundaries of the property it had presumably once marked, the names of the owner and of the witnesses to the "deed," and a short imprecation threatening the curses of the gods *whose emblems were carved upon the stone* should this testimony be destroyed. The stage from the bourn to the idea of a witness-stone is almost imperceptible. The stone becomes something on which solemn oaths can be sworn, as is exemplified by pillar-stones and their folk-lore, especially such as have a hole through which may be passed the clasped hands of two persons making a contract. The *Lia Fail* at Tara and other stones on which Irish kings and chiefs took their oaths at their inauguration, and the *Bocca della Verita* in Rome, display the persistence of such an idea into historic times. Similar traditions have clung for longer periods to witness-stones or *pierres de justice* among the primitive stone monuments of Brittany, Cornwall, Wales, Scotland and Ireland.

Once a memorial pillar or a witness-stone became invested with such a sacral character it would easily itself become the object of propitiatory rites, especially if marked with sacred emblems. Thus the drivers travelling the lonely desert routes uniting India, China, Tibet, Russia and Persia pour libations of wheel oil on the anthropomorphic stone wayside cairns and sacred wooden pillars set up at certain stages of their road. (*See* also *Genesis* xxviii., 16–22.)

As to the representation of the human form or of its life-giving organs, the more primitive idea is not the symbology associated with fertility cults, but the intention to represent a particular man or a supernatural being in the likeness of man however crude. This is demonstrable, because although standing-stones or menhirs rudely hewn into effigies, recognizably female by their indications of femininity (and almost certainly intended to represent or symbolize a Mother Goddess), are compatible with a very primitive knowledge of physiology, and call for no esoteric or philosophical explanation, the case with phallic (*see* PHALLICISM) representations is rather different. A religion calling for the recognition of that symbol as representative of fertility (as distinct from fecundity) presupposes a society cognizant of the respective parts played by the male and female functions in nature in the production of offspring, and long familiar with husbandry and cattle-raising, whereas in very primitive societies the physical association of the sexes, though regulated by custom, is often unrelated to paternity. The child is known to be physiologically produced by its mother. Socially it may belong to its maternal uncle (*see* AVUNCULATE), uterine relationship between brothers and sisters being easily demonstrable. Even when the observed association of maternal fecundity with post-initiate sexual connection brings about recognition of cause and effect in specific cases, there is still some way to go intellectually before the symbol of male fertility can take the natural place in the ideology of magic or religion that is taken by the crude representation of a human form with female breasts. The stone pillar that is recognizably a phallus is not on the same primitive plane with the menhir having indications of eyes, nose, mouth and breasts, but rather with the esoteric symbology of the holed stone.

Mystery dramas, in which the initiate actually passes through the circular gate of exit from "his mother's womb" to that new life, and domestic altars on which phallus and holed stone are not the accessories of indecent rites but the emblems of an exalted interpretation of the twin principles of life, must have been sufficiently common to perpetuate, as appears to have been the case, the esoteric significance of these symbols through long ages. We see the origin of the doubly solemn nature of an asseveration or contract made by passing the hand through a holed stone, and of the idea of passing sick children bodily through such stones. The cult of the *lingam* stone in India to-day illustrates this point.

Thus, no doubt, many of the rude stone monuments characteristic of Brittany, Cornwall, Wales, Scotland, Ireland, etc., came to have their connection in folk-lore and folk memory with fertility cults, the furtive practice of whose associated rites might well be condemned by the unthinking as fundamentally indecent, and by the early Christian Church as subversively pagan. Such monuments, therefore, are not so much primitive in themselves as relics of a highly elaborate order of ideas.

The ideas connected with pillar and holed-stone cults probably go back to 4000 or 5000 B.C., although not introduced into Western Europe till somewhere about 2500 to 2000 B.C. Long before that, however, men probably put up small rude bourns and memory stones (where stone was available) as more permanent than marked trees or wooden posts or cairns of loose stones. It is difficult to disentangle, from among a welter of stone monuments (such, *e.g.*, as those at Carnac which range from small unhewn pillars 2 feet high to elaborately chambered barrows), primitive commemorative menhirs that may have survived from an earlier day. The more primitive-seeming stone monuments—menhirs in isolation—are almost invariably found in districts where the elaborate chambered barrow, the cromlech and the stone avenue are equally characteristic. In the Naga Hills, lying between Assam and Burma, we can observe a rather primitive society erecting just such menhirs as we see in the megalithic districts of Western Europe, to mark social occasions and events of their lives. Such primitive monuments as standing-stones are erected by men according to a prescribed etiquette to commemorate contemporary events of their own lives and need not necessarily be either funereal or in the nature of witness-stones or boundary-marks. It is arguable that the stone-raising Nagas, like the peasants of Ireland or Brittany with their cults of the stones, are merely keeping alive customs which originated in a more complex society, and certain other Naga customs connected with the use of stone and the symbolism of horns bear this out.

When, therefore, we come to deal with such stone monuments as are really rude human effigies, we are far away from the symbolical ideas already discussed. Primitive folk to-day provide the disembodied spirit with an effigy, preferably near his grave, thus preventing him from taking up his abode in an already occupied body.

Other rough stone monuments as avenues, cromlechs and quadrilateral enclosures, or dolmens—those remains of what have once been stone chambers or artificial grottoes covered over by mounds of earth or stones—are not strictly primitive, as has been demonstrated by the excavations at Carnac, in Brittany (*see* CARNAC, *Megalithic Monuments*).

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STONE MOUNTAIN MEMORIAL. Stone mountain, situated about 15 m. north of Atlanta, Ga., is a solid grey granite monadnock, shaped like a half parabola, 867 ft. high, nearly a mile long, and without a tree, shrub, or patch of earth to disguise the stone. In 1916 the sculptor, Gutzon Borglum (*q.v.*), conceived the plan of carving upon this mountain side a gigantic memorial to the valour and loyalty of the South to the lost Confederate cause. The design, 200 ft. high and 1,300 ft. long, was to represent the army of the Confederacy with Robert E. Lee and other southern leaders at its head. Work was begun by Borglum in 1917, interrupted by the World War, and continued in 1923–25 when a dispute with the Stone Mountain Monumental Association, which raised the funds, resulted in his dismissal. In 1926 Augustus Lukeman was employed as Borglum's successor. Borglum's head of Lee was unveiled in 1924 and a section of Lukeman's work was unveiled in 1928, but the total then accomplished represented but a corner of one section of the complete design. Funds may ultimately be raised to complete the monument.

STONE RIVER, BATTLE OF, a battle of the American Civil War, called the battle of Murfreesboro by the Confederates, fought on Dec. 31, 1862, and Jan. 2, 1863. After his appointment in October to command the Army of the Cumberland, Gen. W. S. Rosecrans, with Chattanooga as his objective, moved from Nashville upon Gen. Braxton Bragg, who left the winter quarters he had established at Murfreesboro and met the Union army on Stone river immediately north of Murfreesboro, on the last day of December. The plan of attack on each side was to crush the enemy's right. Bragg's left, commanded by Lieut.-gen. W. J.

Hardee, overlapped and bore back the Union right under Maj.-gen. A. McD. McCook, and Maj.-gen. T. L. Crittenden, commanding the Union left, was hurriedly called back from his attack on the Confederate right to support McCook. The Union right was crumpled up on the centre, where Maj.-gen. G. H. Thomas's corps checked the Confederate attack. There was practically no fighting on Jan. 1, but on the 2nd the Confederates renewed the attack, Maj.-gen. J. C. Breckinridge with Bragg's right attempting in vain to displace one of Crittenden's divisions which had established itself during the 1st on high ground across the river. On the night of the 3rd Bragg withdrew and the Union army occupied Murfreesboro. Tactically a drawn battle, Stone River was strategically a Union victory. The losses on both sides were heavy: of 37,712 Confederates present for duty, 1,294 were killed, 7,945 were wounded, and about 2,500 were missing; and of 44,800 Union soldiers present for duty, 1,677 were killed, 7,543 were wounded, and 3,686 were missing.

See A. F. Stevenson, *The Battle of Stone's River* (Boston, 1884); and W. J. Vance, *Stone's River, the Turning-Point of the Civil War* (1914).

STONEWORT, the common name for Algae (*q.v.*) of the division Charales, so called from the deposit of lime in their superficial membranes. They grow in fresh and brackish water.

STONINGTON, a borough of Connecticut, U.S.A. Pop. (1920), 2,100. There is a good harbour. In the 18th and 19th centuries whaling and sealing were important industries. Nathaniel B. Palmer, who discovered Palmer Land in the Antarctic early in the 19th century, was a whaling captain of Stonington. The village was a military depot during the Revolution, and in Aug. 1775, was bombarded by a British frigate. In 1801 it was incorporated as a borough, the first in the State. An attack by a British squadron in Aug. 1814, was repulsed.

STONY POINT, a township in Rockland county, N.Y., U.S.A. Pop. (1925) 3,511. Area, about 30 sq. miles. It was named from a rocky promontory which juts into the Hudson. During the Revolutionary War it was of considerable strategic importance. The Americans occupied it in Nov. 1776, and about two years later erected a blockhouse upon it. The garrison, however, was very small, and on May 31, 1779, it was taken by the British, who immediately erected much stronger fortifications. On the night of July 15–16, it was recovered by Gen. Anthony Wayne, in command of about 1,350 picked American troops, the garrison (under Lieut.-Col. Henry Johnson) losing 63 in killed, 70 in wounded and 543 taken prisoner. The American loss was only 15 killed and 83 wounded. The Americans, however, had no thought from the first of holding the place and evacuated it on July 18; whereupon it was reoccupied by the British, but late in October they, too, abandoned it. In the "old Treason house" in the township Gen. Benedict Arnold and Major John André met before daylight on Sept. 22, 1780, to settle upon plans for the surrender of West Point by Arnold to the British.

See H. P. Johnston, *The Storming of Stony Point* (1900); E. H. Hall and F. W. Halsey, *Stony Point Battle-Field* (1902); and D. Cole and E. Gay, *History of Rockland County* (1884).

STOOLBALL. Of the ancient game of stoolball very little indeed is known, and it has nothing whatever in common with the modern game which, since 1916, has made astonishing progress. During the war a simple but not strenuous outdoor game was very badly needed for wounded officers, soldiers and sailors; and the idea occurred to Maj. W. W. Grantham, who was stationed at Brighton, that the old game of stoolball adapted to modern requirements, would be suitable for the purpose. The game was soon played in scores of hospitals and convalescent homes, in England and France. He made a few simple rules adapted from cricket, and the first public match took place on the County cricket ground of Hove in 1917.

In 1924 a Stoolball Association was formed at Lord's, and by the end of 1927 it was estimated that nearly 3,000 clubs had become members. In Sussex alone the game is played in hundreds of villages, and by large numbers of schools of all kinds, women's institutions and girl guides associations. It has been introduced into Iceland, Japan, Siberia, Switzerland and Finland.

The materials required for the game are very few and very simple; and although with the exception of the ball they can be easily and quickly made by any carpenter they may now be obtained from most of the outfitters. Two bats, a ball, and two wickets comprise the materials. The bats are wooden, made like a racket, the diameter of the round part being not more than 7½in., and, including the handle, the bat must be not more than 18in. in length. The ball is usually known as "best tennis No. 3," but a hard lawn tennis ball will serve the purpose. Each of the two wickets consists of a board 1ft. square fastened to a stout post which must be firmly fixed in the ground in such a way that the top of the board is 4ft. 8in. above the ground; a tripod is often substituted for the post.

The wickets must be fixed at a distance of 16yds. from each other, and a bowling crease not more than 1yd. in length must be marked at a spot 10yds. from each wicket, for this is where the bowler stands. The bowling is underhand, and the number of balls to an over, originally ten, has been reduced to eight. A batsman may be bowled, caught, or run out (the ball hitting the face of the board), or may be given out "body before"; runs are made just as in cricket. In order that the batsman shall be out, "bowled," the ball must hit the face or edge of the wicket (but not the stump), without having previously touched the ground—in other words the ball must be a full pitch. On all points for which there are no special rules, the laws of cricket, as far as possible, hold good for stoolball. The game can be played on any piece of ground which is fairly level and not so rough as to be dangerous; the minimum space required would be about half the size of an ordinary cricket ground.

The ancient form of the game was once very popular in England, and was commonly considered to be the ancestor of cricket. Writing in 1801, Joseph Strutt gives a description of it.

See W. W. Grantham, *Stoolball Illustrated and How to Play it.*

(W. A. Be.)

STORACE, STEPHEN (1763–1796), English composer, was born in London but studied (under his father, Stefano Storace, an Italian contrabassist) at the Conservatorio di Sant' Onofrio, at Naples. His first opera, *Gli Sposi malcontenti*, was produced at Vienna, in 1785. Here he made the acquaintance of Mozart, in whose *Nozze di Figaro* his sister, Anna Selina Storace, first sang the part of Susanna. Here also he produced a second opera, *Gli Equivoci*, founded on Shakespeare's *Comedy of Errors*, and a Singspiel entitled *Der Doctor und der Apotheker*. In England, after creating a favourable impression by bringing out his Singspiel at Drury Lane, under the title of *The Doctor and the Apothecary*, Storace attained his first great success in 1789, in *The Haunted Tower*, an opera which ran for fifty nights in succession. The music of *The Pirates* (1792) affords one of the earliest instances of the introduction of a grand *finale* into an English opera. Storace's music is pre-eminently English. He doubtless learnt something from his sister Anna (1766–1817), a brilliant singer who died leaving £50,000. Storace himself died on March 19, 1796.

STORAGE, COLD: *see* REFRIGERATION AND ICE MANUFACTURE.

STORAGE BATTERY: *see* ACCUMULATORS.

STORK (*Ciconia alba*), a well-known bird, which is a summer visitor to most parts of the European continent, breeding from southern Sweden to Spain and Greece. It reappears again in Asia Minor, the Caucasus, Persia, and Turkestan, but farther east it is replaced by *C. boyciana*, which reaches Japan. Though occasionally using trees for the purpose, the stork generally places its nest on buildings, and is everywhere a cherished guest, popular belief ascribing good luck to the house to which it attaches itself. To consult its convenience a stage of some kind, often a cart-wheel, is in many places set up. Its food, consisting mainly of frogs and insects, is gathered in marshes and pastures, across which it may be seen stalking with an air of quiet dignity; but in the pairing season it indulges in grotesque gestures—leaping from the ground with extended wings in a kind of dance, and, though voiceless, clattering its mandibles. Apart from its size—a stork stands more than 3ft. in height—its contrasted plumage of white and black, with its bright red bill and legs, makes it a conspicuous and beautiful object. In winter the storks of Europe retire to Africa—some of them reaching Cape Colony—while those of Asia visit India. A second species, with much the same range, is the black stork, *C. nigra,* of which the upper parts are black, brilliantly glossed with purple, copper and green, while it is white beneath, the bill, legs, and the bare skin round the eyes being red. The bird breeds in lofty trees. Two other dark-coloured species are the African *C. abdimii* and *C. episcopus,* which is found in Africa, India, Java, and Sumatra. The New World has only one true stork, *Dissura maguari,* which inhabits South America and resembles *C. boyciana,* differing therefrom in its greenish-white bill and black tail. Both these species are very like *C. alba,* but are larger and have a bare patch of red skin round the eyes.

The storks form the family *Ciconiidae,* and, together with the ibises (*q.v.*), are ranked as a sub-order of Ciconiiform birds (*see* Ornithology). In all the storks the eggs are white, and pitted with granular depressions.

STORM, THEODOR WOLDSEN (1817–1888), German poet and novelist, was born at Husum, Schleswig, on Sept. 14, 1817, studying jurisprudence at Kiel and Berlin, where he formed a close friendship with the brothers Theodor and Tycho Mommsen. Storm is hardly less remarkable as a lyric poet than as a novelist. As the former, he made his début, with the two Mommsens, with *Liederbuch dreier Freunde* (1843); but his *Gedichte* (1852; 12th edition, 1900) first obtained for him general recognition. As a novelist he gained his first great success with *Immensee* (1852; 51st edition, 1901); and this was followed by numerous other short stories. He is at his best when dealing retrospectively with episodes and incidents from his own earlier life. Later he passed to psychological problems with *Aquis submersus* (1877) and *Zur Chronik von Grieshuus* (1884), and made a deep impression with his fantastic *Schimmelreiter* (1888).

Storm's *Gesammelte Schriften* appeared in 19 vols. between 1868 and 1889; new edition in 8 vols. (1898); *Sämtliche Werke* (A. Köster, 1919). His correspondence with E. Mörike was published in 1891, with G. Keller in 1904 and with Paul Heyse (1917). *See* E. Schmidt, *Charakteristiken,* i. (1886); also P. Schütze, *Theodor Storm, sein Leben und seine Dichtung* (1887); F. Wehl, *Theodor Storm, ein Bild seines Lebens und Schaffens* (1888); A. Biese, *Th. Storm und der moderne Realismus* (1888); and P. Remer, *Theodor Storm als norddeutscher Dichter* (1897); C. J. A. Biese, *Theodor Storms Leben und Werke* (Leipzig, 1917); R. Pitnou, *La vie et l'oeuvre de Th. Storm, 1817–1888* (1920).

STORM. A gale is classed as a storm when the wind reaches force 10 on the Beaufort Scale (*q.v.*). (For magnetic storms *see* Terrestrial Magnetism.)

STORMBERG, ACTION OF (Dec. 10, 1899): *see* South African War.

STORNOWAY (Norse, *Stjarna vagr,* "Stjarna's Bay"), the principal town of the county of Ross and Cromarty. Pop. (1921), 4,079. It is situated on the east coast of Lewis, at the head of a harbour accessible for steamers of 3,000 tons. Stornoway, which was made a burgh of barony by James VI., is the centre of the Outer Hebrides fishery district and during the herring season the population is very largely increased. Steamers run daily in summer to Hallaig and weekly to Glasgow, Belfast, Keith and Verpool.

STORY, JOHN (*c.* 1510–1571), English martyr, was educated at Oxford, where he became lecturer on civil law in 1535, being made later principal of Broadgates Hall, afterwards Pembroke college. He appears to have disavowed his Roman Catholic opinions just after the accession of Edward VI., but having been chosen a member of parliament in 1547 he gained notoriety by his opposition to the act of uniformity in 1548. For crying out "Woe unto thee, O land, when thy king is a child," he was imprisoned by the House of Commons, but he was soon released and went into exile. Returning to England in 1553, he resigned his position at Oxford, which was now that of regius professor of civil law, and was made chancellor of the dioceses of London and of Oxford and dean of arches. Story was one of Queen Mary's most active agents in prosecuting heretics, and was one of her proctors at the trial of Cranmer at Oxford in 1555. Under Elizabeth he was again returned to parliament, but in 1560 he underwent a short imprisonment for boasting about his work in the former reign. In 1563 he was again arrested, but managed to escape to Flanders, where he became a pensioner of Philip II. of Spain. The duke of Alva authorized him to exclude certain classes of books from the Netherlands and, in 1570, while engaged in this work, he was decoyed on to a ship at Antwerp and conveyed to Yarmouth. In spite of his claim that he was a Spanish subject, he was tried for high treason, and executed at Tyburn on June 1, 1571. In 1886 Story was beatified by papal decree.

STORY, JOSEPH (1779–1845), American jurist, was born at Marblehead (Mass.), on Sept. 18, 1779. He graduated from Harvard in 1798, and was admitted to the bar at Salem (Mass.), in 1801, a Democrat. In Nov. 1811, at the age of 32, he became, by President Madison's appointment, an associate justice of the U.S. Supreme Court. This position he retained until his death. Soon after Story's appointment, the Supreme Court began to bring out into plain view the powers which the Constitution had given it over State courts and State legislation.

The leading place in this work belongs to Chief Justice John Marshall, but Story has a very large share in that remarkable series of decisions and opinions, from 1812 until 1832, by which the work was accomplished. In addition to this he built up the department of admiralty law in the U.S. courts; he devoted much attention to equity jurisprudence, and rendered invaluable services to the department of patent law. In 1819 he attracted much attention by his vigorous charges to grand juries, denouncing the slave trade, and in 1820 he was a prominent member of the Massachusetts Convention called to revise the State Constitution. In 1829 he became the first Dane professor of law at Harvard university, and continued until his death to hold this position. He died at Cambridge (Mass.), on Sept. 10, 1845.

Among his publications are: *Commentaries on the Law of Bailments* (1832); *Commentaries on the Constitution of the United States* (1833), a work of profound learning which is still the standard treatise on the subject; *Commentaries on the Conflict of Laws* (1834), by many regarded as his ablest work; *Commentaries on Equity Jurisprudence* (1835–36); *Equity Pleadings* (1838); *Law of Agency* (1839); *Law of Partnership* (1841); *Law of Bills of Exchange* (1843); and *Law of Promissory Notes* (1845).

See *The Life and Letters of Joseph Story* (Boston and London, 1851), by his son, W. W. Story.

STORY, WILLIAM WETMORE (1819–1895), American sculptor and poet, was born at Salem (Mass.), Feb. 12, 1819. A graduate of Harvard college (1838), he studied law under his father, Justice Joseph Story and for six years he only wrote poetry and criticism, modelled and painted to amuse himself. A request that he make the public monument to his father resulted in a journey abroad, which caused him to find that his "heart had gone over from the Law to Art." Thereafter he spent his life in Italy, where he died, Oct. 7, 1895. What Hawthorne called "his perplexing variety of talents and accomplishments" prevented his high contemporary reputation from becoming permanent. His statue of Cleopatra is most famous because of the enthusiastic description in Hawthorne's *Marble Faun;* typical of the majority of his sombre feminine figures are *Semiramis* and *Medea* in the Metropolitan Museum. His *Poems* (1885), *He and She; or, A Poet's Portfolio* (1884) and *A Poet's Portfolio: Later Readings* (1894) show his love of beauty, but, like his statues, they lack vitality, as do his other books.

See Mary E. Phillips, *Reminiscences of William Wetmore Story* (1897); Henry James, *William Wetmore Story and His Friends* (1903); and Lorado Taft, *History of American Sculpture* (1924).

STOSS, VEIT (1438 or 1440–1533), German sculptor and wood carver, was born in Nuremberg. In 1477 he went to Cracow, where he was actively engaged until 1499. It was here that he carved the high altar for the Marienkirche, between 1477 and 1484. On the death of King Casimir IV. in 1492 Stoss carved his tomb in red marble for the cathedral in Cracow. He also executed the marble tombstone of the archbishop Zbigniew Ollsnicki in the cathedral at Gnesen and the Stanislaus altar for the Marienkirche at Cracow. In 1496 he returned to Nuremberg, where he did a great deal of work in completing altars. His main works are: a relief with the Coronation of the Blessed Virgin in the Germanic museum at Nuremberg, a statue of the Blessed Virgin in the

Frauenkirche, the Annunciation in the Lorenzkirche, and the circular rosary in the Germanic museum.

STÖSSEL, ANATOLI MIKHAILOVICH (b. 1848), Russian general, born at St. Petersburg (Leningrad), on July 10, 1848, entered the Russian army in 1864. He served in the Russo-Turkish War of 1877–78 and in the Boxer campaign of 1900. At the outbreak of the Russo-Japanese War (1904) he was placed in command at Port Arthur. After a prolonged defence (*see* Russo-Japanese War) he surrendered the city to the Japanese (Jan. 2, 1905). He was tried by court-martial and imprisoned. Stössel was released in May 1909. The date of his death is uncertain.

STOTHARD, THOMAS (1755–1834), English subject painter, was born in London on Aug. 17, 1755, the son of a well-to-do innkeeper in Long Acre. After a delicate childhood, he was apprenticed in Spitalfields to a draughtsman of patterns for brocaded silks. In 1778 he became a student of the Royal Academy, of which he was elected associate in 1792 and full academician in 1794. In 1812 he was appointed librarian. He died in London on April 27, 1834.

Among his earliest book illustrations are plates engraved for *Ossian* and for *Bell's Poets;* and in 1780 he became a regular contributor to the *Novelist's Magazine,* for which he executed 148 designs, including his 11 admirable illustrations to *Peregrine Pickle* and his graceful subjects from *Clarissa* and *Sir Charles Grandison.* He contentedly designed plates for pocket-books, tickets for concerts, illustrations to almanacs, portraits of popular players—and into even the slightest and most trivial sketches he infused a grace and distinction which render them of value to the collectors of the present time. He is at his best in domestic or ideal subjects; the heroic and the tragic were beyond his powers.

His oil pictures are usually small in size, and rather sketchy in handling; but their colouring is often rich and glowing, Stothard having been a great admirer of Rubens. The "Vintage," perhaps his most important oil painting, is in the National Gallery. He was a contributor to Boydell's Shakespeare gallery, but his best-known painting is the "Procession of the Canterbury Pilgrims," also in the National Gallery, the engraving from which, begun by Luigi, continued by Niccolo Schiavonetti and finished by James Heath, attained an immense popularity. It was followed by a companion work, the "Flitch of Bacon," which was drawn in sepia for the engraver but was never carried out in colour.

Among his illustrations are the two sets to *Robinson Crusoe,* one for the *New Magazine* and one for Stockdale's edition, and the plates to *The Pilgrim's Progress* (1788), to Harding's edition of Goldsmith's *Vicar of Wakefield* (1792), to *The Rape of the Lock* (1798), to the works of Gessner (1802), to Cowper's *Poems* (1825), to *The Decameron,* the superb editions of Roger's *Italy* (1830) and *Poems* (1834).

Stothard also decorated the grand staircase of Burghley House, near Stamford (1799–1803); the mansion of Hafod, North Wales, (1810) and the cupola of the upper hall of the Advocates' Library, Edinburgh (now occupied by the Signet Library), with Apollo and the Muses, and figures of poets, orators, etc. (1822). His designs for a frieze and other decorations for Buckingham Palace were not executed, owing to the death of George IV. He also designed the magnificent shield presented to the duke of Wellington by the merchants of London, and executed with his own hand a series of eight etchings from the various subjects which adorned it. In the British Museum is a collection, in four volumes, of engravings of Stothard's works, made by Robert Balmanno.

An interesting but most indiscriminately eulogistic biography of Stothard, by his daughter-in-law, Mrs. Bray, was published in 1851. A. C. Coxhead's *Thomas Stothard, R. A., an Illustrated Monograph* (1906), contains a short biographical chapter, and an accurately dated summary of the various books and periodicals illustrated by Stothard; see also Austin Dobson, *Eighteenth Century Vignettes,* 1st series (1892).

STOUR, the name of several English rivers, an ancient word of doubtful etymology. (1) The East-Anglian Stour rises in south-east Cambridgeshire and flows 60 miles to the North Sea at Harwich. (2) The Kentish or Great Stour rises on the south of the North Downs, one branch, the East Stour, rising near Hyde but flowing away from the sea, while the western branch rises near Lenham and the two unite at Ashford. Passing Canterbury, the Stour again divides, one branch reaching the English Channel in Pegwell Bay, while the smaller enters the North Sea at Reculver. The Stour is navigable to Fordwich. Its length is about 40 m. Other rivers named Stour are (3) a tributary of the Hampshire Avon, (4) a left bank tributary of the Severn, which it joins at Stourport, and (5) a small tributary of the upper Avon, rising west of Banbury.

STOURBRIDGE, town in Worcestershire, England. Pop. (1921) 18,016. There is an endowed grammar school founded by Edward VI., and a bluecoat or hospital school. The principal manufactures are in iron, leather and skins; there are glue works and fire-brick works. Coal and fire-clay are mined. The manufacture of glass was established in 1556. Annual fairs are held. The town was originally called Bedcote, a name retained by the manor.

STOURPORT, market town, Worcester, England. Pop. (1921) 4,777. At Redstone is a hermitage excavated out of the red sandstone bank of the Severn.

STOUT, SIR ROBERT (1844–   ), New Zealand judge and statesman, was born on Sept. 28, 1844 at Lerwick, Shetland Isles, where he became a pupil teacher at the parish school. He went to New Zealand in 1863, was admitted (July 4, 1871) as barrister and solicitor of the supreme court of New Zealand, and from 1874–1876 was law lecturer there. In 1875 he was elected Liberal M.P. for Caversham, and in Feb. 1878 became attorney-general and minister of lands and minister of immigration in Sir George Grey's ministry. He resigned in 1879 but returned to public life in 1884 as member for Dunedin East. On the defeat of Sir Harry Atkinson's Government he joined Sir Jules Vogel in forming a ministry (Aug. 16–28, 1884), but after another Atkinson government had held office for a few days (Aug. 28–Sept. 3) a second Stout-Vogel government was formed which lasted three years. In both the Stout-Vogel governments Sir Robert Stout was premier and attorney-general. At the general election in 1887 he lost his seat. In 1893 he was elected as an independent Liberal for Inangahua, at a by-election, and at the general elections of 1893 and 1896 he was elected for Wellington city, to which he transferred his legal practice. In 1898 he resigned his seat, and from 1899 to 1926 was Chief Justice.

Sir Robert Stout's principal measures were the Land Act of 1877, the first Land Tax Act (drafted in co-operation with Ballance and which became law in 1878), and the Civil Service Reform Act of 1886 when he was made K.C.M.G. As a member of a royal commission appointed in 1881 he helped Allen Holmes to form the code of civil procedure, which was enacted in 1882 and made the supreme court procedure of New Zealand one of the simplest in the world. He was also interested in educational and temperance reform. He became member of the New Zealand university senate in 1884 and of the Victoria University college council, Wellington, and from 1903 to 1923 was chancellor of the university. He was elected a member of the Legislative Council of New Zealand in 1926.

STOUT: *see* Beer; Brewing.

STOVES: *see* Household Appliances; Gas Stoves; Furnaces; Heating and Ventilation.

STOW, JOHN (*c.* 1525–1605), English historian and antiquary, was the son of Thomas Stow, a tailor, and was born about 1525 in London, in the parish of St. Michael, Cornhill. He learned the trade of his father, but possibly did not practise it much after he grew up. In 1549 he "kept house" near the well within Aldgate, but afterwards he removed to Lime Street ward, where he resided till his death. About 1560 he made the acquaintance of the leading antiquaries of his time, including William Camden, and in 1561 he published his first work, *The woorkes of Geffrey Chaucer, newly printed with divers addicions whiche were never in printe before.* This was followed in 1565 by his *Summarie of Englyshe Chronicles,* which was frequently reprinted, with slight variations, during his lifetime. In 1580 Stow published his *Annales, or a Generale Chronicle of England from Brute until the present yeare of Christ 1580.*

The work by which Stow is best known is his *Survey of London,* published in 1598, not only interesting from the quaint simplicity of its style and its amusing descriptions and anecdotes, but of unique value from its minute account of the buildings, social condition and customs of London in the time of Elizabeth.

Through the patronage of Archbishop Parker, Stow was enabled to print the *Flores historiarum* of Matthew of Westminster in 1567, the *Chronicle* of Matthew Paris in 1571, and the *Historia brevis* of Thomas Walsingham in 1574. At the request of Parker he had himself compiled a "farre larger volume," *An history of this island,* but the manuscript is lost. Stow remained poor all his life, and was authorized by James I. to appeal for alms in 1604. He died on April 6, 1605, and was buried in the church of St. Andrew Undershaft, where is his monument.

A number of Stow's manuscripts are in the Harleian collection in the British Museum. Some are in the Lambeth library (No. 306); and from the volume which includes them were published by the Camden Society, edited by James Gairdner, *Three Fifteenth-Century Chronicles, with Historical Memoranda by John Stowe the Antiquary, and Contemporary Notes of Occurrences written by him* (1880).

Of the many editions of Stow's *Survey of London, see* that with notes by C. L. Kingsford (Oxford, 1908).

STOWE, HARRIET ELIZABETH (BEECHER) (1811–1896), American writer and philanthropist, seventh child of Lyman and Roxana (Foote) Beecher, was born at Litchfield (Conn.), June 14, 1811. Her parents were descended from founders of New Haven; and the community in which she spent her childhood was one of the most intellectual in New England. At her mother's death, in 1815, she came most directly under the influence of her eldest sister, Catherine, a woman of keen intellect, who a few years later set up a school in Hartford, to which Harriet went, first as a pupil, afterwards as teacher. In 1832 her father, who had for six years been the pastor of a church in Boston, accepted the presidency of the newly-founded Lane Theological seminary at Cincinnati. Catherine Beecher, who was eager to establish what should be in effect a pioneer college for women, accompanied him; and with her went Harriet as an assistant, taking an active part in the literary and school life, contributing stories and sketches to local journals, and compiling a school geography. She was married Jan. 6, 1836, to one of the professors in the seminary, Calvin Ellis Stowe. In the midst of privation and anxiety, due largely to her husband's precarious health, she wrote continually, and in 1843 published *The Mayflower, or Sketches of Scenes and Characters among the Descendants of the Pilgrims.* She lived 18 years in Cincinnati, separated only by the Ohio river from a slave-holding community, coming in contact with fugitive slaves, and learning from friends and her own visits the life of the South. When, therefore, in 1850, Mr. Stowe was elected to a professorship in Bowdoin college, Brunswick (Me.), and removed his family thither, Mrs. Stowe was prepared for the great work which came to her, bit by bit, as a religious message which she must deliver. There she wrote, for serial publication in the *National Era,* an anti-slavery paper of Washington (D.C.), the story of *Uncle Tom's Cabin; or, Life Among the Lowly.* The publication in book form (March 20, 1852) was a factor which must be reckoned in summing up the moving causes of the Civil War. The book sprang into unexampled popularity, and was translated into at least 23 languages. Mrs. Stowe reinforced her story with *A Key to Uncle Tom's Cabin,* in which she accumulated a large number of documents and testimonies against the great evil; and in 1853 she made a journey to Europe, devoting herself especially to creating an *entente cordiale* between English and American women on the question. In 1856 she published *Dred: a Tale of the Dismal Swamp,* in which she threw the weight of her argument on the deterioration of a society resting on a slave basis. The establishment of the *Atlantic Monthly,* in 1857, gave her a constant vehicle for her writings; also the *Independent* of New York, and later the *Christian Union,* of which papers successively her brother, Henry Ward Beecher, was one of the editors.

From this time she led the life of a woman of letters, writing novels, of which *The Minister's Wooing* (1859) is best known, and many studies of social life in the form both of fiction and essay. Her *Pearl of Orr's Island* (1862), Sarah Orne Jewett credited with having revealed to her the literary value of the country folk. Mrs. Stowe published also a small volume of religious poems, and towards the end of her career gave some public readings from her writings. In 1852 Prof. Stowe accepted a professorship in the Theological seminary at Andover (Mass.), and the family made its home there till 1863, when he retired wholly from professional life and removed to Hartford. After the close of the war for the Union, Mrs. Stowe bought an estate in Florida, chiefly in hope of restoring the health of her son, Capt. Frederick Beecher Stowe, who had been wounded in the war, and there she spent many winters. After the death of her husband in 1886, she lived in the seclusion of her Hartford home, where she died on July 1, 1896. She is buried by the side of her husband at Andover.

See the *Life and Letters of Harriet Beecher Stowe* (1897) which were edited by Annie Fields. Recent lives are C. E. and L. B. Stowe, *Harriet Beecher Stowe: the Story of Her Life* (1911), and a biography for girls (1913) by Martha F. Crow. *See* also "Harriet Beecher Stowe" in John Erskine's *Leading American Novelists* (1910). The Riverside edition of Mrs. Stowe's works was published in 1899 and 1906 in 16 volumes (with an additional volume of biography). (H. E. S.)

STOWELL, WILLIAM SCOTT, BARON (1745–1836), English judge and jurist, was born at Heworth, near Newcastle, on Oct. 17, 1745, the son of a "coalfitter" (or tradesman engaged in the transport of coal). His younger brother John became the famous Lord Chancellor Eldon. Scott was educated at the Newcastle grammar school and Corpus Christi College, Oxford. In 1774 he was Camden reader of ancient history, and in 1779 he graduated as doctor of civil law and, after the customary "year of silence," commenced practice in the ecclesiastical courts. His professional success was rapid. In 1783 he became registrar of the court of faculties; in 1788 judge of the consistory court and advocate-general; and in 1798 he was made judge of the high court of admiralty. Sir William Scott twice contested Oxford University—in 1780 without success, but successfully in 1801. He also sat for Downton in 1790. Upon the coronation of George IV. (1821) he was raised to the peerage as Baron Stowell. Lord Stowell retired from the bench—from the consistory court in August 1821, and from the high court of admiralty in December 1827. He died on Jan. 28, 1836. Lord Stowell was twice married —in 1781 to Anna Maria, eldest daughter of John Bagnall of Early Court, Berks., and in 1813 to the dowager marchioness of Sligo. The doctrines of international law with the assertion and illustration of which the name of Lord Stowell is identified are these: the perfect equality and entire independence of all states (*"Le Louis,"* 2 Dod. 243)—a logical deduction from the Austinian philosophy and still one of the fundamental principles of English jurisprudence; that the elementary rules of international law bind even semi-barbarous states (the *"Hurtige Hane,"* 2 Rob. 325); that blockade to be binding must be effectual (the *"Betsey,"* 1 Rob. 93); and that contraband of war is to be determined by "probable destination" (the *"Jonge Margaretha,"* 1 Rob. 189). In the famous Swedish convoy case (the *"Maria,"* 1 Rob. 350; *see,* too, the *"Recovery,"* 6 C. Rob. 348–9) Lord Stowell asserted that "a prize court is a court not merely of the country in which it sits but of the law of nations." "The seat of judicial authority," he added, in words which have become classic, "is indeed locally here, in the belligerent country, but the law itself has no locality." His dictum concerning the right of a belligerent to sink a neutral ship, when unable to take her before a prize court, was much quoted in 1904 in reference to the sinking of the "Knight Commander" by the Russians in the Far East.

The judgments of Lord Stowell were, almost without exception, confirmed on appeal, and they are to this day the international law of England, and have become presumptive though not conclusive evidence of the international law of America. "I have taken care," wrote Justice Story, "that they shall form the basis of the maritime law of the United States, and I have no hesitation in saying that they ought to do so in that of every civilized country in the world."

See W. C. Townsend, *Lives of Twelve Eminent Judges,* vol. ii. (2 vols., 1846); W. E. Surtees, *Sketch of the Lives of Lords Stowell and Eldon* (1846); E. S. Creasy, *First Platform of International Law: Reports of Prize Cases from 1745 to 1859* (1876; new ed. E. S. Roscoe, 2 vols., 1905), contains the most important of Stowell's judgments.

STOWMARKET, a town in Suffolk, England. Pop. 4,243. The church of St. Peter and St. Mary is Decorated and Early English, with a tower and wooden spire. The ancient vicarage has associations with Milton through his tutor, Dr. Young.

STRABANE, the principal town of Co. Tyrone, Ireland. Pop. (1921) 5,107. It stands at the junction of the rivers Mourne and Finn, which thenceforward form the Foyle. The trade in corn is considerable. Linen is the principal industry.

STRABO [STRABON] (born *c.* 63 B.C.), Greek geographer, was born at Amasia in Pontus, a city which had been much Hellenized. He studied at Nysa under the grammarian Aristodemus, under the grammarian Tyrannio at Rome, under the philosopher Xenarchus, and he studied Aristotle with Boethus. He also states that he saw P. Servilius Isauricus, who died at Rome in advanced years in 44 B.C., from which it has been inferred that he visited Rome early in life. He also tells us that he was at Gyaros (one of the Cyclades) when Augustus was at Corinth on his return to Rome from the East in 29 B.C., and that he accompanied the prefect of Egypt, Aelius Gallus, on his expedition to Upper Egypt, which seems to have taken place in 25–24 B.C. These are the only dates in his life which can be accurately fixed. The latest event mentioned in his work is the death of Juba, king of Mauretania, which took place in A.D. 21.

Although he had seen a comparatively small portion of the regions which he describes, he had travelled much. As he states himself: "Westward I have journeyed to the parts of Etruria opposite Sardinia; towards the south from the Euxine to the borders of Ethiopia." His *Geography* was finally revised between A.D. 17 and 23.

Works.—His earliest writing was an historical work now lost, which he himself describes as his *Historical Memoirs.* He tells us (xi. 9, 3) that the sixth book of the *Memoirs* was identical with the second of the *Continuation of Polybius;* probably, therefore, books i.–iv. formed an introduction to the main work. Plutarch, who calls him "the Philosopher," quotes Strabo's *Memoirs* (*Luc.* 28), and cites him as an historian (*Sulla,* 26). Josephus calls him "the Cappadocian," and often quotes from him.

The *Geography* is the most important work on that science which antiquity has left us. It follows Eratosthenes, who had first laid down a scientific basis for geography. The earlier book was too small to contain the description of separate countries which Strabo included. The historical notices are all his own. He regarded Homer as the source of all wisdom and knowledge—indeed, his description of Greece is largely drawn from Apollodorus's commentary on the Homeric "Catalogue of Ships"—and treated Herodotus with undeserved contempt, classing him with Ctesias and other "marvel-mongers."

Strabo chiefly employed Greek authorities (the Alexandrian geographers Polybius, Poseidonius and Theophanes of Mytilene, the companion of Pompey) and made comparatively little use of Roman authorities. He probably amassed his material in the library of Alexandria, so that Greek authorities would naturally furnish the great bulk of his collections, and then returned to Rome, where he perhaps used the chorography of Agrippa, a map of the Roman Empire set up in the Porticus Vipsaniae.

The *Geography* consists of seventeen books, of which the seventh is imperfect. The first two are introductory, the next eight deal with Europe, two being devoted to Spain and Gaul, two to Italy and Sicily, one to the north and east of Europe, and three to Greek lands. The eleventh book treats of the main divisions of Asia and the more easterly districts, the next three of Asia Minor. Book xv. deals with India and Persia, book xvi. with Assyria, Babylonia, Syria and Arabia, and the closing book with Egypt and Africa.

Editions.—The Aldine (Venice, 1516) was unfortunately based on a very corrupt ms. The first substantial improvements in the text were due to Casaubon (Geneva, 1587; Paris, 1620), whose text remained the basis of subsequent editions till that of Coraës (Paris, 1815–19), who removed many corruptions. The mss. were first scientifically collated by Kramer (Berlin, 1844–52), who demonstrated that Par. 1,397 was the best authority for the first nine books (it contains no more) and Vat. 1,329 for the remainder. Of later editions the most important are those of C. Müller (Paris, 1853) and Meineke (Leipzig, 1866–77). H. F. Tozer's volume of selections (Oxford, 1893) is useful. Napoleon I., an admirer of Strabo, caused a French translation of the *Geography* to be made by Coraës, Letronne and others (Paris, 1805–19); German translation by Grosskurd (Berlin, 1831–34); Eng. trans. by H. L. Jones, Loeb Classical Lib. (5 vols. 1922–28). For fragments of the *Historical Memoirs* see *Leipziger Studien XI.*, 1891. *See* also Müller's *Fragmenta historicorum graecorum,* iii. 490 *sqq.*; Bunbury's *History of Ancient Geography,* vol. ii. chs. 21, 22; and F. Dubois's *Examen de la géographie de Strabon* (Paris, 1891) should also be consulted.

STRACHAN, JOHN (1778–1867), first bishop of Toronto, was born at Aberdeen, Scotland, on April 12, 1778. After taking his degree at Aberdeen he emigrated in 1799 to Canada. There he was ordained (1803) and appointed to the parish of Cornwall, and in 1812 to York.

Strachan was appointed to the executive council of Upper Canada in 1815. He was soon the leading spirit in that dominant group known in Upper Canadian history as the Family Compact. In 1820 he was appointed by Sir Peregrine Maitland a member of the legislative council in order that the governor might have a confidential medium through whom to make communication to the council. At the instance of the lieutenant-governor he went to England in 1824, to discuss various colonial questions with the colonial secretary. He paid a second visit to England in 1826–27 to obtain a royal charter for King's College. In 1827 Strachan became archdeacon of York.

The break-up of the Liverpool ministry in 1827 interrupted Strachan's plans for placing the government endowments for religion and education under the Episcopal Church. Adverse criticism and a suggestion from the colonial office led to his resignation from the executive council, but he declined to resign from the legislative council.

On the death of Bishop Stewart of Quebec the Canadian see was divided, and Strachan was made bishop of Toronto in August 1839. He energetically opposed the act of 1840, which sought to settle the Clergy Reserves question by dividing the proceeds among the different religious denominations, the larger share still remaining with the Church of England.

The university of King's College was finally established, with certain modifications of its charter, in 1843, Bishop Strachan being the first president. The renewed agitation finally resulted in the elimination of all religious tests by the act of 1849, which also changed the name to that of the university of Toronto. Strachan at once took steps to found another university which should be completely under the control of the Episcopal Church, hence the establishment of Trinity University, which was opened in 1852. Bishop Strachan also raised once more the question of the disposal of the Clergy Reserves. The Reserves were completely secularized in 1854, provision being made for the life-interest of beneficiaries at the time. Bishop Strachan devoted the latter years of his long life entirely to his episcopal duties, and by introducing the diocesan synod he furnished the Episcopal Church in Canada with a more democratic organ of government. He died in November 1867.

STRACHEY, JOHN ST. LOE (1860–1927), British journalist, was born at Sutton Court, Somerset, on Feb. 9, 1860, the second son of Sir Edward Strachey, 3rd Bart., and Mary Isabella, daughter of John Addington Symonds. He studied at Balliol College, Oxford, and was called to the bar, but adopted journalism as his profession. After writing for some time for the *Saturday Review,* the *Economist,* and other papers, he became in 1886, with Mr. Charles Graves, editor of the *Liberal Unionist,* and in the same year assistant editor of the *Spectator.* After the death of R. H. Hutton and the retirement of Meredith Townsend (1897) he became proprietor of the *Spectator,* which, under his editorship not only maintained but increased its great influence upon English opinion. St. Loe Strachey also edited (1896–97) *The Cornhill Magazine.* He resigned from the editorship of the *Spectator* in 1925, but continued to contribute to its columns.

His publications include *The Manufacture of Paupers* (1907); *The Problems and Perils of Socialism* (1908); *The Practical Wisdom of the Bible* (1908); *A New Way of Life* (1909); *The Madonna of the Barricades* (a novel, 1925); *American Soundings* (1926).

STRACHEY, LYTTON (1880–   ), British writer, son of Sir Richard Strachey, the Indian administrator, was born on March 1, 1880, and educated at Trinity college, Cambridge. He was an occasional contributor to the monthly and quarterly reviews, and published a short but illuminating book on *Landmarks in French Literature* (1912). He achieved wider renown by *Eminent Victorians* (1918), vivid, polished and unusually caustic portraits of Cardinal Manning, Florence Nightingale, Dr. Arnold and General Gordon. In *Queen Victoria* (1921) Strachey's biographical power and his ironic style showed themselves broadened and mellowed, the result being a most successful blend of sympathy and detachment in depicting the queen, her family and her epoch. The two books set up a fresh standard for modern English biography which a good many contemporary writers were quick to acknowledge. A collection of essays, *Books and Characters*, appeared in 1922, his "Leslie Stephen" lecture on Pope in 1925, and *Elizabeth and Essex* in 1928.

STRACHWITZ, MORITZ KARL WILHELM ANTON, Graf von (1822–1847), German poet, was born on March 13, 1822, at Peterwitz near Frankenstein in Silesia. After studying in Breslau and Berlin he settled on his estate in Moravia, where he devoted himself to literary pursuits. When travelling in Italy in 1847 he was taken ill at Venice, and died on Dec. 11 at Vienna in his 25th year. He had already revealed a lyric genius of remarkable force and originality. His first collection of poems, *Lieder eines Erwachenden*, appeared in 1842 and went through several editions. *Neue Gedichte* were published in 1848.

Strachwitz's collected *Gedichte* appeared first in 1850 (8th ed., 1891); a convenient reprint will be found in Reclam's *Universalbibliothek. See* A. K. T. Tielo, *Die Dichtung des Grafen Moritz von Strachwitz* (1902).

STRADELLA, ALESSANDRO (?1645–1682), Italian composer, one of the most accomplished musicians of the 17th century, was probably born at Naples. The generally accepted story of his life was first circumstantially narrated in Bonnet-Bourdelot's *Histoire de la musique et de ses effets* (1715). According to this account, Stradella was engaged by a Venetian nobleman to instruct his mistress, Ortensia, in singing. Stradella eloped with Ortensia to Rome, whither the outraged Venetian sent two paid *bravi* to put him to death. On their arrival in Rome the assassins learned that Stradella had just completed a new oratorio, over the performance of which he was to preside on the following day at S. Giovanni in Laterano. They determined to kill him as he left the church; but the beauty of the music conquered them, and they warned the composer of his danger. Thereupon Stradella fled with Ortensia to Turin, where, notwithstanding the favour shown to him by the regent of Savoy, he was attacked one night by another band of assassins, who, headed by Ortensia's father, left him on the ramparts for dead. Through the connivance of the French ambassador the ruffians escaped; and Stradella, recovering from his wounds, married Ortensia, by consent of the regent, and removed with her to Genoa. Here he believed himself safe; but a year later he and Ortensia were murdered in their house by a third party of assassins in the pay of the implacable Venetian. Research has, however, driven several holes in this picturesque story.

The first certain date in Stradella's life is 1672, in which year he composed a prologue for the performance of Cesti's opera *La Dori* at Rome; he probably spent a considerable time at Rome about this period, since his cantatas and other compositions contain frequent allusions to Rome and noble Roman families. There is, however, no proof that he ever performed the oratorio *S. Giovanni Battista* in the Lateran. Documents in the archives at Turin relate that in 1677 he arrived there with the mistress of Alvise Contarini, with whom he had eloped from Venice. We hear of Stradella last at Genoa. An opera by him, *La Forza dell' amor paterno*, was given there in 1678, and his last composition, *Il Barcheggio* (*i.e.*, a "Water-Music"), was performed on June 16, 1681 in honour of the marriage of Carlo Spinola and Paola Brignole. That he died at Genoa in Feb. 1682 is established by documents in the archives at Modena.

Stradella's best operas are *Il Floridoro*, also known as *Il Moro per amore*, and *Il Trespolo tutore*, a comic opera in three acts which worthily carried on the best traditions of Florentine and Roman comic opera in the 17th century. The oratorio *S. Giovanni Battista* displays the same skill in construction and orchestration (so far as the limited means at his disposal permitted) as the operas. A serenata for voices and two orchestras, *Qual prodigo ch'io miri*, was used by Handel as the basis of several numbers in *Israel in Egypt*, and was printed by Chrysander (Leipzig 1888); the MS., however, formerly in the possession of Victor Schoelcher, from which Chrysander made his copy, has entirely disappeared. The well-known aria *Pietà, signore*, also sung to the words *Se i miei sospiri*, cannot possibly be a work of Stradella.

The finest collection of Stradella's works extant is that at the Biblioteca Estense at Modena, which contains 148 MSS., including four operas, six oratorios and several other compositions of a semi-dramatic character.

See Heinz Hess, *Die Opern Alessandro Stradellas* (Leipzig, 1905), which includes the most complete catalogue yet made of Stradella's extant works; Catelani, *Delle Opere di A Stradella instenti nell' archivio musicale della r. biblioteca palatina di Modena* (Modena, 1865); and Sedley Taylor, *The Indebtedness of Handel to other Composers* (Cambridge, 1906).

STRADIVARI, ANTONIO (1644–1737), Italian violin-maker, was associated throughout his life with Cremona, where he brought the craft of violin-making to its highest pitch of perfection. The obscure details of his life have been thoroughly worked out in the monograph on him by W. H. Hill, A. F. Hill and Alfred Hill (1902). He was still a pupil of Nicolas Amati in 1666, when he had begun to insert his own label on violins of his making, which at first follow the smaller Amati model, solidly constructed, with a thick yellow varnish. It was not till 1684, that he began to produce larger models, using a deeper coloured varnish, and beautifying them in various details, his "long" patterns (from 1690) representing a complete innovation in the proportions of the instrument; while from 1700, after for a few years returning to an earlier style, he again broadened and otherwise improved his model. He also made some beautiful violoncellos and violas. The most famous instruments by him are:—*Violins:* the "Hellier" (1679), the "Sellière" (before 1680), the "Tuscan" (1690), the "Betts" (1704), the "Ernst" (1709), "La Pucelle" (1709), the "Viotti" (1709), the "Vieuxtemps" (1710), the "Parke" (1711), the "Boissier" (1713), the "Dolphin" (1714), the "Gillot" (1715), the "Alard," the finest of all (1715), the "Cessot" (1716), the "Messiah" (1716), the "Sasserno" (1717), the "Maurin" (1718), the "Lauterbach" (1719), the "Blunt" (1721), the "Sarasate" (1724), the "Rode" (1722), the "Deurbroucq" (1727), the "Kiesewetter" (1731), the "Habeneck" (1736), the "Muntz" (1736). *Violas:* the "Tuscan" (1690), two of 1696 formerly belonging to the king of Spain, the "Archinto" (1696), the "Macdonald" (1701), and the "Paganini" (1731). *Violoncellos:* the "Archinto" (1689), the "Tuscan" (1690), the "Aylesford" (1696), the "Cristiani" (1700), the "Servais" (1701), the "Gore-Booth" (1710), the "Duport" (1711), the "Adam" (1713), the "Batta" (1714), the "Piatti," the finest of all (1720), the "Bandiot" (1725), the "Gallay" (1725). Antonio Stradivari's sons Francesco (1671–1743) and Omobono (1679–1742) were also violin-makers, who assisted their father, together with Carlo Bergonzi, who appears to have succeeded to the possession of Antonio's stock-in-trade. The Stradivari method of violin-making created a standard for subsequent times; but the secret of his varnish, soft in texture, and shading from orange to red, though much debated, has never been discovered. (*See* also Violin.)

STRAFFORD, THOMAS WENTWORTH, Earl of (1593–1641), English statesman, son of Sir William Wentworth, of Wentworth Woodhouse, near Rotherham and of Anne Atkins, was born on April 13, 1593, in London. He was educated at St. John's College, Cambridge, was admitted a student of the Inner Temple in 1607. In 1614 he represented Yorkshire in the Addled Parliament, but, so far as is now known, it was not till the parliament of 1621, in which he sat for the same constituency, that he took part in the debates.

Wentworth was returned for Pontefract to the parliament of 1624, but appears to have taken no part in the proceedings. In the first parliament of Charles I., June 1625, he again represented Yorkshire, and opposed the demand made under the influence of Buckingham for subsidies for a war with Spain, and was consequently, after the dissolution in November, made sheriff of Yorkshire, in order to exclude him from the parliament which met in 1626. Yet his position was very different from that of the regular opposition. He was anxious to serve the Crown, but he disapproved of the king's policy. After the dissolution of the parliament he was dismissed from the justiceship of the peace and the office of *custos rotulorum* of Yorkshire, to which he had been appointed in 1615. He refused in 1627 to contribute to the forced loan, and was imprisoned in consequence.

In the parliament of 1628 Wentworth joined the popular leaders in resistance to arbitrary taxation and imprisonment, but he was jealous for the prerogative of the Crown, to which he looked as a reserve force in times of crisis. A moderate bill supported by Wentworth for securing the liberties of the subject was wrecked between the uncompromising demands of the parliamentary party, who would give nothing to the prerogative, and Charles's refusal to make the necessary concessions, and the leadership was thus snatched from Wentworth's hands by Eliot and Coke. Later in the session he fell into conflict with Eliot, as he desired to modify the Petition of Right.

On July 22, 1628, Wentworth was created Baron Wentworth, and received a promise of the presidentship of the Council of the North at the next vacancy. He was now at variance with the parliamentary party both on the constitutional and on the religious question. In December he became Viscount Wentworth and president of the Council of the North. In the speech delivered at York on his taking office he said, almost in the words of Bacon: "Whoever," he said, "ravels forth into questions the right of a king and of a people shall never be able to wrap them up again into the comeliness and order he found them."

The session of 1629 ended in a breach between the king and the parliament which made the task of a moderator hopeless. He stood definitely for the maintenance of the king's prerogative.

The Policy of Thorough.—In January 1632 Wentworth was named lord-deputy of Ireland, and he arrived in Dublin in July 1633. He reformed the administration, getting rid summarily of the inefficient English officials. He obtained the necessary grants from parliament, and secured its co-operation in various useful legislative enactments. He set on foot a new victualling trade with Spain, established or promoted the linen manufacture, and encouraged the development of the resources of the country in many directions. The customs rose from a little over £25,000 in 1633–1634 to £57,000 in 1637–1638. He raised an army. He swept the pirates from the seas. He reformed and instilled life into the Church and rescued church property. His strong and even administration broke down the tyranny of the great men over the poor. Such was the government of "Thorough," as Strafford expresses it. Yet these good measures were carried out by arbitrary methods, and their aim was the benefit to the English exchequer; Strafford suppressed the trade in cloth "lest it should be a means to prejudice that staple commodity of England." Extraordinary acts of despotism took place, as in the case of Esmond, Lord Chancellor Loftus and Lord Mountnorris, the last of whom Strafford caused to be sentenced to death in order to obtain the resignation of his office, and then pardoned. Strafford broke Charles's promise that no colonists should be forced into Connaught, and, raking up an obsolete title—the grant in the 14th century of Connaught to Lionel, duke of Clarence, whose heir Charles was—he insisted upon the grand juries in all the counties finding verdicts for the king. High-handed as Wentworth was by nature, his rule in Ireland made him more high-handed than ever. As yet he had never been consulted on English affairs, and it was only in February 1637 that Charles asked his opinion on a proposed interference in the affairs of the Continent. In reply, he assured Charles that it would be unwise to undertake even naval operations till he had secured absolute power at home. He wished that Hampden and his followers "were well whipped into their right senses." When the Scottish Puritans rebelled he advocated the most decided measures of repression, in February 1639 sending the king £2,000 as his contribution to the expenses of the coming war, but he deprecated action before the English army was trained, and advised concessions in religion.

Wentworth arrived in England in September 1639, after Charles's failure in the first Bishops' War, and from that moment he became Charles's principal adviser. In January 1640 he was created earl of Strafford, and in March he went to Ireland to hold a parliament, where the Catholic vote secured a grant of subsidies to be used against the Presbyterian Scots. An Irish army was to be levied to assist in the coming war. When in April Strafford returned to England he found the Commons holding back from a grant of supply, and tried to enlist the peers on the side of the king. On the other hand he induced Charles to be content with a smaller grant than he had originally asked for. The Commons, however, insisted on peace with the Scots. Charles, on the advice of Vane, returned to his larger demand of twelve subsidies; and on May 9, at the privy council, Strafford, though reluctantly, voted for a dissolution. The same morning the Committee of Eight of the privy council met again. Vane and others were for a mere defence against invasion. Strafford's advice was for a vigorous prosecution of war.

Bill of Attainder.—The Long Parliament assembled on Nov. 3, 1640, and Charles immediately summoned Strafford to London. Under safe conduct from Charles, he arrived on the 9th and on the 10th proposed to the king to forestall his impeachment, now being prepared by the parliament, by accusing the leaders of the popular party of treasonable communications with the Scots. But Pym immediately took up the impeachment to the Lords on the 11th. Strafford came to the house to confront his accusers, but was ordered to withdraw and committed into custody. On Nov. 25, the preliminary charge was brought up, whereupon he was sent to the Tower, and, on Jan. 31, 1641, the accusations in detail were presented. These were, in sum, that Strafford had endeavoured to subvert the fundamental laws of the kingdom. Behind the legal aspect of the case lay the great constitutional question of the responsibility to the nation of the leader of its administration. The Commons, convinced that the destruction of Strafford was essential to the liberties of the kingdom, dropped the impeachment, and brought in and passed a bill of attainder, though, owing to the opposition of the Lords and Pym's own preference for the more judicial method, the procedure of an impeachment was practically adhered to. Strafford might still have been saved but for the king's ill-advised conduct. The revelation of the army plot on May 5, caused the Lords to pass the attainder. Nothing now remained but the king's signature. Charles yielded, giving his assent on May 10. Strafford met his fate on May 12, on Tower Hill, receiving Laud's blessing, who was then also imprisoned in the Tower, on his way to execution.

Thus passed into history "the great person," as Clarendon well calls him, without doubt one of the most striking figures in the annals of England. Strafford's patriotism and ideas were fully as noble as those of his antagonists. Like Pym, a student of Bacon's wisdom, he believed in the progress of England along the lines of natural development, but that development, in opposition to Pym, he was convinced could only proceed with the increase of the power of the executive, not of the parliament, with a government controlled by the king and not by the people.

Strafford was married three times: (1) in 1611 to Lady Margaret Clifford, daughter of Francis, 4th earl of Cumberland; (2) in 1625 to Lady Arabella Holles, daughter of John, 1st earl of Clare; (3) in 1632 to Elizabeth, daughter of Sir Godfrey Rhodes. He left three daughters and one son, William, 2nd earl of Strafford.

See the article on Strafford in the *Dict. Nat. Biog.* by S. R. Gardiner; Strafford's *Letters*, ed. by W. Knowler (1739); R. Browning's *Life of Strafford*, with introduction by C. H. Firth (1892); *Papers relating to Thos. Wentworth* ed. by C. H. Firth for the Camden Society (1890), Camden *Miscellany*, vol. ix.; *Private Letters from the Earl of Strafford to his third Wife* (Philobiblon Soc. Biog. & Hist. Misc. 1854, vol. i.); *Lives* by H. D. Traill (1889) in "English Men of Action Series," and by Elizabeth Cooper (1886); *Cat. of State Papers, Domestic and Irish, esp. 1633–1647 Introduction; Hist. MSS. Comm. MSS. of Earl Cowper;* Strafford's *Correspondence*, of which the volumes published by Knowler represent probably only a small selection, remains still in MS. in the collection of Earl Fitzwilliam at Wentworth Woodhouse; also H. O'Grady, *Strafford and Ireland* (Dublin, 2 vols., 1923).

STRAITS QUESTION, THE. The Straits Question is composed of diverse elements—political, economic, sentimental. In its simplest form it consisted in the desire of Russia to control the straits of the Bosphorus and Dardanelles—the doors to the Black Sea—and to obtain the sacred city of her religious dreams—Constantinople. Although forming a part of the greater Eastern Question (*q.v.*), it was not co-extensive with that question; but throughout the 19th and early 20th centuries was solely concerned with the narrower issue of the disposal of Constantinople and the Straits in event of a break-up of the Ottoman power in Europe. Moreover, compared with other great political issues, the Straits Question is of very recent date.

Peter the Great.—Although known to the Ancient World as an economic and strategic problem in a very rudimentary form, it only emerged as an actual political problem in the 18th century, and then thanks to the initiative and imperialistic ambitions of a Russian tsar—Peter the Great. By his establishment of arsenals in the Crimea, and on the shores of the Sea of Azov, and by his foundation of a Russian navy, Peter the Great initiated that southward expansion of Russia so energetically furthered by his successors.

If not the first to perceive that nature had placed a severe handicap upon Russia in her struggle with the other nations by virtually excluding her from access to an ice-free sea, Peter was undoubtedly the first Russian tsar to understand the full complications of that handicap. Unless Russia were to secure access to an ice-free sea, she would start on an unequal footing with other nations in the race for world-power. Ever since Peter the Great's death Russia has unswervingly pursued the aim of obtaining a free outlet from the Black Sea to the Mediterranean for her military and mercantile marine. Since the attainment of that object presupposed the destruction of the Ottoman power in Europe, and the acquisition of Constantinople by Russia, the Mediterranean powers—France, England and Austria, as well as the Sultan, were concerned to frustrate the Russian design. Hence throughout the 19th century the Straits Question resolved itself into a contest between Russia and the Western Powers for the eventual possession of Constantinople and the Straits. Throughout the contest Turkey was little more than a tool in the hands of the rival protagonists, while Austria, whose interests were less directly threatened than those of France and England by a possible Russian acquisition of Constantinople, essayed intermittently to play the honest broker. Later, the emergence of a united Italy introduced a new factor.

International Policy.—The diplomatic negotiations which centred from time to time round this problem were long and tortuous; but it is only possible to describe in brief outline the general trend of those negotiations, and of the policies pursued by the several powers. After the Treaty of Adrianople (Sept. 14, 1829) Russia seemed to be on the point of realizing her ambition. Under the Treaty of Paris (1856) she was forced temporarily to relinquish her project and to suffer the annihilation of her naval power in the Black Sea.

Russian Self-assertion.—The years (1856–70) that intervened between the conclusion of the Paris Treaty and the unilateral denunciation in 1870 of its Black Sea provisions by Russia, who seized the opportunity afforded by the Franco-Prussian war to free herself from the humiliating composition of 1856, were filled with protests from England against alleged infractions of the treaty by Russia. In the negotiations that preceded the assembling of the Conference of London (1870–71), and at the conference itself, England took the lead in insisting upon a formal withdrawal by Russia of her unilateral denunciation as the price for the actual removal of the neutralization of the Black Sea. At this conference England stood almost alone in opposition to Russia. France was too weak to render effective support; Favre indeed hoped to purchase Russian mediation with Prussia by a sympathetic attitude towards her in the Straits Question, while Bismarck had almost certainly secured Russian neutrality in the war by promising Gortchakov his co-operation towards revising the Paris Treaty in the sense desired by Russia. Austria alone supported England. But Austria was too fearful of the new might of Prussia, and her Foreign Minister, Beust, was too much of an opportunist (in 1867 he had attempted to gain Russia's friendship by promising his assistance in obtaining a revision of the Paris Treaty) for her support to be of real value.

As the century advanced, various discussions were initiated (notably in 1885 and 1894) over a possible alteration in the existing regime of the Straits; but always without result. England held tenaciously to her traditional belief that the presence of a Russian fleet in the Mediterranean would be a menace to the Suez Canal. In 1894 Lord Rosebery, then Secretary of State for Foreign Affairs and about to succeed to the premiership, actually declared to the Austrian Ambassador, Count Deym, that any attempt by Russia to change the existing situation in regard to the Straits would be looked upon by the British Government as affording a *casus belli*. Nor was Sir Edward Grey (later Viscount Grey of Fallodon) more sympathetic towards Isvolsky's suggestion in 1908 that the time had perhaps come for a revision of the Convention of 1841 in a sense favourable to Russia. It was doubtless urgent necessity that forced Sir Edward Grey in 1915 to reverse England's traditional policy by assenting to the conclusion of the Straits Agreements, by which Russia was promised the fulfilment of her long-cherished ambitions at the conclusion of peace.

The Straits Convention of 1923.—At the end of the World War Russia was no longer in a position to enforce execution of the 1915 Agreement. The Straits Convention of July 24, 1923, however, actually imposed a settlement answering to Russia's traditional ambition. Ironically enough, at the Lausanne Conference at which the convention was drawn up, Russia strongly opposed the opening of the Straits and England no less strongly advocated it. The reason for this complete reversal of traditional policies lay in the altered political and military situation in the Near East effected by the war. Russia was temporarily rendered powerless to threaten Great Britain in the Mediterranean, while the opening of the Straits to warships enabled Great Britain to intervene in the civil war in Russia.

The emergence of the new nationalist Turkish State at Angora also modified the situation. For the first time in the long history of the Straits Question it was the Turks who virtually dictated the new regulations regarding the passage of the Straits. The regulations dictated by the allies in the still-born treaty of Sèvres were so whittled down by Nationalist Turkey as to become practically valueless. The commission for the regulation of the Straits was reduced to little more than a conservancy board under Turkish chairmanship; Turkey was accorded the right (denied her in the Sèvres treaty) to possess a fleet; she was allowed to maintain a garrison in Constantinople; and the demilitarized zones on either side of the Straits were both reduced in area and closed to the military forces of the allies as well as of Turkey—thus removing the one positive military sanction for Turkey's observance of the regulations. The three chief European allied Powers and Japan undertook to guarantee the freedom of navigation and the security of the demilitarized zones in return for the concession by Turkey of a restricted right of passage for warships. Against the regime thus set up, the Russian Government protested very strongly; but nevertheless became a party to the convention on Aug. 4, 1923. The regime, however, obviously depended for its further existence upon the weakness in naval strength of Russia.

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STRAITS SETTLEMENTS, the collective name given to the Crown colony formed by the British possessions on or adjacent to the mainland of the Malay peninsula, as opposed to the Federated and Unfederated Malay States, the British protectorates in the same region. The Straits Settlements consist of the island of Singapore with about a score of islets of insignificant size lying in its immediate vicinity, of the town and territory of Malacca, the islands and territory of the Dindings, the island of Penang, sometimes officially called Prince of Wales island, and Province Wellesley.

The colony of the Straits Settlements is administered by the governor with the aid of an executive council, composed of official and unofficial members, and there is a legislative council, composed partly of official and partly of unofficial members, of whom the former have a narrow permanent majority. The governor of the Straits Settlements is also high commissioner for the Federated Malay States of the peninsula, for British North Borneo, Brunei and Sarawak in Borneo, and since the administration of the colony of Labuan, which for a period was vested in the British North Borneo company, has been resumed by the British Government, he is also governor of Labuan. The Cocos Keeling islands (which were settled and are still owned by a Scottish family named Ross) and Christmas island were formerly attached to Ceylon, but in 1886 the care of these islands was transferred to the Government of the Straits Settlements. Penang and Malacca are administered, under the governor, by resident councillors British residents administer the native States of Perak, Selangor, Negri Sembilan and Pahang, but since July 1, 1896, when the federation of these States was effected, a resident-general (now styled chief secretary) responsible to the high commissioner, has been placed in charge of all the States forming the federation. The work of administration, both in the colony and in the Federated Malay States, is carried on by a civil service whose members are recruited by competitive examination held annually in London.

The following are the area and population, with details of race distribution, of the colony of the Straits Settlements, the figures being those of the census of 1921:—

	Area in square miles	Population in 1891	Population in 1921						
			Total	Europeans	Eurasians	Chinese	Malays	Indians	Other nationalities
Singapore	206	184,554	425,912	6,231	5,451	317,491	58,520	32,456	5,763
Penang, Province Wellesley and Dindings	381	235,618	304,335	1,476	1,919	135,288	110,382	53,339	1,931
Malacca	659	92,170	153,522	442	1,768	45,768	86,451	18,833	260
Total	1,246	512,342	883,769	8,149	9,138	498,547	255,353	104,628	7,954

The population, which in 1867 was 283,384, was estimated at 1,025,835 in 1926. The birth-rate in 1926 was highest among the Chinese. The total death-rate, 27·26 per 1,000 in 1925, was the lowest on record; the death-rate per 1,000 among Europeans was 7·82. Malaria remains a prolific, though diminishing, cause of death; as for beri-beri, the deaths were reduced from 2,056 (with a total population of 705,405) in 1911, to 910 in 1924 and 1,098 in 1926, owing probably, in part, to a better understanding of dietary requirements. Chinese immigrants reached maximum numbers in 1926 (348,593) exceeding emigrants by 228,285; 95,715 were women and children, a record number, and their coming commonly implies intention to settle permanently. An increase of immigration in recent years is due partly to improvement in commerce, but partly also to the disturbed conditions in southern China. Immigrant Indians arrived at Penang to an average yearly number of 54,000 in 1921–24; the numbers fluctuate with the conditions of trade. In 1926 they numbered 174,795 (*see* MALAY STATES, FEDERATED).

There was an increase in the gross value of trade from £63,600,000 in 1914 to £148,200,000 in 1917. The Chinese community was prosperous during the World War, and while the increased cost of living and the high rate of exchange with China bore hardly upon the poorer classes, the increase of wages counterbalanced these disadvantages. The Chinese freely supported patriotic and charitable funds, and after some demur, before its purpose was fully understood, recognized without further difficulty the War tax ordinance of 1917. The War produced its problems for the community. It was necessary to establish a censorship, and in June 1919 an anti-Japanese boycott resulted in rioting in Singapore and Penang.

The export trade of the colony depends primarily upon tin and rubber. The British Malay territories produce nearly half the world's yield of tin ore (the Federated Malay States yielding the great bulk), and more than half the smelted tin. Smelting is carried on at Pulau Brani, near Singapore, and at Penang, ore being imported not only from the Federated Malay States but also from the Dutch islands (Banka, etc.). Tin was more early developed than rubber, mainly, in the first instance, by Chinese enterprise. The production of rubber was not large until 1909–10.

The reaction from prosperity which began to affect world commerce after 1920 struck at the tin and rubber trades of the colony and Malay States. The assistance of the Government was necessary for both. Tin was purchased by the Government at agreed prices, and the stock for which there was no immediate market was brought into the so-called Bandoeng pool, formed in co-operation with the Government of Netherlands India on behalf of the mining industry of Banka and other Dutch islands; the stock thus retained was disposed of by 1924–25 as prices revived. The output of rubber was restricted by legislation in concert with the Government of Ceylon, on the basis of the Stevenson scheme. Restriction, however, was removed in 1928.

Traders have been encouraged to develop a wide range of products. Rice, fish, areca nuts, sago, copra, pepper and preserved pineapples are among the exports. In 1925 the fisheries department started research, with a shore institution and a trawler, into the possibilities of extending the fish trade. The value of exports for Malaya as a whole in 1926 was £148,095,402; and that of imports was £122,381,054. The revenue of the colony amounted to £4,284,818, and the expenditure to £4,609,998 in 1926. The value of the dollar is fixed at 2s. 4d.

The centenary of the modern foundation of Singapore by Sir Stamford Raffles was the occasion for local celebrations in Feb. 1919, and by way of commemoration it was decided to found a Raffles college for higher education. Evidence of the general enthusiasm for this scheme was given by the prompt subscriptions which ensured its success. The Straits Settlement Government promised a donation of $1,000,000 and a site; the same Government and those of Johore and Kelantan guaranteed annuities in perpetuity amounting to $63,000, and by the Governments of the Federated Malay States and Kedah, and from various private sources, annuities for a term of years, amounting to $655,000, were promised. Designs for the new buildings were adopted in 1924, and the erection of science and administrative blocks, a hostel and staff quarters is nearly completed. The Rockefeller Foundation in 1924 granted an endowment of $350,000 for chairs of bacteriology and biochemistry in King Edward VII. College of Medicine at Singapore, the Government undertaking to bring the provision for these chairs up to the level of others in the college.

The Dindings and Province Wellesley.—The various settlements of which the colony of the Straits Settlements is composed, and the protectorates named in this article, are dealt with separately, except the Dindings and Province Wellesley. The Dindings are sparsely inhabited and unimportant politically.

Province Wellesley, which is situated on the mainland opposite to the island of Penang, was ceded to Great Britain by the sultan of Kedah in 1798. It marches with Perak on the south. It is administered by a district officer, with some assistants, who is responsible to the resident councillor of Penang. The country consists of fertile plain, thickly populated by Malays, and occupied largely by rubber planters employing Chinese and Tamil labour. About a tenth of the whole area is covered by low hills. Large quantities of rice are grown, and between October and February there is excellent snipe-shooting to be had in the rice-fields. A railway from Prai, opposite to Penang, runs through Province Wellesley into Perak, and thence via Selangor and Negri Sembilan to Malacca, and through Johore to Singapore.

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STRALSUND, a seaport in the Prussian province of Pomerania, on an arm of the Baltic, 1½ m. wide, which separates the island of Rügen from the mainland, 135 m. by rail N. from Berlin and 45 m. N.W. of Rostock. Pop. (1925), 39,412. A steam railway ferry connects it with the island railway on Rügen, and so with Sassnitz, whence a regular steamboat mail service affords communication with Trelleborg in Sweden.

Stralsund was founded in 1234, and, though several times destroyed, steadily prospered. It was one of the five Wendish towns whose alliance extorted from King Eric of Norway a favourable commercial treaty in 1284–1285; and in the 14th century it was second only to Lübeck in the Hanseatic League. Although under the sway of the dukes of Pomerania, the city was able to maintain a marked degree of independence. Its early Protestant sympathies placed it on the side of Sweden during the Thirty Years' War, and in 1628 it successfully resisted a siege of eleven weeks by Wallenstein. After the peace of Westphalia Stralsund was ceded with the rest of Western Pomerania to Sweden; and for more than a century and a half it was exposed to attack and capture as the *tête-de-pont* of the Swedes in continental Europe. It was taken by France in 1807, and in 1815 it passed to Prussia.

The situation of the town proper, on a small triangular islet only connected with the mainland by three moles and bridges at the angles, has always rendered its fortification comparatively easy. Since 1873 the ramparts have been levelled. The defences of the place are now solely confined to the island of Dänholm, known down to the 13th century as Strehla or Strehlo, lying in the Sound. Many of the houses present tall, curious and handsome gables to the street. The four Gothic churches of St. Nicholas, with a series of 14th century frescoes, St. Mary, with a lofty steeple, St. James and The Holy Ghost, and the mediaeval town hall, dating in its oldest part from 1306 and restored in 1882, are among the more striking buildings. The latter houses the provincial museum and the municipal library. Among the educational establishments of the place must be mentioned the Gymnasium, founded in 1560, and a school of navigation.

STRAMONIUM, in medicine, a drug obtained from the leaves and seeds of the *Datura stramonium.* Both contain the alkaloid daturine. The physiological action of stramonium resembles that of belladonna, except that stramonium relaxes to a greater extent the unstriped muscle of the bronchial tubes; for this reason it is used in asthma to relieve the bronchial spasm. Cigarettes made of stramonium leaves may be smoked or the tincture may be taken internally. Frequently equal quantities of the powdered leaves of stramonium, *Cannabis Indica* and lobelia mixed with potassium nitrate are burned in an open dish. The preparation gives off dense fumes which afford great relief.

STRANDLOOPER. The term "Strandlooper" is applied to the extinct people whose remains are found in caves, shelters and kitchen-middens along the eastern coast of southern Africa from Cape Town to Port Elizabeth. They were probably the purest variety of Bushmen (*q.v.*).

STRANG, WILLIAM (1859–1921), Scottish painter and engraver, was born at Dumbarton, N.B., on Feb. 13, 1859, the son of Peter Strang, builder. In 1875 he went to London, where he studied under Legros at the Slade School for six years. He became assistant master in the etching class, and was one of the original members of the Royal Society of Painter-Etchers, exhibiting at their first exhibition in 1881. In his imaginative etchings he achieved almost painfully realistic effects without sacrificing anything of his fine, clean drawing and severity of design. He worked in many manners—etching, dry-point, mezzotint, sand-ground mezzotint—and invented a burin of his own for burin engraving.

His portrait etchings introduced a new form of reproductive portraiture, each proof being in a sense an original. Thomas Hardy, Henry Newbolt and Rudyard Kipling are among the many distinguished men who sat to him for these plates. Strang's paintings, portraits, nude figures in landscapes, and groups of peasant families have been exhibited in the Royal Academy, the International Society and several German exhibitions. In 1902 Strang retired from the Society of Painter-Etchers as a protest against the inclusion in its exhibitions of etched or engraved reproductions of pictures. He afterwards exhibited chiefly at the "Society of Twelve," the International Society of Sculptors, Painters and Gravers, and the Royal Academy. He was a member of the International Society, and became, in 1906, an A.R.A. for engraving, on the revival of that degree, and in 1921 R.A. (Engraving). In 1918 he was made president of the International Society. He died at Bournemouth on April 12, 1921.

Strang's engraved work includes "Tinkers", "St. Jerome", "A Woman washing her feet", an "Old Book-stall with a man lighting his pipe from a flare," the "Head of a Peasant Woman" (on a sand-ground mezzotint), "Hunger", "the Bachelor's End" and "The Salvation Army." Among his sets of etchings are the "Pilgrim's Progress," the "Ancient Mariner", his own "Allegory of Death" and the "Plowman's Wife"; in collaboration with J. B. Clark he illustrated *Baron Munchausen, Sindbad the Sailor,* and *Ali Baba.* Proofs from his portrait plates have great value. In the Tate Gallery, London, are two self-portraits and a landscape. A collection of 136 etchings is in the British Museum. The catalogue of his etched work, containing small representations of all his plates (747) was published in 1906 (supplements in 1912 and 1923).

STRANGE, SIR ROBERT (1721–1792), Scottish line engraver, was born in Orkney on July 14, 1721, and was apprenticed in 1735 to Richard Cooper, a line-engraver in Edinburgh, afterwards starting on his own account as an engraver in 1741. In 1745 he joined the Jacobite army, and fought at Culloden. He superintended the illustrations of Dr. William Hunter's *Gravid Uterus,* and by his plates of the "Magdalen" and "Cleopatra," engraved after Guido in 1753, established his reputation. In 1760 Strange travelled in Italy, and received many distinctions on the Continent. In 1766 he was elected a member of the Incorporated Society of Artists. In 1775 he published an attack on the Royal Academy (which excluded engravers) entitled *An Enquiry into the Rise and Progress of the Royal Academy of Arts at London.* He was knighted in 1787 and died in London on July 5, 1792.

STRANRAER, a royal and police burgh, parish and seaport of Wigtownshire, Scotland. Pop. (1921), 6,138. It is situated at the head of Loch Ryan, an arm of the North channel (Irish sea), 59 m. S.S.W. of Ayr by the L.M.S. railway, with a station in the town and at the harbour. It lies 39 m. E. by N. of Larne in Co. Antrim, Ireland, with which there is daily communication by mail steamer. Stranraer, originally called St. John's Chapel, became a burgh of barony in 1596, and a royal burgh in 1617. In the centre of the town are the ruins of the castle of the 15th century, occupied for a time by John Graham of Claverhouse, Viscount Dundee, when he held the office of sheriff of Galloway (1682). Grain-milling and nursery-gardening are carried on, and there is a large trade in farm and dairy produce. Harbour accommodation has been extended and steamers run twice daily to Larne in Ireland. There are fine oyster beds, and whitefish and herrings are caught. Three miles east of Stranraer is Lochinch, the residence of the earl of Stair, a modern structure in the Scots Baronial style. The grounds include the White and Black Lochs and the ruins of Castle Kennedy, finely situated on the isthmus between the lakes. This castle was erected in the reign of James VI. for the earls of Cassilis, and passed into the hands of the Stair family in the 17th century. It was burned down in 1716 and never rebuilt.

STRAP WORK, in architecture and the decorative arts, a form of ornament developed in Germany, Flanders and England during the latter half of the 16th and the 17th century and consisting of scrolls, straight lines, rectangles and shield forms carved or modelled in flat relief, often with a raised fillet at the edge, and often pierced with circular or oval holes; the whole composition is usually formed of connected units, all upon the same plane, as though made by an elaborately cut out and pierced strap applied to a background. It is a development of certain Italian early Baroque motives, such as the multiple shield or cartouche frames, and certain approximations of it occurred in Italian metal-work as early as the silver work of Benvenuto Cellini (1500–71); these forms are, themselves, Italian interpretations of the flat scrolls so common in Mohammedan metal-work. Strap work was used extensively in the Renaissance woodwork of Germany and is occasionally found in stone, as in the Salzhaus at Frankfurt A.M. (end of the 16th century). In Flanders and the Netherlands strap work received an even more complete development, for although in Germany it was usually only a subsidiary motive, in the architectural woodwork and furniture of the Low Countries it often became the only type of ornament used. The form was introduced into England by the flood of Flemish and German woodworkers that came in in the latter part of the 16th and early 17th centuries. (T. F. H.)

STRASBOURG (STRASSBURG), a town of France, the capital of the department of Bas-Rhin, at the junction of the Ill and the Breusch, 2 m. W. of the Rhine, 88 m. by rail N. from Basle. Pop. (1926) 164,136. The Ill divides into arms forming an island on which the city grew; it was long a strongly fortified place and the removal of the fortifications immediately around the city has given opportunities of large expansion in the last half century. The old city contains the cathedral, or Münster (11th to 15th centuries). Part of the crypt dates from 1015; the apse is Transitional; and the nave, finished in 1275, is pure Gothic. The elaborate west façade has a screen of double tracery, numerous sculptures and two towers, the northern with a tall spire. The cathedral has some fine stained glass, a sculptured pulpit and the famous astronomical clock in the south transept; this contains some fragments of the clock built by the mathematician, Conrad Dasypodius, in 1574. The Protestant church of St. Thomas is a Gothic building of the 13th and 14th centuries.

The Palais de Rohan or old episcopal palace, built in 1731–41, was used for university purposes from 1872 to 1895; it is now the municipal museum of art. Other notable buildings are the Frauenhaus, with some interesting sculptures, and the Hôtel du Commerce, the finest Renaissance building in the town. The University of Strasbourg, founded in 1566 and suppressed during the French Revolution as a stronghold of German sentiment, was reopened in 1872 and again as a French institution in 1922.

The chief industries of Strasbourg are tanning, brewing, printing and the manufacture of metal goods, paper and tobacco. To these must be added the fattening of geese for Strasbourg's celebrated *pâté de foie gras*.

History.—Strasbourg has always been a place of great strategical importance, and as such has been strongly fortified. The pentagonal citadel constructed by Vauban in 1682–84 was destroyed during the siege of 1870. The site of the town was originally occupied as a Celtic settlement, which was captured by the Romans, who replaced it by the fortified station of *Argentoratum*, afterwards the headquarters of the eighth legion. In 357 the emperor Julian gained here a decisive victory over the Alamanni, who 50 years later re-conquered the whole of the district. Towards the end of the 5th century the town passed to the Franks, who gave it its present name. The famous "Strassburg oaths" between Charles the Bold and Louis the German were taken here in 842, and in 923, through the homage paid by the duke of Lorraine to the German king Henry I., began the connection of the town with the German kingdom which lasted for over seven centuries. The early history of Strasbourg consists mainly of struggles between the bishop and the citizens. This conflict was finally decided in favour of the citizens by the battle of Oberhausbergen in 1262, and the position of a free imperial city which had been conferred upon Strasbourg by the German king, Philip of Swabia, was not again disputed. In 1332 there was an internal revolution, which admitted the gilds to a share in the government of the city.

In 1381 the city joined the Städtebund, or league of Swabian towns, and a century later it helped the Swiss confederates at Granson and Nancy. The reformed doctrines were readily accepted in Strasbourg about 1523, and the city was skilfully piloted through the ensuing period of religious dissensions by Jacob Sturm von Sturmeck, who secured for it very favourable terms at the end of the war of the league of Schmalkalden. In the Thirty Years' War the town observed a prudent neutrality. In 1681, during a time of peace, it was suddenly seized by Louis XIV., and this unjustifiable action received formal recognition at the Peace of Ryswick in 1697. At the French Revolution the city was deprived of its privileges as a free town. In the war of 1870–71 Strasbourg, with its garrison of 17,000 men, surrendered to the Germans on Sept. 28, 1871. The city and the cathedral suffered considerably from the bombardment.

The bishopric of Strasbourg existed in the days of the Merovingian kings, being probably founded in the 4th century, and embraced a large territory on both banks of the Rhine, which was afterwards diminished by the creation of the bishoprics of Spires and Basel. The bishopric was in the archdiocese of Mainz and the bishop was a prince of the empire. The episcopal lands were annexed by France in 1789 and the subsequent Roman Catholic bishops of Strasbourg discharged spiritual duties only.

Strasbourg is the seat of a bishop, of a prefect and of the departmental organization, and of the special Government offices for the territories returned to France after 1918. Kehl, with a population (1925) of 9,467, on the German bank of the Rhine, opposite Strasbourg, was constituted one with the port of Strasbourg for purposes of exploitation for a period of seven years from 1919. Extensive improvement schemes were approved in 1924, including the creation of a large port above Strasbourg, connecting with the harbour by canal, and a petroleum harbour below the town. (X.)

Battle of Strasbourg (A.D. 357).—A rising of the Sarmatians, Suevi and Quadi on the Danube compelled the Emperor Constantius to hasten there in 357. Julian, the Caesar, was at Sens with an army 13,000 strong, and as the emperor was unable to assist him he despatched Barbatio, *magister peditum* and 25,000 troops to Gaul. Julian was to march north, and Barbatio to co-operate with him with Basel as his base of operations. The forces of the barbarians were to be enclosed between them.

Moving to Reims, Julian concentrated his forces. Thence he marched to Zabern. Meanwhile Barbatio who had refused to obey his orders was surprised by the Germans and driven back to Basel. Julian's position was now an extremely dangerous one; he was far distant from the emperor, and Barbatio's defeat had raised the *moral* of the Germans who, under the leadership of Chnodomar, crossed the Rhine and encamped on its left bank near Strasbourg. Undaunted by this mishap Julian set out from Zabern to meet the horde, which was some 35,000 strong. The Romans marched in close order and in two columns, the cavalry on the right and the infantry on the left, and as evening was approaching Julian was desirous of deferring the battle until the following day. His men, in spite of the heat and the long march, urged him to lead them on. This Julian agreed to, and took command of the right wing consisting of heavy cavalry and archers. This wing coming into contact with the barbarians was fiercely charged by light horse and driven back. A panic was only stayed by the Caesar riding amongst his men and exhorting them to rally. The brunt of the attack was borne by the Roman centre and the left, and it was a struggle of footmen against footmen. In spite of the valour of the barbarians, the discipline of the Roman infantry carried the day, the Germans being driven into the Rhine where large numbers perished; 6,000 dead were also left on the field. Chnodomar was captured and sent a prisoner to Constantius.

This victory resulted in the recovery of the upper Rhine, and the freeing of Gaul from barbarian invasions.

See E. Gibbon, *The Decline and Fall of the Roman Empire,* chap. xix.; *The Cambridge Medieval History,* vol. i. (J. F. C. F.)

STRATA-FLORIDA (*Ystradflur*), the ruins of a Cistercian abbey of Cardiganshire, Wales, near the river Teifi, 2 m. from the village of Pontrhydfendigaid (bridge of the blessed ford) on the Teifi. Excavations have brought to light encaustic tiles. The elaborate western portal is a fine specimen of transitional Norman-Irish 12th century architecture. A silver seal of the abbey is in the British Museum. Founded and endowed in 1164 by Rhys ap Griffith, prince of South Wales, the Cistercian abbey of St. Mary (which was probably a revival of an older monastic house on or near the same site) was much favoured by Welsh bards, nobles and princes. In 1138 Llewelyn ap Iorwerth, "the Great," summoned his vassals to this spot to do homage to his heir, Prince David II. The abbey suffered severely during the Edwardian wars, and in or about 1294 a large portion of its buildings was destroyed by fire. Edward I. helped to restore the fabric.

STRATEGUS, strictly a general, but frequently the name of a state officer with much wider functions (*στρατηγός*) found in many Greek states. The best known is the Athenian strategus, originally a military official, who, in the latter half of the 5th century B.C., became the most important executive magistrate in the state: it is certain that until the end of the 6th century the archon (*q.v.*) was the most important state official. The Strategia (board of ten generals) was a result of the tribal system of Cleisthenes. Some maintain that Cleisthenes himself created it, but the evidence (*Ath. Pol.* xxii.) is against this. At all events, as late as the battle of Marathon the head of the army was the polemarch. (*See* ARCHON.) It follows that the strategus was, until 487 B.C., subordinate to the polemarch, the story of successive days of command in Herodotus being due to a misunderstanding of the powers of the strategi at the time (*cf.* G. B. Grundy, *The Great Persian War*). The tribal unit was represented in the army by the *taxis,* and each *taxis* was led by a strategus. After the Persian wars the command of the *taxis* passed to officers called taxiarchs, who acted as colonels under the strategi. It was the customary practice in the 5th century to appoint a certain number of the generals, usually three or five, for a particular field of operations, and to assign the chief command to one of them. Exceptions to this rule are found in the well-known instances of the Sicilian expedition (when the three commanders, Nicias, Alcibiades and Lamachus were given co-ordinate powers), and the battle of Arginusae, when the command was divided among the whole board. In crises such as the Samian revolt, the outbreak of the Peloponnesian War, or that which led to the recall of Alcibiades, we find the whole board subordinated to a single member (*e.g.,* Pericles or Alcibiades). Originally each strategus was elected by and out of the tribe he commanded (*Ath. Pol.* lxi.). In the 4th century, however, the strategi were elected out of all the citizen body irrespective of tribes; in 433, one of Pericles' colleagues was Diotimus, a member of his own tribe (*cf.* Alcibiades and Adeimantus in 408 B.C.). But from Xenophon (*Memorab.* iii. 4) we learn that one strategus was still elected by each tribe, *i.e.,* each strategus represented a tribe, though he might not be a member of it. Though the strategi were the nominal heads of the army, they had no power to choose their taxiarchs, who were elected by the tribes. It was only the *lochagoi* (commanders of λόχοι, companies) that the Ecclesia allowed them to select.

In the course of the 5th century the powers of the strategia were increased by important political functions, especially in foreign affairs; hence the office, unlike that of the archon (*q.v.*), remained elective and was held by the most important men (*e.g.* Pericles, Nicias, Alcibiades). As the Boulē was the chief administrative body, it was necessary to bring the strategi into close connection with it; though not members, they were allowed to attend its meetings and to bring motions before it. As the Boulē of one year rarely contained members of the previous Boulē, the strategi acquired great power from the fact that they were frequently re-elected for many years together, and so had greater experience and continuity of policy. In the Ecclesia, the strategus' business took precedence (the meetings always discussed first the question of national defence), and he could, in cases of emergency, convene a special meeting (*cf.* Thuc. ii. 59 and iv. 118).

The strategia was by no means analogous to the British cabinet which has collective responsibility and whose members are heads of state departments. The strategi had no collective responsibility, and their appointment for special duties (*ἐπὶ τοὺς ὁπλίτας, ἐπὶ τὴν ἀκτήν, κ.τ.λ.*) dates from the 4th century. Without being actually a foreign office, they acted on *ψηφίσματα* of the Ecclesia in negotiating and concluding treaties and alliances. Their real power was mainly due to two considerations. They were elected, when other great officials were chosen by lot and thus were picked men approved by the Ecclesia. They were capable of re-election and a man who commanded the confidence of the people was often re-elected (*e.g.,* Pericles). Such magistrates gained wide administrative experience and enjoying the confidence of the Ecclesia were able to dominate their colleagues and the state (*λόγῳ μὲν δημοκρατία ἔργῳ δὲ τοῦ πρώτου ἀνδρὸς ἀρχή*). It was to this personal ascendancy and hold over the Ecclesia rather than to the constitutional authority of his office that the power of the great strategus was due.

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STRATEGY. The term in its original and literal sense means "the art of the general" (Greek *στρατεγος*). But no military term, perhaps no technical term of any kind, has undergone more changes of meaning, suffered more attempts to reach a standard definition, or been more diversely interpreted. And rarely has a difficulty of definition had such an effect on the course of history. For the vagueness which has surrounded the term has influenced the issue of wars and the destiny of nations by encouraging doubt and dissension as to the respective spheres of the military command and the government in time of war.

Change of Meaning.—The word "strategy" as a technical term appears in European military literature early in the 18th century, when the great impetus to military studies given by the wars of the 17th was crystallizing into the formation of academic, and often pedantic schools of thought and theory. The conditions of warfare at that period helped to preserve to the term its strict sense, even a straitened sense. These conditions comprised the uniformity of armaments; the superior development of fortification (*q.v.*) to weapons; the professionalization of armies—which complicated their systems of supply and made them instruments too expensive to be employed carelessly or wastefully; the fact that wars were often waged for limited political objects, aiming at extension of territory or power, and controlled by shrewd calculation of the price worth paying, rather than national life and death struggles with passion dominating reason. Last, and above all, the indivisibility of armies—which usually fought and moved as a solid block, making temporary detachments to carry out special missions and to hold strategic points, but not organized in permanently self-contained fractions.

These conditions tended to produce an equilibrium in the theatre of war, and on the battlefield, which easily settled into a stalemate unless upset by some ruse or stratagem on the part of one of the commanders. But the French Revolutionary and Napoleonic Wars brought about an enlargement of the meaning of "strategy"—at first called *stratégique* in French or "strategics" in English. The fractioning of the army into permanent divisions and Napoleon's development of this new organization, applied in his vast strategic manoeuvres, caused a great acceleration and enlargement of operations. To regulate and co-ordinate the movements of a number of widely separated columns to a common end was a task which both enlarged the power of generalship and the demands made upon the general's attention. Hence this "logistical" meaning, that of directing the movements of an army, came to be added to the term strategy, and even to overshadow the older meaning. One effect, not a happy one, can be traced in the growing 19th century tendency for the idea of the application of force, as rapidly and concentratedly as possible, to obsess military thought and leadership to the undue neglect of the subtler art of surprise by ruse and stratagem.

But the term was to undergo still further expansion of meaning in the 19th century. Clausewitz in his monumental work "On War" defined it as "the art of the employment of battles as a means to gain the object of the war. In other words, strategy forms the plan of the war, maps out the proposed course of the different campaigns which compose the war, and regulates the battles to be fought in each." This definition intruded on the sphere of policy, or the higher conduct of the war, which must necessarily be the responsibility of the government and not of the military leaders it employs as its agents in the executive control of operations. At the same time the definition narrowed the meaning of "strategy" to the pure utilization of battle, thus conveying the idea that battle was the only means to the strategical end. It was an easy step for his less profound disciples to confuse the means with the end and to reach the conclusion that in war every other interest and consideration should be subordinated to the aim of fighting a decisive battle.

Relation to Policy.—To break down the distinction between strategy and policy would not matter much in cases where the two functions were combined in the same person as with a Frederick or a Napoleon. But as such autocratic soldier-rulers have always been rare, and became extinct in the 19th century, the effect was insidiously harmful. For it encouraged soldiers to make the preposterous claim that policy should be subservient to their conduct of operations and, especially in democratic countries, it drew the statesman on to overstep the indefinite border of his sphere and interfere with his military employee in the actual use of his tools.

Moltke reached a clearer, and wiser, definition in terming strategy "the practical adaptation of the means placed at a general's disposal to the attainment of the object in view." This definition fixes the responsibility of a military commander to the government by which he is employed. His responsibility is that of expending most profitably to the interest of the higher war policy the force allotted to him within the theatre of operations assigned to him. If he considers that the force allotted is inadequate for the task indicated he is justified in pointing this out, and if his opinion is overruled he can refuse or resign the command, but he exceeds his rightful sphere if he attempts to dictate to the government what measure of force should be placed at his disposal.

On the other hand the government, which formulates war policy, and adapts it to conditions which often change as a war progresses, can rightly intervene in the strategy of a campaign not merely by replacing a commander in whom it has lost confidence but by modifying his object according to the needs of its war policy. While it should not interfere with him in the handling of his tools it should indicate clearly the nature of his task. Thus strategy has not necessarily the simple object of seeking to overthrow the enemy's military power. When a government appreciates that the enemy has the military superiority either in general or in a particular theatre, it may wisely enjoin a strategy of limited aim. It may desire to wait until the balance of force can be changed by the intervention of allies or by the transfer of forces from another theatre. It may desire to wait, or even to limit its military effort permanently, while economic or naval action decides the issue. It may calculate that the overthrow of the enemy's military power is a task definitely beyond its capacity, or not worth the effort, and that the object of its war policy can be assured by seizing territory which it can either retain or use as bargaining counters when peace is negotiated. Such a policy has more support from history than military opinion recognizes and is less inherently a policy of weakness than its apologists imply. It is, indeed, bound up with the history of the British Empire and has repeatedly proved a life-buoy to Britain's allies and a permanent benefit to herself. However unconsciously followed, there is ground for enquiry whether this unmilitary policy does not deserve to be accorded a place in the theory of the conduct of war.

But the more usual reason for adopting a strategy of limited aim is that of awaiting a change in the balance of force, a change often sought and achieved by draining the enemy's force, weakening him by pricks instead of risking blows. The essential condition of such a strategy is that the drain on him is disproportionately greater than on oneself. The object may be sought by raiding his supplies, by local attacks which annihilate or inflict disproportionate loss on parts of his force, by luring him into unprofitable attacks, by causing an excessively wide distribution of his force and, not least, by exhausting his moral and physical energy. Such a strategy is popularly called Fabian, after the illustrious Roman who thereby thwarted Hannibal's designs in Italy. More strictly it was a Fabian war policy, and this closer definition sheds light on the question, previously raised, of a general's independence in carrying out his own strategy inside his theatre of operations. For if the government has decided upon a Fabian war policy the general who, even within his strategic sphere, seeks to overthrow the enemy's military power may do more harm than good to the government's war policy. Usually a war policy of limited aim imposes a strategy of limited aim, and a decisive aim should only be adopted with the approval of the government which alone can decide whether it is "worth the candle."

Scope of Strategy.—The nature of war, the objects for which it is waged, and the policy which should govern the conduct of war, are outside the scope of this article. These subjects are dealt with in the article War, and for more extensive analysis the reader may be referred to Clausewitz's volumes "On War," a great, if one-sided, work, whose survey has in recent times been enlarged by Fuller's brilliant and profound analysis, entitled "The Foundations of the Science of War."

Strategy covers the distribution and transmission of military means to fulfil the ends of policy. It is concerned not merely with the movements of armies—as its role is often defined—but with the effect. But when the application of the military instrument merges into actual fighting, the dispositions for and control of such direct action are termed "tactics" (*q.v.*).

The two categories, however, although convenient for discussion, can never be truly divided into separate compartments because each not only influences but merges into the other. Nor has clear thought been assisted by the attempts to subdivide into, or to bridge the indefinite dividing line by, fresh categorical definitions. First among these was the term "grand tactics," which came into use in the late 18th century to express the combination and movements of forces preparatory to, and in readiness for, the battle. This term likewise has undergone changes of meaning, and is often employed to denote the plan upon which the application of force, as distinct from other agencies, is to be based. It embraces the combined use of armies, navies and now air forces, but excludes economic or political instruments.

A term which fills a greater need, and is less productive of confusion, is that of "grand strategy." If practically synonymous with the policy which governs the conduct of war, as distinct from the permanent policy which formulates its object, the term "grand strategy" serves to bring out the sense of "policy in execution." For the role of grand strategy is to co-ordinate and direct all the resources of a nation towards the attainment of the political object of the war—the goal defined by national policy.

Grand strategy should both calculate and develop the economic resources and man-power of the nation in order to sustain the fighting services. So also with the moral resources—for to foster and fortify the will to win, and to endure, is as important as to possess the more concrete forms of power. And it should regulate the distribution of power between the several services, and between the services and industry. Nor is this all, for fighting power is but one of the instruments of grand strategy. It should take account of and apply the power of financial pressure, diplomatic pressure, commercial pressure, and, not least, ethical pressure to weaken the opponent's will. A good cause is a sword as well as a buckler. Furthermore, while the horizon of strategy is bounded by the war, grand strategy looks beyond the war to the subsequent peace. It should not only combine the various instruments, but so regulate their use as to avoid damage to the future state of peacefulness, secure and prosperous. Little wonder that, unlike strategy, the realm of grand strategy is for the most part *terra incognita!*

Pure Strategy.—Having cleared the ground, we can build up our conception of strategy on its original and true basis—that of "the art of the general." This depends for success, first and most, on a sound calculation and co-ordination of the end and the means. The end must be proportioned to the total means, and the means used in gaining each intermediate end which contributes to the ultimate must be proportioned to the value and needs of that intermediate end—whether it be to gain an objective or to fulfil a contributory purpose. An excess may be as harmful as a deficiency. A true adjustment would establish a perfect economy of force, in the deeper sense of that oft-distorted military term. But, because of the nature and uncertainty of war, an uncertainty aggravated by its unscientific study, a true adjustment is beyond the power of military genius even and success lies in the closest approximation to truth. This relativity is inherent because however our knowledge of the science of war, at present an almost unexplored region, be extended, war is a science which depends on art for its application. Art can not only bring the end nearer to the means, but by giving a higher value to the means enable the end to be extended. This complicates calculation, because no man can exactly calculate the capacity of human genius and stupidity nor the incapacity of will.

Elements and Conditions.—Nevertheless in strategy calculation is simpler and a closer approximation to truth possible than in tactics. For in war the chief incalculable is the human will, which manifests itself in resistance, which in turn lies in the province of tactics. Strategy has not to overcome resistance, except from nature. Its purpose is to diminish the possibility of resistance, and it seeks to fulfil this purpose by exploiting the elements of movement and surprise. Movement lies in the physical sphere and depends on a calculation of the conditions of time, topography and transport capacity. By transport capacity one implies both the means by which and the measure in which force can be moved and maintained.

Surprise lies in the psychological sphere and depends on a calculation, far more difficult than in the physical sphere, of the manifold conditions, varying in each case, which are likely to affect the will of the opponent.

Although strategy may aim more at exploiting movement than at exploiting surprise, or conversely, yet the two elements react on each other. Movement generates surprise, and surprise gives impetus to movement. For a movement which is accelerated or changes its direction inevitably carries with it a degree of surprise, even though it be unconcealed; while surprise smoothes the path of movement by hindering the enemy's counter-measures and counter-movements. As regards the relation of strategy to tactics, while in execution the borderline is often shadowy, and it is difficult to decide exactly where a strategical movement ends and a tactical movement begins, yet in conception the two are distinct. Tactics lies in and fills the province of fighting. Strategy not only stops on the frontier, but has for its purpose the reduction of fighting, to the slenderest possible proportions.

Aim of Strategy.—This statement may be disputed by those who conceive the destruction of the enemy's armed forces as the only sound aim in war, who hold that the only goal of strategy is battle, and who are obsessed with the Clausewitzian saying that "blood is the price of victory." Yet if one should concede this point and meet its advocates on their own ground, the statement would remain unshaken. For even if a decisive battle be the only goal, all recognize that the object of strategy is to bring about this battle under the most advantageous circumstances. And the more advantageous the circumstances, the less proportionately will be the fighting.

The perfection of strategy would therefore be to produce a decision—the destruction of the enemy's armed forces through their unarming by surrender—without any fighting. History provides examples where strategy, helped by favourable conditions, has practically produced such a result. Caesar's Ilerda (*q.v.*) campaign was one, Cromwell's Preston campaign (*see* GREAT REBELLION) another, while in recent times there have been the operations which culminated at Sedan (*q.v.*) in 1870 and between Galilee and the hills of Samaria in 1918. (*See* PALESTINE, OPERATIONS IN.)

It rests normally with the government, responsible for the grand strategy of a war, to decide whether strategy should make its contribution by achieving a military decision or otherwise. And just as the military is but one of the means to the end of grand strategy—one of the instruments in the surgeon's case—so battle is but one of the means to the end of strategy. If the conditions are suitable, it is usually the quickest in effect, but if the conditions are unfavourable it is folly to use it.

Let us assume that a strategist is empowered to seek a military decision. His responsibility is to seek it under the most advantageous circumstances in order to produce the most profitable result. Hence his true aim is not so much to seek battle as to seek a strategic position so advantageous that if it does not of itself produce the decision its continuation by a battle is guaranteed to do so. In other words, dislocation is the aim of strategy; its sequel may either be the enemy's dissolution or his disruption in battle. Dissolution may involve some partial measure of fighting but this has not the character of a battle. Famous examples, beyond those already quoted, from history include Hannibal at Trasimenus (*q.v.*), Turenne's last campaign in Alsace (*see* DUTCH WARS), and Napoleon's Ulm campaign. (*See* NAPOLEONIC CAMPAIGNS.) Among clear cases where disruption was an inevitable sequel to the strategic advantage previously gained one may instance Scipio's campaign of Ilipa (*q.v.*), Cromwell's of Worcester (*q.v.* and also GREAT REBELLION), Napoleon's of Jena, Grant's of Vicksburg (*q.v.*).

Action of Strategy.—How is the strategic dislocation produced? In the physical, or "logistical," sphere it is the result of a move which (a) upsets the enemy's dispositions and by compelling a sudden "change of front" dislocates the distribution and organization of his forces; (b) separates his forces; (c) endangers his supplies; (d) menaces the route or routes by which he could retreat in case of need and re-establish himself in his base or homeland. A dislocation may be produced by one of these effects but is more often the consequence of several. Differentiation, indeed, is difficult because a move directed towards the enemy's rear tends to combine these effects. Their respective influence, however, varies and has varied throughout history according to the size of armies and their complexity of the organization. With armies which "live on the country," drawing their supplies locally by plunder or requisition, the line of communication has negligible importance. Even in a higher stage of development, a small force has less dependence on the line of communication and enables supplies to be transported with it for limited periods. The larger an army and the more complex its organization the more prompt and serious in effect is a menace to its line of communication.

Where armies have not been so dependent, strategy has been correspondingly handicapped, and the tactical issue of battle has played a greater part. Nevertheless, even thus handicapped, strategic artists have frequently gained a decisive advantage previous to battle by menacing the enemy's line of retreat, the equilibrium of his dispositions, or his local supplies.

To be effective such a menace must usually be applied at a point closer, in time and space, to the enemy's army than a menace to his communications, and thus in early warfare it is often difficult to distinguish between strategical and tactical manoeuvre.

In the psychological sphere, dislocation is the result of the impression on the commander's mind of the physical effects which we have listed. The impression is strongly accentuated if his realization of being at a disadvantage is sudden, and if he feels that he is unable to counter the enemy's move. Psychological dislocation, indeed, fundamentally springs from the sense of being trapped. This is the reason why it has most frequently followed a physical move onto the enemy's rear. An army like a man cannot properly defend its back from a blow without turning round to use its arms in the new direction. "Turning" temporarily unbalances an army as it does a man, and with the former the period of instability is inevitably much longer. In consequence, the brain is much more sensitive to any menace to its back. In contrast, to move directly on an opponent is to consolidate his equilibrium, physical and psychological, and by consolidating it to augment his resisting power. In war as in wrestling the attempt to throw the opponent without loosening his foothold and balance tends to self-exhaustion, increasing in disproportionate ratio to the effective strain imposed upon him. Because of this disproportion, which increases as the effort advances, victory by such a method can only be attainable if the assailant possesses a great margin of strength. Even so, it tends to lose decisiveness, for in the case of an army it rolls the enemy back towards their reserves, supplies and reinforcements, so that as the original front is worn thin new layers are added to the back. And, at best, it imposes a strain rather than producing a jar.

Thus a move round the enemy's front against his rear has the aim not only of avoiding resistance on its way but in its issue. In the profoundest sense, it takes the line of least resistance. The equivalent in the psychological sphere is the line of least expectation. They are the two faces of the same coin, and to appreciate this is to widen our understanding of strategy. For if we merely take what obviously appears the line of least resistance, its obviousness will appeal to the opponent also and this line may no longer be that of least resistance. In studying the physical aspect we must never lose sight of the psychological, and only when both are combined is the strategy truly an indirect approach, calculated to dislocate the opponent's equilibrium.

Examples.—Hannibal in 217 B.C. took the line of least resistance and least expectation by moving into Etruria through the marshes and on to the rear of the Roman army encamped at Arretium. But, after ravaging the country, he then moved straight on, and by thus appearing to ignore contemptuously this Roman army impelled the consul Flaminius far more strongly than by any threat to his rear or supplies to rush precipitately on Hannibal's heels and into the deadly ambush at Lake Trasimene (*q.v.*).

Schlieffen, framing the German plan for 1914, sought a logistical indirect approach by sweeping through Belgium with a massive right wing. But the real subtlety of his plan was not on his right but on his left, which he made so weak that any French offensive in Lorraine would push it back. And the further it was pushed back, the further would the French be committed in this direction and the more would their rear be exposed to the sweep of his right wing through Belgium. Like a neck their communications would be stretched out to receive the falling axe. The plan was shrewdly based on an insight into the French temperament and their new doctrine of the headlong offensive. Indeed, in the event the French "head" was laid blindfold on the block. But unfortunately for Germany, Schlieffen's successor, Moltke, failed to grasp his conception and, fearing the weakness of the left wing, so strengthened this as to counteract its essential purpose. While the French rushed to fall into the trap, Moltke rushed German troops to save them. An irony of history.

The Indirect Approach.—Thus we see that the mere fact of marching indirectly towards the enemy and on to the rear of his dispositions does not constitute a strategic indirect approach. Strategic art is not so simple. Such an approach may start by being indirect in relation to the enemy's front, but by the very directness of its progress towards his rear may allow him to change his dispositions so that it soon becomes a direct approach to his new front.

Because of the risk that the enemy may achieve such a change of front, it is usual, and usually necessary, for the dislocating move to be preceded by a move or moves, which can perhaps best be classified under the term "distract" in its literal sense of "to draw asunder." The purpose of this "distraction" is to deprive the enemy of his freedom of action, and it should operate in both the physical and psychological spheres. In the physical, by causing a distension of his forces or their diversion to unprofitable ends, so that they are too widely distributed and too committed elsewhere to have the power of interfering with one's own decisively intended move. In the psychological sphere, the same effect is sought by playing upon the fears of, and by deceiving the opposing command. "Stonewall" Jackson realized this when he framed his strategical motto—"Mystify, mislead, and surprise." For to mystify and to mislead constitutes "distraction," and surprise is the essential cause of "dislocation." And it is through the "distraction" of the commander's mind that the distraction of his forces follows. The loss of his freedom of action is the sequel to the loss of his freedom of conception.

Realizing how the psychological permeates and dominates the physical sphere, we begin to see what Napoleon meant by his famous dictum that "the moral is to the physical as three to one." This realization warns us, too, of the fallacy and shallowness of attempting to analyze and theorize about strategy in terms of mathematics. To treat it quantitatively, as if the issue turned merely on a superior concentration of force at a selected place is as faulty as to treat it geometrically as a question of lines and angles. Yet voluminous works have been devoted to a "compartmented" analysis of strategy under such headings as "the relation between the fronts of opposing armies and their respective lines of communication with their base," "Case of both armies forming on a front parallel to the line of communication with the base," and so on.

But a prolonged abstract analysis of psychological strategy would be wearisome without being helpful, for it is only possible to probe into the mind of a commander through the medium of historical examples. Lack of space here forbids even an outline of strategical history, and all that can be done is to give some indication of the examples most worthy of study and of the main developments in methods and conditions. But while the means of strategy change and develop, so that there is progress in the physical sphere, in the psychological sphere it is no more possible to talk of the evolution of strategy than it is to talk of the evolution of painting. The history of strategy is an arid waste—of reliance upon sheer force—illumined by the genius of occasional masters for playing upon the mind of their opponents.

In ancient warfare the absence of "lines of communication" limited the scope for strategy. Hence the use of the indirect approach is mainly seen in grand strategy or in the immediate prelude to a battle. In one case, however, the scale and range of the effort compelled the adoption of what was virtually a "line of communication" for its maintenance. This was in the first "Great War" of European history—the Great Persian War. The indirect approach which dislocated the Persian invasion of 481 B.C. was made by sea, and it is noteworthy that the power of strategic mobility at sea was realized much earlier than on land.

In land warfare true strategy, and the indirect approach, are first manifested when Thebes challenged Sparta for the supremacy which she had wrested from Athens. Epaminondas might well be called the "father of strategy" was it not that the term suggests the idea of subsequent evolution. Certainly in strategy as in tactics he was the first master, and the operations which preceded the battle of Mantineia (*q.v.*) reveal the ripening of his art. Until his final campaigns on the Indian border, his strategy is direct and devoid of subtlety. The cause would appear to be, first, that in the youthful Alexander, bred to kingship and triumph, there was more of the Homeric hero than in the other great captains of history; and, still more perhaps, that he had such justifiable confidence in the superiority of his instrument and his own battle-handling of it that he felt no need to dislocate preparatorily his adversaries' strategic balance. His lessons for posterity lie at the two poles—war-policy and tactics.

With Hannibal and Scipio tactical art reached the highest level of ancient times, perhaps of all times, and if strategy was still handicapped by its means, certain phases of the war are most illuminating. We have already dwelt upon the Trasimene episode. Thereafter both sides adopted a war policy of indirect approach to a political rather than a military end. Roman strategy, under the direction of Fabius, was too convinced of Hannibal's military superiority to risk a military decision, and while seeking to avoid this, aimed by military pin-pricks to wear down the endurance of the invader and coincidently prevent his strength being recruited from the Italian cities or from his Carthaginian base. Hannibal, either from doubt as to the wisdom of testing the resisting power of the walls of Rome itself or from subtler reasons, spent the succeeding years in trying to loosen Rome's hold on her Italian allies and to weld them into a coalition against her. Victories were merely a moral impetus towards this goal. The superiority of his cavalry gave his tactical instrument an assured advantage if he could lure the enemy to battle on the plains. He succeeded once at Cannae (*q.v.*), but otherwise Rome's inflexible resolution in pursuing her own strategy of evasion at any sacrifice combined with the conditions of the age, with his own comparative weakness, and with his situation as the invader—of a primitively organized land—to thwart his aim. When Scipio later replied by a counter-invasion of Africa he found the more highly developed economic and social structure of Carthage an aid to his plans.

But before this, the Italian theatre had witnessed an example of strategy which is an historical landmark. Nero's Metaurus (*q.v.*) operation is the first clear case of what in strategical jargon is commonly called "interior lines," a term which certainly does not explain itself. It may perhaps be more clearly defined as using a central position between two enemy forces to fall upon one of them with the bulk of one's force. At its best this strategy is an indirect approach whereby one enemy force is bluffed into passivity while the other, isolated, is crushed. If Nero's was the first example, it has hardly been surpassed.

Scipio's operations began in Spain, Hannibal's strategic base and source of reinforcements, and by first depriving the Carthaginian armies there of their local base, Cartagena (*q.v.*), he led up to the complete overthrow of the Carthaginian power in Spain. Then, instead of attacking Hannibal in Italy, as his seniors wished and so many of his predecessors had tried in vain, Scipio sailed for Africa. There, while still in small force, he repeatedly trapped and broke up the forces of Carthage without hazarding any direct advance on the fortified city but exploiting his military successes to lop off its supply areas and allies.

To reinforce these forms of moral suasion he advanced to Tunis, in sight of Carthage, as "a most effective means of striking the Carthaginians with terror and dismay." Coming on top of the other indirect forms of pressure it was sufficient to dislocate the Carthaginians' will to resist, and they sued for peace. But while awaiting ratification in Rome, the provisional peace was broken when Carthage had news of Hannibal's return, and of his landing at Leptis. In such circumstances, an orthodox general would either have taken the offensive, in order to prevent Hannibal reaching Carthage, or have stood on the defensive to await relief. Instead, Scipio moved swiftly against Carthage's main source of supplies from the interior, and thus lured Hannibal to an area of his own choosing, where Hannibal lacked the material reinforcement, stable pivot, and shelter in case of defeat which he would have had if the battle had taken place near Carthage. Still Scipio was not content, but drew Hannibal to a camping ground where the Carthaginians suffered from lack of water and to a battle-ground in the plain where Scipio's newly gained advantage in cavalry could have full play. He had taken the first two tricks; on the battlefield of Zama (*q.v.*) he was enabled to take the rubber by tactically overtrumping Hannibal's former "cavalry" trump. The bloodless surrender of Carthage followed.

Mediaeval Warfare.—With the submersion of the Roman empire in the West, the art of war was also submerged, but in the Eastern Roman Empire (*see* article BYZANTIUM) it continued to flourish. Actual examples are too obscure for analysis, but the Byzantine textbooks exude the pure spirit of strategy and of the indirect approach. No generals knew better than the Byzantine the importance of adjusting the end to the means.

In the West during the Middle Ages the military spirit of feudal "chivalry" was inimical to art, although the drab stupidity of its military course is lightened by a few bright gleams. King John of England had a real insight into grand strategy, and Prince Edward, later Edward I., produced a masterly example of mobility in exploiting a central position in the Evesham (*q.v.*) campaign. The 13th century was also marked by the paralyzing lesson taught by the Mongols to European chivalry. Slight as our knowledge of events it is sufficient to trace the outline of strategic conceptions as grand in scale as they were subtle in calculation. (*See* further MONGOL CAMPAIGNS.)

Dawn of Modern History.—On entering the domain of modern history, we find that the Renaissance extended its influence to military affairs and that the regained inspiration of classical examples gave an invigorating impulse to the conduct of war.

But in the strict sense of the term, Cromwell stands out as the first great strategist of modern history. Perhaps none in all history can show a consecutive series of three masterpieces comparable to the Preston, Dunbar and Worcester campaigns, for breadth of manoeuvre and skill in "unhinging" the enemy's balance. Their swift decisiveness was all the more notable because the First Civil War had been so drawn out, so indecisive in its course despite the prevalence of a decision-desiring spirit rare in 17th century warfare. (*See* GREAT REBELLION.)

Conditions of 17th and 18th Centuries.—On the continent, during the 17th and most of the 18th century, warfare was as indecisive as it was continual. The common explanation is that these wars sprang from dynastic causes, that they were undertaken to gain small extensions of territory or power, and that as the professional armies of the time were expensive instruments, rulers were chary of damaging them and of risking too much for the sake of such limited aims. The development of standing armies and the high standard of training required by the development of individual firearms and the complex drill evolutions undoubtedly placed a check on the lavish use and expenditure of professional soldiers. But this check can be, and has been, exaggerated. Professional soldiers formed only the backbone of the armies of the time, which were usually made up by militia men recruited by lot. Again, common-sense, reacting from the injurious practice of pillage and devastation which had injured all parties in the Thirty Years' War (*q.v.*), reinforced a growing humanitarianism in protest against such gross interference with and exactions from the civil population. This feeling contributed to the development of the practice of feeding and maintaining armies from supply trains based on an organized chain of magazines. But a still greater impulse was given by example—the impressive success attained by the armies of Louis XIV. which, under Louvois' administration, embodied the essential elements of modern military organization. Its system of supply from magazines was not inspired by mere humanitarianism but by the desire for efficiency—to avoid the constant checks on mobility and on the scope of operations which were inevitable so long as armies lived like locusts, forced to evacuate areas of country because of the pressure of their own hunger after exhausting its resources. If this system of magazines enhanced the importance of fortresses as a site for them, it also gave a new importance to and opportunity for threats to the lines of communication. The one cancelled out the other. We must seek elsewhere for the main explanation of the indecisiveness of this period of warfare.

Nor shall we find it in the limited political aims or "geographical objectives." While these often prevailed, they did not dominate the horizon of such rulers and statesmen as Richelieu, Louis XIV. and Frederick. Their correspondence, urging energetic and decisive action, dispels such illusions.

The real explanation, more obvious and more natural, is that the military conditions of the time hindered decisive results. On the one hand was the development of fortification, field and permanent, in reply to the earlier growth of artillery. Protection caught up and outpaced the effect of weapons. It gave to the defensive a preponderance such as the development of the machine-gun revived in the 20th century. On the other hand the indivisibility of armies limited the capacity of strategy to upset this defensive balance of power. For they still moved and fought normally as a solid block, a single "piece" on the chessboard of war, a condition which limited their ability to deceive the opponent and to cramp his freedom of movement. Previous to the inauguration of the "divisional" organization, about 1760, by de Broglie, only Cromwell's campaigns show a full appreciation of the strategic value of what one may call "the distribution of force for a concentrated purpose."

Yet in the annals of 17th century warfare there is one example, Turenne's winter campaign of 1674–75 (*see* DUTCH WARS), which shows how art might be employed to decisive result even under the handicapping conditions of the period. At a time when all manoeuvres were based on fortress pivots he cut loose from this base of operations and sought, in surprise and mobility, not only a decision but his security. It was a just calculation, not a gamble, for the dislocation, psychological and physical, created among the enemy afforded him throughout an ample margin of security.

The War of the Spanish Succession (*q.v.*) which lasted for 12 years, 1701–1713, was made up largely of an abortive succession of direct approaches or scarcely more purposeful indirect moves. It was illumined, however, by the genius of Marlborough, and the war's purposeful indirect approaches are chiefly but not entirely associated with his name. Their significant interest lies in the way they mark the several turning points of the war.

Unlike Marlborough, Frederick was free from the responsibility and limitations which are imposed on a strategist, in the strict sense of the word. For he combined in his person the functions of grand strategy and strategy. Other advantages which he enjoyed over Marlborough were the comparative scarcity of fortresses in his theatres of war and the greater scope for moving troops off the roads. Yet despite a long string of victories in battle the Seven Years' War (*q.v.*) was not only indecisive in its course, but saw Frederick almost stripped of resources and incapable of further resistance by 1762 when external factors came to his rescue. The cause deserves enquiry.

Although faced by the coalition of Austria, France, Russia, Sweden and Saxony, with England as his only ally, Frederick had at the outset and until midway through the second campaign, a superiority in the actual forces available. In addition he had the asset of a central position. This enabled him to practise what is commonly called the strategy of "interior lines," striking outwards from his central pivot against one of the forces on the circumference, and utilizing the shorter distance he had thus to travel to concentrate against one of the enemy forces before it could be supported by the others. Ostensibly, it would seem that the further apart these enemy forces, the easier it must be to achieve a decisive success. In terms of time, space and number, this is undoubtedly true. But once more the moral element intrudes. When the enemy forces are widely separated each is self-contained and tends to be consolidated by pressure. When they are close together they tend to coalesce and "become members one of another," mutually dependent in mind, moral and matter. The minds of the commanders affect each other, moral impressions are quickly transfused, and even the movements of each force easily hinder or disorganize those of the others. Thus if the antagonist has less time and space for his action, the dislocating results of it take effect more quickly and easily. Further, when forces are close together the enemy's mere divergence from his approach to one of them may become an unexpected, and therefore truly indirect approach to another. In contrast, when forces are widely separated there is more time to prepare to meet, or avoid, the second blow of the army which is exploiting its central position.

Frederick consistently used his central position to concentrate against one fraction of the enemy. And he always employed tactics of indirect approach. Thereby he gained many victories. But his tactical indirect approach was normally only in the sphere of logistics and for all their executive skill, these manoeuvres were narrow. The opponent might be unable to meet the following blow, owing to the rigidity of his mind or his functions, but the blow itself did not fall unexpected by him.

As Frederick's roll of victories lengthened, his prospects and his resources diminished, until by 1759 he could do no more than passively block the enemy.

If many lessons are to be culled from Frederick's campaigns, the main one would appear to be, in a sentence, that "His indirectness was too direct." Or, to express it in another way, that he regarded the indirect approach as a matter of pure mobility, instead of a combination of mobility and surprise. Thus, despite all his brilliance, his economy of force broke down.

Thirty years later the outbreak of the French Revolutionary Wars gave Napoleon Bonaparte the opportunity to make the greatest of all developments in the physical sphere of strategy. In this development he exploited and combined the assets latent in three fresh conditions. The first condition arose from the composition and spirit of the Revolutionary armies. (*See* FRENCH REVOLUTIONARY WARS and CONSCRIPTION.) Their impetuous and undisciplined enthusiasm, instability of temper, and large infusion of new blood, made the old precise drill impossible. This difficulty, in compensation, gave birth to a simple yet vital change whereby the French marched and fought at a quick step of 120 paces to the minute, while their opponents adhered to the orthodox 70 paces. This elementary difference, in days before mechanical science endowed armies with means of movement swifter than the human leg, made possible the rapid transference and redistribution of force whereby the French could, in Napoleon's phrase, multiply "mass by velocity" both strategically and tactically.

The second condition was the organization of the army into permanent "divisions." Initiated by de Broglie, the emergency of the Revolution crystallized the reform. Then Carnot initiated and Bonaparte developed the idea that these divisions while operating separately should co-operate to a common goal. This new condition enabled a far wider range of strategic combinations than had been possible before.

The third condition, linked with this, was that the chaotic supply system and the undisciplined nature of the Revolutionary armies compelled a reversion to the old practice of "living on the country." And the distribution of the army in divisions meant that this practice detracted less from the army's effectiveness than in old days. Where, formerly, the fractions had to be collected before they could carry out an operation, now they could be serving a military purpose while feeding themselves. Moreover, the effect of "moving light" was to accelerate their mobility, and to enable them to move freely in mountainous or forest country. Similarly, the very fact that they were unable to depend on magazines and supply trains for food and equipment lent impetus to hungry and ill-clad troops in descending upon the rear of an enemy who had, and depended on, such direct forms of supply.

Napoleon Bonaparte.—Bonaparte's development of these conditions into a new strategic method is to be traced in his Italian campaigns of 1796–97. The physical, or logistical, indirect approach formed its foundation and the dislocating surprise which it produced was the product of his astonishing mobility rather than of any research for pure surprise. His first great development of strategical methods was the disposition of his forces in a loose and wide-flung grouping which could be swung in any direction. Like a net weighted with heavy stones, when one of the enemy's columns came in contact with it, the pressure caused the net to tighten round it, and the stones crashed together on it. The self-protective formation of the divisions thus became, on impact, a concentrated offensive formation. It evolved into the more highly developed *bataillon carré*, with army corps replacing divisions, of his later wars. His second was the idea of a strategic "barrage" created by gaining and using a "natural position," such as a river or mountain range across the enemy's rear. Such a position, offering natural obstacles, afforded him a secure pivot from which to prepare a firm embrace for the enemy, whose "natural" tendency, when cut off from their line of retreat and supply, was to turn and flow back, usually in driblets, towards him. Its use is particularly well illustrated in his 1800 and 1805 campaigns. (*See* FRENCH REVOLUTIONARY WARS and NAPOLEONIC CAMPAIGNS.)

Strategical Degeneration.—But, from the time he became Emperor and had seemingly inexhaustible resources at his disposal, this assured superiority of force had a growing influence on his strategy. From 1806 onwards Napoleon seems concerned mainly with the single end of bringing his enemy to battle, confident that, when this happened, his machine would overpower the enemy. He still uses the manoeuvre onto their rear, but it is more as a means of gripping them firmly so that they can be drawn into his jaws, than as a means of liquefying their morale so that mastication may be easier. Moreover when hitches occur in the execution of these manoeuvres, his impatience leads him to gamble on a direct approach and battle. At Aspern–Essling (*q.v.*) he suffers in consequence his first great defeat.

The Russian campaign of 1812 is the natural climax to the tendencies already seen to be growing in Napoleon's strategy—that of relying more on mass than on mobility, and on strategic formation rather than on surprise. The geographical conditions merely serve to accentuate its weaknesses.

The disastrous results of the subsequent retreat from Moscow were due less to the severe weather—the frost was actually late—than to the demoralization of the French army, which was the reaction from the frustration of its direct battle-aimed strategy.

Only in 1814 when he had dissipated his resources and his credit, did he resharpen his old tools and strive to re-establish an adjustment between end and means. Realizing that his means were too impoverished for military success, he aimed to dislocate the co-operation between the allied armies, and exploited mobility to this end. Even so, astonishing as his success in retarding the enemy's end, it might perhaps have been more effective and enduring, if his ability to continue this strategy had not been diminished by his inherent tendency to consummate every strategic success by a tactical one.

The American Civil War.—The next breeding ground of generals worthy of the title of strategists was the American Civil War (*q.v.*). But, despite a refreshing breadth of view and fertility of resource in what may be termed local strategy, the conventional aim at first directed the major operations.

The repulse of Lee's invasion at Gettysburg has commonly been acclaimed the turning point of the war, but the claim is only justified in a dramatic sense, and the sober verdict of historical opinion has more and more emphasized that the decisive effects came from the West. The first was achieved, on the central Mississippi on the same day, July 4, as Lee began his retreat from Gettysburg. This was the capture of Vicksburg (*q.v.*) by Grant, which gave the Federals complete control of this vital artery. Thereby the Confederacy was deprived permanently of the nourishment of reinforcements and supplies from the Trans-Mississippi states. Grant took the calculated risk of cutting himself loose from his base and moving to place himself on the rear of Vicksburg and astride its communications with the main Eastern states of the Confederacy. It is worth while to note that while Napoleon had used the line of a river or range of hills as his strategic barrage, Grant's strategic barrage was constituted by the possession of a single point—a railway junction. This secured, he then turned about and moved on Vicksburg, which was now isolated long enough to ensure its capitulation seven weeks later. The strategic sequel was the opening of the Chattanooga gateway into Georgia, the granary of the Confederacy, and thence into the Eastern states as a whole.

Defeat was now hardly avoidable by the Confederacy. Yet the Federals almost forfeited the victory already ensured. For in 1864 with the North growing weary under the strain, the moral element became preponderant. The peace party was gathering weight, and unless Lincoln was to be supplanted by a president pledged to seek a compromise peace, a solid guarantee of early victory must be forthcoming. To this end Grant was summoned from the West to take over the supreme command.

But he decided on the old direct overland approach southward from the Rappahannock towards Richmond. In justice, it should be noted that if his approach was direct in the broad sense, it was in no sense a mere frontal push. Indeed, he continuously sought to turn his enemy's flanks by manoeuvre, if of a narrow radius.

Yet by the end of the summer of 1864 the ripe fruit of victory had withered in the hands of the North. The Federals had almost reached the end of their endurance, and Lincoln despaired of re-election—a sorry repayment for the blank cheque he had given his military executant. It is an ironical reflection that the determination with which Grant had wielded his superior weight, now fearfully shrunk after the fierce battles of the Wilderness and Cold Harbour, had utterly failed to crush the enemy's army, while the chief result—the geographical advantage of having worked round close to the rear of Richmond—was gained by the bloodless manoeuvres which had punctuated his advance. He had thus the modified satisfaction of being back, after immense loss, in the position which McClellan had occupied in 1862. But when the sky looked blackest it suddenly lightened. At the November elections Lincoln was returned to power. The relief came not from Grant's campaign, which made little progress after July, and flickered out with a costly double failure in mid-October. Sherman's capture of Atlanta in September was the instrument of salvation. Atlanta, the base of the enemy army guarding the back-door of the Confederacy, was not only an important junction and source of supplies but a moral symbol. And in gaining it Sherman's economy of force by manoeuvre is the more notable because, compared to Grant in Virginia, he was practically tied to one line of railway for his supplies. Yet, rather than commit his troops to a direct attack he cut loose temporarily even from this, and he manoeuvred so skilfully as to lure the Confederates time after time into vain attacks. Thus to force an opponent acting on the strategic defensive into a succession of costly tactical offensives was a triumph of strategic artistry. Atlanta gained, Sherman took a risk greater than ever before, and one for which he has been much criticized by military commentators. He was convinced that if he could ruin the railway system of Georgia and the Carolinas and so prevent supplies going north to Richmond and Lee's army, the resistance of the Confederates would collapse. Hence, ignoring Hood's army, which he had forced to evacuate Atlanta, he began his famous "march to the sea" through Georgia, living on the country while he destroyed the railways. On November 15, 1864 he left Atlanta; on December 10 he reached the outskirts of Savannah and there reopened his communications, this time by sea, as well as depriving the South of its chief remaining ports. Then he moved northwards through the Carolinas towards Lee's rear. Not until over three months later, the beginning of April, did Grant resume his advance. This obtained a dramatic success, and the surrender of Richmond was followed within a week by the surrender of Lee's army. Superficially it was a triumphant vindication for Grant's direct pressure. But for a serious judgment the time factor is all important. The collapse of the Confederate resistance was due to the emptiness of its stomach reacting on its morale.

The American Civil War had revealed the influence not only of the development of railways upon strategy, but of changing economic conditions, but its embryonic lesson was largely obscured by the war of 1870 in Europe. Here inferiority of force and stupidity of mind so weighted the scales against the French that a quick military decision was obtained. The World War (*q.v.*) and its strategical lessons are discussed in detail elsewhere.

Conclusion.—Throughout history the direct approach, aiming to gain a decision by the tactical application of a superior concentration of force, has been the normal form of strategy; a purposeful indirect approach, the rare exception. Yet the latter form of strategy has many decisive successes to its credit; the former, few. And those few have been purchased at exorbitant cost. In numerous cases, moreover, the indirect approach has only been adopted as a last resource, even a last gamble, after the failure of a direct approach. A decisive success in such deteriorated conditions invests the lesson with special significance.

Reflection suggests, and history confirms, that a direct approach is the worst of all military "risks"—worse than the passage of mountains, deserts or swamps, worse than that of cutting oneself loose from one's supplies or of operating with inferior force. Natural hazards, however formidable, are inherently less dangerous and uncertain than fighting hazards. For all conditions are more calculable, all obstacles more surmountable than those of human resistance. By reasoned calculation and preparation they can be overcome almost "to time-table."

It was Clausewitz who, reacting against the "geometrical" interpretation of Napoleon's strategy, laid down that "the independent will-power of his opponent" is the least calculable and most formidable of the factors with which a commander has to deal. But his line of thought and teaching led him to place excessive emphasis on force applied through the bodies of a commander's troops as the means of damaging the commander's will. It is curious that he should have neglected the heightened power and speed of impressions made immediately on the opposing commander's mind, in favour of impressions made through a "third party" channel. But the teaching of Clausewitz was directed more to fortify the will of the commander on his own side than to undermine the will of the opposing commander. And he was a cultivator of expectancy, rather than an exponent of the unexpected.

Hence force overshadowed surprise and mobility on the strategical horizon of the 19th and early 20th centuries. Hence the relative neglect not only of psychological surprise but of new inventions which might contribute to it. So also with mobility—rate of movement was treated as an invariable factor. In staff rides and exercises, calculations and plans were based on "normal" times, and little research was made into the advantages of unexpected acceleration by new means or by a partial sacrifice of strength and convenience. In contrast to Napoleonic practice, undue stress was laid on the importance of bringing a force entire to its destination—tying it to the pace of its slowest elements. Equally neglected was the lesson contained in Napoleon's *marche de manoeuvre*—guns and trains upon the road, infantry and cavalry moving across country. Even since the World War, although the strategic value of tanks and the newer forms of transport lies as much or more in their power of cross-country movement as in their speed, the strategic advantages of such movement are rarely applied or realized. This failure of comprehension is perhaps the less surprising when, in studying the history of the past hundred years, we see the failure of strategists to grasp the idea underlying Napoleon's use of the divisional system. By 1870 the intervals had become much narrower and by 1914 armies were back in the old solid block, with the divisions rubbing shoulders in a long, inflexible, unmanoeuvrable, line. Yet all the time the increasing range of weapons had progressively diminished the risk and increased the profit of leaving intervals—of a calculated distribution of force for a concentrated purpose. For the divisional organization was by its nature a fresh aid to the strategy of indirect approach, whose psychological purpose may be epitomized in the one word "trap"—the trap being most often baited by a military move directed against an economic target—the sources of supply of the opposing state or army. The future is likely to strengthen this experience, for national conditions and the development of civilization are bringing new influences to bear on strategy and opening to strategy new channels of influence. These were foreshadowed in the American Civil War.

To overthrow the enemy's armed forces may still be the quickest and most effectual way to cause the collapse of the enemy nation's will to resist. But the new civil conditions provide a far stronger argument against attempting it unless the military conditions are highly favourable to its success. The civil conditions give the strategist not only an alternative channel of action but an additional lever towards his military aims. By threatening economic objectives he may be able both to distract and dislocate the enemy's military dispositions, while the greater frequency and sensitiveness of such civil objectives may give him opportunities to slip past the military shield and strike at them with decisive results. This potential development of strategy is greatly favoured by the advent of the air weapon, which introduces a third dimension of movement. Metaphorically, the effect may be defined as the replacement of a "draughts-board" theatre of war by a "halma-board"—for aircraft have the power of "hopping over" resistance. (B. H. L. H.)

Bibliography.—Among a host of books the following may be selected as illustrating the thought of different periods and schools: The *Chinese Book of War;* Machiavelli, *Dell' arte Della Guerra;* Jomini, *Précis de l'art de la Guerre;* Clausewitz, *vom Kriege;* Willisen, *Theorie des Grossen Krieges;* Moltke, *Taktisch-strategische Aufsätze;* Colin, *Les Transformations de la Guerre;* Bloch, *La Guerre;* Fuller, *The Foundations of a Science of War;* Liddell Hart, *The Decisive Wars of History.* Any general survey should be supplemented by the study of good military biographies, but they are rare.

STRATEGY, NAVAL: *see* Naval Strategy and Tactics.

STRATFORD, JOHN DE (d. 1348), archbishop of Canterbury, was born at Stratford-on-Avon and educated at Merton College, Oxford, afterwards entering the service of Edward II. He served as archdeacon of Lincoln, canon of York and dean of the court of arches before 1323, when he became bishop of Winchester, an appointment which was made during his visit to Pope John XXII. at Avignon and which was very much disliked by Edward II. In 1327 the bishop joined Queen Isabella's partisans; he drew up the six articles against Edward II., and was one of those who visited the captive king at Kenilworth to urge him to abdicate in favour of his son. Under Edward III. he became a member of the royal council, but his political importance dates from the fall of Roger Mortimer. In November 1330 Stratford became chancellor, and for the next ten years he was the king's most prominent adviser and the "head of the Lancastrian or constitutional party" (Stubbs). In 1333 he was appointed archbishop of Canterbury, and he resigned the chancellorship in 1334. He was again chancellor from 1335 to 1337 and for about two months in 1340. In November 1340 Edward III., humiliated, impecunious and angry, returned suddenly to England from Flanders and vented his wrath upon the archbishop's brother, the chancellor, Robert de Stratford. Fearing arrest John de Stratford fled to Canterbury, but after a violent dispute the principle was established that peers were only to be tried in full parliament before their own order (*en pleyn parlement et devant les piers*). The archbishop acted as president of the council during Edward's absence from England in 1345 and 1346, although he never regained his former position of influence. He died at Mayfield in Sussex on Aug. 23, 1348.

STRATFORD, a city and port of entry of Ontario, Canada, and capital of Perth county, situated 83 m. W.S.W. of Toronto by the Canadian National railway, on the Avon river. Pop. (1921) 16,094. The repair and engineering shops of the railway, flour-, saw- and woollen-mills, engine and agricultural implement works are the principal industries. A large export trade in cheese and other dairy and farm produce is carried on.

STRATFORD DE REDCLIFFE, STRATFORD CANNING, Viscount (1786–1880), British diplomatist, was born in Clement's Lane in the city of London, on Nov. 4, 1786. His father, Stratford Canning, uncle of George Canning (*q.v.*), who had been disinherited for his marriage with Mehetabel Patrick, died when the boy was six months old. He was educated at Eton, and had kept two terms at King's College, Cambridge, when, in 1807, his cousin, George Canning, gave him an appointment in the foreign office. In 1808 he was appointed first secretary to Robert Adair, ambassador to Constantinople. When Adair was transferred to Vienna in 1810, Canning remained at Constantinople as *chargé d'affaires.* Canning was left entirely to his own discretion. In May 1812 he helped to arrange the peace of Bucharest between Turkey and Russia, which left a powerful Russian army free to repel Napoleon's invasion. Canning was able to hasten the decision of the Turks, by making judicious use of Napoleon's plan for the partition of their empire. A copy of it had been left in his hands by Mr. Adair to be used at the proper moment. In July he left Constantinople with the desire to enter political life at home. But Castlereagh arranged for him to receive a retaining fee binding him to the service. He spent four years as minister at Berne (1814–18). In 1819 he was appointed minister at Washington, a station of great difficulty owing to the many questions outstanding between the British and the American governments. Canning, who had a quick temper, came into occasional collision with John Quincy Adams, the American secretary of State. Yet they parted with mutual respect. Canning returned to England in 1823. The general treaty he had arranged with Mr. Adams was rejected by the United States Senate.

In 1824 Canning was selected as ambassador to Turkey, and proceeded to Constantinople after a preliminary visit to Vienna and to St. Petersburg, where he discussed the Alaska boundary question and sounded the Russian Government as to the course to be taken with the Greek revolt against Turkey. He left for Constantinople in October 1825. At Constantinople he was engaged with the French and Russian ambassadors in the hopeless task of inducing Sultan Mahmud II. to make concessions to the Greeks, without the pressure of armed force. After the battle of Navarino (*q.v.*) on Oct. 20, 1827, the ambassadors retired to Corfu. Canning then went home, but was sent back on July 8, 1828. Canning did not agree on all points with Lord Aberdeen, and in 1829 he, for the time being, turned from diplomatic to parliamentary life. He sat for Old Sarum, for Stockbridge (rotten boroughs) and for Southampton, but did not make much mark in parliament. He was twice absent on diplomatic missions. At the end of 1831 he went to Constantinople to attend the conferences on the delimitation of the Greek frontier, arriving immediately after the receipt of the news of Mohammed Ali's invasion of Syria. (*See* MOHAMMED ALI.) Sultan Mahmud now proposed to Canning an alliance between Great Britain and Turkey, and Canning strongly urged this upon Palmerston, pointing out the advisability of helping the sultan against Mohammed Ali in order to forestall Russia, and of at the same time placating Mohammed Ali by guaranteeing him certain advantages. This advice, which largely anticipated the settlement of 1841, was not followed; but Canning himself was in high favour with the sultan. In 1833 he was selected as ambassador to Russia, but the Tsar Nicholas I., who knew his peremptory methods, refused to receive him.

Canning was again sent to Constantinople in Jan. 1842 and remained there as ambassador until 1858. His tenure of office in these years was made remarkable—first by his constant efforts to induce the Turkish Government to accept reform and to conduct itself with humanity and decency; then by the Crimean War (*q.v.*). Canning had no original liking for the Turks. He was the first to express an ardent hope that they would be expelled from Europe with "bag and baggage"—a phrase made popular in after times by Gladstone. But he had persuaded himself that under the new sultan Abd-ul-Mejid they might be reformed. On the fall of Palmerston's ministry in Feb. 1858 he resigned. He had been raised to the peerage in 1852. During his later years he wrote several essays collected under the title of *The Eastern Question* (1881). In 1873 he published his treatise, *Why I am a Christian,* and in 1876 his play, *Alfred the Great at Athelney*. The only son of his second marriage died before him. His wife and two daughters survived him. Lord Stratford died on Aug. 14, 1880, and was buried at Frant in Sussex. A monument to him was erected in Westminster Abbey in 1884.

See S. Lane Poole, *Life of Lord Stratford de Redcliffe* (1888).

STRATFORD-ON-AVON, a market town mainly on the west bank of the Avon, in the Stratford-on-Avon parliamentary division of Warwickshire, England; on a branch line of the Great Western Railway (London 92½ m.: Birmingham 33½). Pop. (1921), 9,392. The neighbourhood is beautiful though of no considerable elevation. The river flows in exquisite wooded reaches, navigable only for small boats. The Stratford canal communicates with the Warwick and Birmingham canal. The river is crossed at Stratford by a stone bridge of 14 arches, built by Sir Hugh Clopton in the reign of Henry VII. The church of the Holy Trinity occupies the site of a monastery, which existed before 691, when the bishop of Worcester received it from Ethelred of Mercia. It is a fine cruciform structure, partly Early English and partly Perpendicular. It was greatly improved in the reign of Edward III. by John de Stratford, who rebuilt the south aisle. He also in 1332 founded a chantry for priests, and in 1351 Ralph de Stratford built for John's chantry priests "a house of square stone," in connexion with which the church became collegiate. The present choir was built by Dean Balshall (1465–91), and in the reign of Henry VII. the north and south transepts were erected. A window commemorates the Shakespearian scholar Halliwell-Phillipps. The chapel of the gild of the Holy Cross was begun by Robert de Stratford. The gild, for both sexes, was in existence early in the 13th century, and was incorporated by charter from Edward III. in 1322. It was dissolved in 1547. The gildhall is a picturesque half-timbered building. A beautiful 16th century house belonged to Thomas Rogers, whose daughter was mother of John Harvard, founder of Harvard college, U.S.A. Among public buildings are the town hall (1633, rebuilt 1767, altered 1863), market house, corn-exchange and three hospitals. There are recreation grounds. Brewing is carried on, but the trade is principally agricultural. Area, 4,013 acres.

Shakespearian Connexion.—The task of preserving for modern eyes the buildings which Shakespeare saw was not entered upon till the end of the 18th century, when much of the visible connexion with his times had been destroyed. A room is by tradition shown as his birth-room, bearing innumerable signatures, among which such names as Walter Scott, Dickens and Thackeray may be deciphered. Part of the building, used by the poet's father as a wool-shop, is fitted as a museum. Shakespeare may have attended the grammar school in Church street, a foundation in connexion with the gild of the Holy Cross, but refounded after the dissolution by Edward VI. in 1553, and bearing his name. The site of "New Place," built by Sir Hugh Clopton and bought by Shakespeare in 1597, was acquired by public subscription, chiefly through the exertions of Halliwell-Phillipps, and handed over to the trustees in 1876. Shakespeare is buried in the chancel of Holy Trinity church next his wife. Over his grave are the lines beginning

Good friend, for Jesus' sake forbeare
To digg the dust enclosed heare.

For the effigy *see* SHAKESPEARE: *Portraits*. Further connexions with the poet and his family are to be found. The museum adjacent to New Place was the house of Thomas Nash, who married Shakespeare's granddaughter Elizabeth Hall. At Shottery, 1 m. W. of Stratford, is the thatched cottage in which Shakespeare's wife, Anne Hathaway, was born. It was purchased for the nation in 1892. The poet's mother was Mary Arden, and this name, that of an ancient county family, survives in the 'Forest' of Arden, north-west of Stratford. At Snitterfield to the north lived Shakespeare's grandfather and uncle.

The principal modern monument to the poet's memory is the Shakespeare Memorial, erected in 1877 to contain a theatre, picture gallery and library. Of this the theatre was destroyed by fire on March 6, 1926, and a national fund was opened to build a new one. A Shakespearian season is given annually.

History.—Stratford is a place of great antiquity. A Roman road may have run past the site; coins, etc., have been found, and the district at any rate was inhabited in Roman times. The manor was granted by Offa to the bishopric of Worcester; and it was under the protection of the bishops of Worcester that the inhabitants of the town early assumed burghal rights. The Gild of the Holy Cross, founded in the 13th century for the support of poor priests and others, exercised authority over the town for many years. Its dissolution was the cause of the incorporation charter of Edward VI. in 1553, by which the town was incorporated under the title of the bailiff and burgesses, who were to bear the name of aldermen. Another charter, altering the constitution of the corporation, was granted in 1611.

STRATHAVEN (locally pronounced *Strĕvn*) a manufacturing and market town of Lanarkshire, Scotland. Pop. (1921) 4,207. It lies on the Avon, 16 m. S.S.E. of Glasgow by road, and is the terminus of the L.M.S. railway company's branch line from Hamilton. It has manufactures of silk, cotton and hosiery and is a market for cheese and grain. The ruins of Avondale castle are situated on a stream that runs through Strathaven to join the Avon, a mile below the town. Six miles S.W., on the moor of Drumclog, the Covenanters defeated John Graham of Claverhouse, Viscount Dundee, on June 1, 1679. A granite obelisk commemorates the battle.

STRATHCLYDE, the name given in the 9th and 10th centuries to the British (Welsh) kingdom, which from the 7th century onwards was probably confined to the basin of the Clyde, together with the adjacent coast districts, Ayrshire, etc., on the west of Scotland. Its capital was Dumbarton (fortress of the Britons), then known as Alcluith. On the south this kingdom bordered on the territories of the Niduari Picts of Galloway, including the modern counties of Wigtown and Kirkcudbright. Strathclyde is also sometimes called Cumbria, or Cumberland, and the survival of the latter name on the English side of the border preserves the memory of a period when the territories of the northern Welsh were of much greater extent.

After the withdrawal of the Romans in the 5th century the northern Britons seem to have shown greater determination in maintaining their independence than any of the southern kingdoms and, according to Welsh tradition, Cunedda, the ancestor of the kings of Gwynedd, had himself come from the north. In the *Historia Brittonum* we read of princes of the northern Britons.

Such notices as we have of the history of Strathclyde in the 7th and 8th centuries are preserved only in the chronicles of the surrounding nations and even these supply us with little more than an incomplete record of wars with the neighbouring Scots, Picts and Northumbrians. It is probable that the Britons were allied with the Scots when Aidan, the king of the latter, invaded Northumbria in A.D. 597. In 642, however, we find the two Celtic peoples at war with one another, for in that year the Britons under their king Owen defeated and slew the Scottish king Domnall Breac. In the same year they came into conflict with the Northumbrian king Oswio. In 649 there appears to have been a battle between the Britons and the Picts, but about this time the former must have become subject to the Northumbrian kingdom. They recovered their independence, however, after the defeat of Ecgfrith by the Picts in 685. In 711 and again in 717 we hear of further wars between the Britons and the Scots of Dalriada, the former being defeated in both years. Towards the middle of the 8th century Strathclyde was again threatened by an alliance between the Northumbrians and Picts, and in 750 the Northumbrian king Eadberht wrested from them a considerable part of their territories in the west including Kyle in Ayrshire. In 756 the North Britons are said to have been forced into submission and from this time onwards we hear very little of their history.

In 870 Dumbarton was attacked and destroyed after four months' siege by the Scandinavian king Ivarr, and for some time after this the country was exposed to ravages by the Norsemen. It is believed that the native dynasty came to an end early in the 10th century and that the subsequent kings belonged to a branch of the Scottish royal family. Toward the end of the reign of Edward the Elder the Britons of Strathclyde submitted to that king together with all the other princes of the north. In the reign of his successor Aethelstan, however, they joined with the Scots and Norwegians in attempts to overthrow the English supremacy, attempts which were ended by their defeat at the battle of Brunanburh in 937. In 945–946 Strathclyde was ravaged by King Edmund and given over to the Scottish king Malcolm I. The fall of the kingdom was only temporary, for we hear of a defeat of the Scottish king Cuilean by the Britons in 971. In the 11th century Strathclyde appears to have been finally incorporated in the Scottish kingdom, and the last time we hear of one of its kings is at the battle of Carham in 1018 when the British king Owen fought in alliance with Malcolm II.

See *Chronicles of the Picts and Scots*, edit. by W. F. Skene (1867); W. F. Skene, *Celtic Scotland* (1876); and Sir John Rhys, *Celtic Britain* (1904). (F. G. M. B.)

STRATHCONA AND MOUNT ROYAL, DONALD ALEXANDER SMITH, BARON (1820–1914), Canadian statesman and financier, was born at Forres, Scotland, on Aug. 6, 1820, the second son of Alexander Smith (d. 1850), a Highland merchant. His mother, Barbara Stewart, of Abernethy, was the sister of John Stewart (d. 1847), a famous fur trader in the Canadian North-West, who gave his name to Stewart Lake and Stewart river. Through him Donald Smith was appointed in 1838 a junior clerk in the Hudson's Bay Company, which at that time controlled the greater part of what is now the Dominion of Canada. Smith was sent to Labrador, and stationed at Hamilton Inlet. For thirteen years he roughed it there, mastering the work of the fur trade, introducing various improvements into the conditions of life, being the first to prove that potatoes and other vegetables could be grown with success on that bleak coast, and varying his business routine with much reading and letter-writing. Then he was for ten years on Hudson Bay, rising in the company's service to be a chief trader and then a chief factor.

In 1868 he was appointed to the post of resident governor, with headquarters at Montreal. In the next year Louis Riel's (*q.v.*) rebellion broke out on the Red river, and in December Smith was sent by the Canadian government with wide powers as special commissioner to endeavour to check the rebellion, and to report "on the best mode of quieting and removing such discontent and dissatisfaction." On arriving at Fort Garry (now Winnipeg) he advised the government that it would be necessary to send troops; in the meanwhile he kept cool in face of a very ugly situation, and it was largely owing to his tact and diplomacy that the lives of the numerous prisoners were saved, that Riel's position was gradually undermined and that the relief expedition under Colonel (afterwards Lord) Wolseley had no fighting to do. Apart from the rebellion, there was difficulty with the company's traders. The company's control over the North-West was to be surrendered to Canada for £300,000, certain grants of lands and certain trading privileges, and the traders on the spot feared that in the distribution of the money their rights might not be guarded, but Smith succeeded in persuading them to trust him to secure their share, and asserted their claims so effectually that £107,000 was paid to them. During these complications in the North-West he occupied for a time the position of acting governor: in December 1870, he was returned for Winnipeg to the Manitoba legislative assembly, and in March 1871, he was elected as one of the four Manitoba representatives to the Dominion House of Commons. In 1871 Smith was appointed chief commissioner for the North-West. In 1872 he became one of the original members of the first North-West council under the act providing for the government of the territories by the lieutenant-governor of Manitoba and a council of eleven.

The construction of the Canadian Pacific railway had now become a practical question. In 1872 a charter was given by Sir John Macdonald's government to a company, with Sir Hugh Allan at its head, for the construction of the line, with a subsidy in land grants and money, but in 1873 disclosures of corrupt practices in relation to this charter (the so-called Pacific Scandal) led to the fall of the government, and the company was soon afterwards dissolved. In the debate which ended in the resignation of the government, a speech by Smith had a powerful effect. The Liberal government which came into power early in 1874 reverted, though timidly, to the policy of government ownership.

Meanwhile Donald Smith, together with his cousin Mr. George Stephen (afterwards Lord Mountstephen), and other Canadian and American financiers, had bought out the Dutch bondholders of the insolvent St. Paul & Pacific railway, an American line, which by 1873 had been completed from St. Paul to Breckenridge, but which lacked funds to proceed farther. After long negotiations the new owners persuaded the government of Manitoba to build a line from Winnipeg to Pembina on the American frontier. This done, in 1879 the partners formed the St. Paul, Minneapolis & Manitoba Railway Company, and by continuing the line from Breckenridge to Pembina united Manitoba with the south and west.

In 1878 the Liberal party was defeated, and Sir John Macdonald returned to office with the support of Smith, who had been driven to rejoin the Conservatives by the over-cautious railway policy of the Liberals. In 1880 the new government made a contract for building the railway with a syndicate of which Stephen was the chief director, and in which Smith, from the first largely interested, came more and more to the front. Both were prominent directors of the Bank of Montreal, and employed its resources in the work without hesitation. Smith also embarked in the work the whole of his private fortune, and it was his dogged perseverance which more than anything else enabled the company to bring its work to a successful conclusion. On Nov. 7, 1885, at Craigellachie in the Rocky Mountains, Donald Smith drove home the last spike of the first Canadian transcontinental railway. In 1882 he left parliament, but returned to it in 1887, and represented Montreal West till 1896, when he was appointed to succeed Sir Charles Tupper in London as high commissioner for Canada. In that year he was made G.C.M.G.; in 1897 he was raised to the peerage and in 1909 made G.C.V.O. In 1889 he became governor of the Hudson's Bay Company. On March 21, 1896 he was appointed government commissioner to Manitoba and the Territories to endeavour to lessen the bitterness in the discussion as to Roman Catholic rights in the public schools, and the compromise of 1897 followed the lines which he suggested. (*See* CANADA.)

In January 1900, during the war in South Africa, he raised, equipped and presented to the British government a regiment of irregular cavalry 600 strong. Strathcona's Horse, as it was called, was recruited in the Canadian West, and did good service during the war. With his cousin, Lord Mountstephen, he founded and endowed the Royal Victoria Hospital in Montreal, and both in Canada and in Scotland gave largely to university work. He was the backbone of the Canadian emigration policy from 1896 onwards. He helped in the improvement of the waterways of the Canadian West, and in placing steamers on them, and gave much assistance to the proposed All Red Route of British-owned steamers, encircling the world. From the first he was a member of the Pacific Cable Board, controlling the cable laid in 1902 by the combined governments of Great Britain, Canada and Australia. No man did more to tighten the ties which bind Canada to the British Empire. He died in London on Jan. 21, 1914.

The *Life* by Beckles Willson contains some useful information. The Histories of the Hudson's Bay Company by Beckles Willson, Rev. George Bryce and Miss Agnes C. Laut tell his early struggles. *Sir Wilfrid Laurier* (2 vols.), by J. S. Willison, describes the financial dealings between the Canadian government and the Canadian Pacific railway. His parliamentary speeches are to be found in the Canadian *Hansard.*

STRATHNAIRN, HUGH HENRY ROSE, 1ST BARON (1801–1885), British field-marshal, third son of the Right Hon. Sir George Henry Rose of Sandhills, Christchurch, Hants., minister plenipotentiary at the Prussian court, was born at Berlin on April 6, 1801. He was educated at Berlin, and received military instruction at the cadet school. He entered the army in 1820, and received rapid promotion. As a major in the 92nd Highlanders he was employed in maintaining order in Ireland in 1830. He then served in the Mediterranean. In 1840 Rose, now a lieutenant-colonel, was selected, with other officers and detachments of Royal Artillery and Royal Engineers, for special service in Syria under the orders of the foreign office. They were to co-operate on shore, under Brigadier-General Michell, R.A.—in conjunction with the Turkish troops—with the British fleet on the coast, for the expulsion of Mohammed Ali's Egyptian army from Syria. Sir Stratford Canning sent Rose from Constantinople on a diplomatic mission to Ibrahim Pasha, commanding the Egyptian army in Syria, and after its execution he was attached, as deputy adjutant-general, to the staff of Omar Pasha, who landed at Jaffa with a large Turkish force from the British fleet. Rose distinguished himself in several engagements, and received many honours. Shortly after he succeeded to the command of the British detachment in Syria with the local rank of colonel, and in April 1841 he was appointed British consul-general for Syria. For seven years, amidst political complications and intrigues, Rose, by his energy and force of character, did much to arrest the horrors of civil war, to prevent the feuds between the Maronites and Druses coming to a head, and to administer justice impartially; and he saved many Christians from massacre.

In 1848 he left Syria on leave, and did not return, as Lord Palmerston appointed him secretary of embassy at Constantinople in January 1851. In 1852 he was chargé d'affaires in the absence of Sir Stratford Canning during the crisis of the question of the "holy places." During the Crimean War Rose was the British commissioner at the headquarters of the French army, with the local rank of brigadier-general. For his services he received the medal with three clasps and the thanks of parliament, was promoted to be major-general, and was made K.C.B. and commander of the Legion of Honour. On the outbreak of the Indian Mutiny in 1857 Rose was given command of the Poona division. He arrived in September, and took command of the Central India force. In January 1858 he marched from Mhow, captured Rathgarh after a short siege, and defeated the raja of Banpur near Barodia in the same month. He then relieved Saugor, captured Garhakota and the fort of Barodia, and early in March defeated the rebels in the Madanpur Pass and captured Madanpur and Chanderi. He arrived before Jhansi on March 20, and during its investment defeated a relieving force under Tantia Topi at the Betwa on April first. Most of Rose's force was locked up in the investment, and to Tantia Topi's army of 20,000 he could only oppose 1,500 men; yet with this small force he routed the enemy with a loss of 1,500 men and all their stores. Jhansi was stormed and the greater part of the city taken on the 3rd, and the rest the following day, and the fort occupied on the 5th. Kunch was captured, after severe fighting in a temperature of 110° in the shade, on May 7. Under the same conditions the march was made on Kalpi. The rebels attacked his small force, exhausted by hard marching and weakened by sickness, but after a severe fight (May 22) they were utterly routed and Kalpi occupied the following day. Sir Robert Napier (*q.v.*) had been appointed to succeed him, when news came of the defection of Sindhia's troops and the occupation of Gwalior by Tantia Topi. Rose at once moved on Gwalior by forced marches, and on June 16 won the battle of Morar. Leaving Napier there, he attacked Gwalior on the 19th, when the city was captured. The fortress was stormed and won the following day, and Napier gained a signal victory over the flying enemy at Jaora-Alipur on the 22nd. Rose then made over the command to Napier and returned to Poona. It was to Rose's military genius that the suppression of the Indian Mutiny was largely due; but owing to official jealousy his merit was only tardily recognized. But in June 1860 he succeeded Lord Clyde as commander-in-chief in India. Rose improved the discipline of the army, and his powerful assistance enabled the changes consequent upon the amalgamation of the East India Company's army with the Queen's army to be carried out without friction.

Rose held the Irish command from 1865 until 1870, and by a good organization and disposition of the troops under his command in 1866 and 1867 he enabled the Irish government to deal successfully with the Fenian conspiracy. He was promoted general in 1867, and field marshal in 1877. He died in Paris on Oct. 16, 1885, and was buried in the graveyard of the Priory Church, Christchurch, Hants. An equestrian statue by E. Onslow Ford, was erected to his memory at Knightsbridge, London.

See Sir Owen Tudor Burne, *Clyde and Strathnairn,* "Rulers of India Series" (1891).

STRATHPEFFER, village and spa of the county of Ross and Cromarty, Scotland, 5 m. W. of Dingwall by a branch of the L.M.S. railway. Pop. (1921), 875. It lies in a valley, sheltered on the west and north. There are several sulphurous and chalybeate springs, in great repute for the cure of rheumatism, skin diseases and anaemia, and Strathpeffer is a popular resort. The ascent of Ben Wyvis is commonly made from Strathpeffer.

STRATHSPEY, Scottish dance believed to have had its origin in the 18th century in the valley, or strath, of the Spey, whence its name.

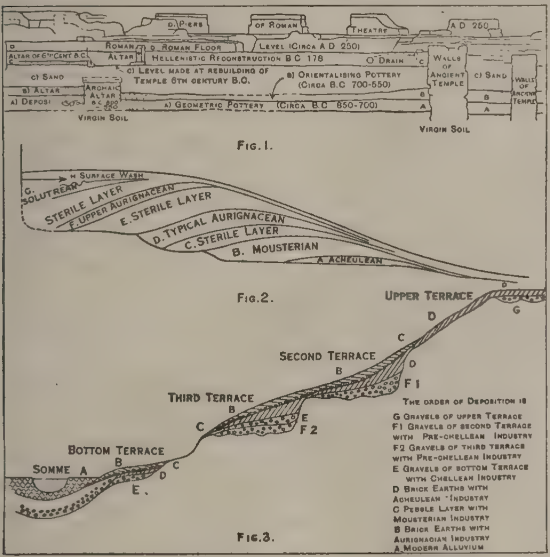
STRATIGRAPHY is a branch of science which may be defined as the study of the relative position and order of succession of deposits containing or separating archaeological material.

Observation of strata is now acknowledged to be as fundamental to archaeology as the equivalent study of the superposition of rocks and their fossil contents is to geology.

Stratified deposits may be classified under three main headings (1) Archaeological, (2) Archaeological and Geological, (3) Geological.

(1) A purely artificial accumulation, as on a town or settlement site of historic or comparatively late prehistoric age. In this case superposed buildings may amplify the stratigraphical information obtained primarily from pottery sequences.

The section through the Temple of Artemis Orthia at Sparta (fig. 1) is a fine example of stratigraphical work yielding chronological information covering at least 1,000 years. Study of this section shows the older deposits divided from the newer by a sand stratum. The lower levels, (a) and (b), dated by their respective potteries, cover the period of an early temple represented by an altar and walls. The sacrificial deposits are of unequal thickness on both sides of the altar, indicating that one side was kept clear for officiation. The altar was therefore in existence while the surrounding strata were accumulating. Contrasted with this is the uniformity of level near the walls, showing that these are more recent than the deposits through which they were cut. This early temple appears to have been destroyed by flood, and our next period (c) belongs to rebuilding in the 6th century B.C. The site was artificially levelled up by a sand deposit of 1½ metres thick in order to raise the new temple above flood level.


D. Piers
of Roman
Theatre
A D 250
D
Roman
D Roman Floor
Level (Circa A D 250)
Altar of 6th Cent B.C.
C
Altar
Hellenistic Reconstruction B C 178
O Drain
C
Walls of Ancient Temple
c) Sand
c) Level made at rebuilding of Temple 6th century B.C.
B) Orientalising Pottery (Circa B.C 700-550)
c) Sand
Walls of Ancient Temple
B) Altar
Archaic Altar B.C. 800–550
B
B
A) Deposi
A) Geometric Pottery (Circa B.C 850-700)
A
A
Virgin Soil
Virgin Soil
Fig. 1.
H Surface Wash
G. Solutrean
Sterile Layer
F. Upper Aurignacean
E. Sterile Layer
D. Typical Aurignacean
C. Sterile Layer
B. Mousterian
A Acheulean
Fig. 2.
Upper Terrace
G
D
C
Second Terrace
B
D
F 1
Third Terrace
B
E
C
F 2
Bottom Terrace
B
Somme A
C
D
E
Fig. 3.
The order of Deposition is
G Gravels of upper Terrace
F1 Gravels of second Terrace with Pre-Chellean Industry
F2 Gravels of third terrace with Pre-Chellean Industry
E Gravels of bottom Terrace with Chellean Industry
D Brick Earths with Acheulean Industry
C Pebble Layer with Mousterian Industry
B Brick Earths with Aurignacian Industry
A Modern Alluvium

BY COURTESY OF THE BRITISH SCHOOL AT ATHENS

FIG. 1.—SECTION OF SANCTUARY OF ARTEMIS ORTHIA, SPARTA
FIG. 2.—SECTION OF ROCK SHELTER OF LAUSSEL. (AFTER LALANNE)
FIG. 3.—CROSS SECTION OF RIVER SOMME, (AFTER COMMONT)

The Greek altar and associated deposits belong to this period. This building remained in use until a Hellenistic reconstruction about 178 B.C. (d) The Roman period is superimposed, beginning about 350 years later; that the Hellenistic temple was then still in use is suggested by the Roman altar; also by the position of a Roman theatre, built *around* the temple area. Inscriptions, ranging from the 4th century B.C. to A.D. 225 built into the foundations of the theatre prove that it can hardly be earlier than A.D. 250, since a stele is unlikely to have been thrown aside less than 25 years after its erection.

(2) A combination of natural and artificial conditions, best exemplified by cave deposits, showing strata of early human occupation, interbedded with strata of geological formation such as stalagmitic floor, or flood-borne silt. Caves (*q.v.*) and rock-shelters were primitive man's abode both before, during, and after the last great ice-age. Here he left his flint and bone implements (not less valuable to archaeologists as period-indicators than the pottery remains of later times), his hearths and the bones of wild beasts killed for food, unconsciously building up, little by little, over a period of many thousand years, in conjunction with geological agencies, a stratigraphy as certain as a town mound. Cave deposits may attain a vertical depth of 45ft. The inequalities of a cave floor render it improbable that the superimposed deposits will be horizontal or evenly distributed. In many cases one well-defined stratum of a series may contain relics of more than one period, and the level in it, at which archaeological transition or change becomes apparent, may be missed unless suitably fine horizontal sub-divisions have been made by the excavator.

In the section through the Rock Shelter at Laussel, S. France (fig. 2) we see strata tilting and overlapping. The oldest deposits (a) and (b) of lower and middle palaeolithic age lie some distance from the sheltering cliff. There follows a long interval (c) when the site was abandoned and cliff detritus and humus raised the level. (d) Upper palaeolithic man returned and resumed discontinuous occupation (f) and (h). Deposits (a)–(h) cover probably a period of at least 25,000 years. The section illustrates interestingly the confusion in interpretation of sequence which would result from unsuitable methods of excavation such as a horizontal trench driven in from the side.

Stratigraphical conditions such as (1) and (2), each with numerous variants, fall within the domain of archaeology. There comes, however, a point at the beginning of the human record when archaeological stratigraphy merges into pure geology. (3) River-terrace gravels illustrate this category.

The major river valleys frequently show old terraces of sand and gravel occurring at various heights above the present stream. These mark former levels of the river when the flow of water was augmented either actively by periods of increased rainfall, or by the melting of glaciers, or passively by change of valley slope, or variation of sea-level. In many cases these old terraces contain fossil animal remains and palaeolithic flint implements of different ages. In the case of river gravels, however, the usual law of stratigraphical sequence as shown in (1) and (2) is inverted; the highest terrace will normally (though not invariably) have been deposited first, and will contain the oldest material, whilst the formation of the lower terraces will be episodes in the later degradation of the river bed. Material from the older deposits may consequently be washed into the later ones; the true age of an alluvial deposit is that of its most recent content.

The cross-section of the Somme near St. Acheul, France (fig. 3) shows that river gravel stratigraphy is rendered additionally complex by reason of over-lying deposits of later date which cover older and younger terraces alike, containing in their turn archaeological material.

See J. P. Droop, *Archaeological Excavations* (1906). (G. C.-T.)

STRAUBING, a town in the republic of Bavaria, on the Danube, 25 m. S.E. of Regensburg, by rail to Passau. Pop. (1925) 23,593. Straubing is a town of remote origin, believed to be identical with the Roman station of *Sorbiodurum.* In definite history, however, it is known only as a Bavarian town, and from 1353 to 1425 it was the seat of the ducal line of Bavaria-Straubing. Its oldest building is the tall square tower dating from 1208. It has eight Roman Catholic churches, among them being the church of St. James, a handsome Late Gothic edifice, the old Carmelite church and that of St. Peter. It has also a Gothic town hall, and a castle. The industries are iron and tin founding, tanning and brewing, the manufacture of machinery and chemicals and trade in wine and cattle.

STRAUSS, DAVID FRIEDRICH (1808–1874), German theologian and man of letters, was born at Ludwigsburg, near Stuttgart, on Jan. 27, 1808. He was educated at the evangelical seminary of Blaubeuren and at the university of Tübingen. After a short interval of teaching he went to Berlin (1831), but Hegel died just at the time of his arrival, and of Schleiermacher's lectures only those on Jesus interested him. But he mixed with the disciples of Hegel, and conceived the main idea of his two great works—the *Leben Jesu* and the *Christliche Dogmatik.* He returned to Tübingen, where he lectured for a time, but soon found it necessary to give his whole energies to the preparation of his book, the *Leben Jesu* (1835). The work produced an immense sensation by its destructive method. In 1837 Strauss replied to his critics (*Streitschriften zur Verteidigung meiner Schrift über das Leben Jean*). In the third edition of the work (1839), and in *Zwei friedliche Blätter,* he made important concessions to his critics, which he withdrew, however, in the fourth edition (1840; translated into English by George Eliot, with Latin preface by Strauss, 1846). In 1840 and the following year he published his *Christliche Glaubenslehre* (2 vols.), the principle of which is that the history of Christian doctrines is their disintegration.

Between the publication of this work and that of the *Friedliche Blätter* he had been elected to a chair of theology in the university of Zürich. But the appointment provoked such a storm of popular ill will in the canton that the authorities pensioned him off before he was installed. With his *Glaubenslehre* he took leave of theology for upwards of twenty years. He then published a series of biographical works, which secured for him a permanent place in German literature (*Schubarts Leben,* 2 vols., 1849;

Christian Märklin, 1851; *Nikodemus Frischlin,* 1855; *Ulrich von Hutten,* 3 vols., 1858–1860, 6th ed. 1895; *H. S. Reimarus,* 1862).

With this last-named work he returned to theology, and two years afterwards (1864) published his *Leben Jesu für das deutsche Volk* (13th ed., 1904). His *Christus des Glaubens und der Jesus der Geschichte* (1865) is a severe criticism of Schleiermacher's lectures on the life of Jesus, which were then first published. From 1865 to 1872 Strauss resided in Darmstadt, and in 1870 published his lectures on *Voltaire* (9th ed., 1907). His last work, *Der alte und der neue Glaube* (1872; 16th ed., 1904; English translation by M. Blind, 1873), caused some consternation among his friends. Like all his critical works it suffered from his lack of critical study of the texts themselves.

Authorities.—Strauss's works were published in a collected edition in 12 vols., by E. Zeller (1876–78), without his *Christliche Dogmatik.* His *Ausgewählte Briefe* appeared in 1895. On his life and works, see E. Zeller, *David Friedrich Strauss in seinem Leben und seinen Schriften* (1874); A. Hausrath, *D. F. Strauss und die Theologie seiner Zeit* (2 vols., 1876–78); F. J. Vischer, *Kritische Gänge* (1844), vol. i., and by the same writer, *Altes und Neues* (1882), vol. iii.; R. Gottschall, *Literarische Charakterköpfe* (1896), vol. iv.; S. Eck, *D. F. Strauss* (1899); K. Harraeus, *D. F. Strauss, sein Leben und seine Schriften* (1901); and T. Ziegler, *D. F. Strauss* (2 vols., 1908–09).

STRAUSS, JOHANN (1804–49), Austrian orchestral conductor and composer of dance-music, was born at Vienna on March 14, 1804. He began as violinist in a small orchestra and then, after acting for a time as deputy conductor, formed a small band of his own, which he introduced to the Vienna public during the carnival of 1826 at the Schwan, in the Rossau suburb, where his famous *Täuberl-Walzer* (op. 1) at once established his reputation as the best composer of dance-music then living. Later he was appointed kapellmeister to the 1st Bürger Regiment, and charged with the duty of providing the music for the court balls. With the growth of his fame so did the size of his orchestra increase until it ultimately numbered over 200 performers. In 1833 he began a long series of tours throughout northern Europe, eventually visiting England in 1838. Back in Vienna, he appeared eventually in the Imperial Volksgarten, which thenceforth became the scene of his most memorable successes, his conducting being marked by a quiet power which ensured the perfection of every minutest *nuance.* He revisited London in 1849, and, after his farewell concert, was escorted down the Thames by a squadron of boats, in one of which a band played tunes in his honour. This was his last public triumph. He died in Vienna on Sept. 25, 1849.

Strauss was survived by three sons—Johann (1825–99), Joseph (1827–70) and Eduard (1835–1916), all distinguished as composers of dance-music. To Johann was due the most famous of all the waltzes associated with the name of the family, *An der schönen blauen Donau* (*The Blue Danube*), and many popular operettas, of which *Die Fledermaus* is the best known.

STRAUSS, RICHARD (1864–), German composer, was born at Munich on June 11, 1864, the son of Franz Strauss, an eminent hornist. To some extent a prodigy, Strauss was something of a pianist at four, a composer at six, and at ten he was already seriously studying music under F. W. Meyer. He had passed through the gymnasium and the university, and his music studies had been thorough. To Bülow, and even more to Alexander Ritter, Strauss owed the awakening in his own mind of the interest in the modern development of music.

In 1885 Strauss succeeded Bülow as conductor of the Meiningen orchestra, but the appointment was held only for a few months, since in April of this year Strauss resigned his post in order to travel in Italy, and on his return in the early autumn he became 3rd conductor of the Munich Opera under Hermann Levi. Four years later he was installed in Weimar as Hofkapellmeister, but once again he held his post for only a brief period, for in 1894, the year of his marriage to Pauline de Ahna, the eminent singer, he was promoted to be 1st conductor at Munich. Between these various appointments and that of Hofkapellmeister in Berlin (1899) Strauss travelled considerably in the Near East and over Europe. He conducted a performance of *Elektra,* in Beecham's season at Covent Garden in the spring of 1910, and again in 1913 (when his *Ariadne auf Naxos* was given at His Majesty's), in 1914 (when he conducted his *Legend of Joseph* at Drury Lane), in 1923 and 1926.

Of the early period of Strauss the composer there is little of importance to be said. Indeed it has often been said that signs of the real Strauss are not to be perceived before his *Don Juan* (op. 20) and *Macbeth* (op. 23). A year only divided *Macbeth* (1887) from *Don Juan* (1888). *Tod und Verklärung* (1889) is a sensational work. Between it and *Till Eulenspiegels lustigen Streiche* (1894), Strauss's first opera, *Guntram,* finds place (first performance, Weimar, 1894), the latter a work that in spite of much *réclame* for the composer failed to hold a position upon the stage. In *Till Eulenspiegel,* one of the most brilliantly clever scores ever penned, is to be found a sense of fun that is worthy of note (as of emulation), and it is perhaps worth recording that no more noteworthy example of the rondo form exists in modern music, while its approximate successor, *Don Quixote* (1897), is an equally outstanding example of the variation. In *Don Quixote* (1897) his zenith as a musical realist was reached. In between came another symphonic poem on the most ambitious scale inspired by and named after Nietzsche's *Also sprach Zarathustra* (1895), which stirred up more temporary strife than any of its predecessors, if not so much perhaps as was aroused later by the production of *Ein Heldenleben* (1898), or by the comparatively ingenuous *Symphonia domestica* (1904).

Up to 1910 Strauss had composed four operas. Of these *Guntram* was on frankly Wagnerian lines and had little success, *Feuersnot,* on the other hand, despite the fact that it is largely in the nature of a satirical skit at the expense of Munich and its citizens, remained sufficiently alive to have merited performance at His Majesty's theatre, London, under Thomas Beecham's direction in July 1910. At Covent Garden in March 1910 *Elektra* was played to crowded houses and aroused great discussion by reason of what was then regarded as its unbridled violence and sensationalism. And later came the not less novel and startling setting of Oscar Wilde's *Salome,* first produced at Dresden in 1905 and afterwards performed at Covent Garden.

A still more important work than any of these was the gay and melodious *Der Rosenkavalier,* which has at the same time such depths of tenderness and romance, which was first brought out at Dresden in 1911 and since then has won friends in all parts of the world. Later came *Ariadne auf Naxos,* forming part originally of a semi-musical setting of Molière's *Le Bourgeois Gentilhomme* but subsequently re-arranged as an independent work. This was followed after the dramatic ballet *The Legend of Joseph,* by *Die Frau ohne Schatten* (*The Woman without a Shadow*), first heard at Vienna in 1919 and containing some of the finest music which the composer has written for the stage; to which were subsequently added a "comic play-opera" *Intermezzo* (with text by the composer) and a ballet-pantomime *Schlagobers* (*Whipped Cream*), both produced at Vienna in 1924; and another opera *Helen of Egypt,* first performed in 1928.

In addition to his operas and big orchestral works Strauss has written also many songs, including some of the finest quality. Not a few of the hundred and more of them could be cited indeed in support of his claim to be regarded as a true descendant of the royal line of German song writers.

STRAVINSKY, IGOR FEDOROVICH (1882–), Russian composer, was born at Oranienbaum, near Leningrad, on June 5 (old style), 1882. He first studied law, and it was on Rimsky-Korsakov's advice that he finally made music his career. His first work, a symphony, was followed by other orchestral pieces. In 1910 he wrote his first ballet, *The Firebird,* for Diaghilev's Russian company, with which he was afterwards so closely associated. This made an immense impression on musicians and the public by the extreme novelty of its construction. It was followed by *Petrushka* (1912), usually considered his masterpiece, and *Le Sacre du printemps,* which was produced in 1913 in Paris. He then wrote an opera on Andersen's "The Nightingale" (1914). This was not a success, and in 1917 he re-wrote the second and third acts as a symphonic poem, "The Song of the Nightingale," and also staged it as a ballet. Next came *Renard* (1915), *L'Histoire du Soldat* (1917), *Pulcinella,* a ballet with songs after Pergolesi, performed in Paris in 1920, a one-act opera *Mavra* (1921) and *Les noces villageoises* (1923).

His latest oratorio-opera, *Oedipus Rex* (1928), possesses some features of remarkable interest. In it he goes back to classical drama, achieving at last almost complete objectivity. The dramatic interest resides in the vocal parts, the orchestra providing often a mere accompaniment of transparent texture and moving statuesquely, with practically no thematic development and a preponderance of wind over strings. The text is in Latin and the chorus is a male one. Against this sober background the solo voices are treated with extraordinary freedom. To the year 1928 belongs the remarkable ballet, *Apollo Musagetes*.

Besides his works for the stage he has written a symphony for wind instruments (1920), rag-time for small orchestras, Concertino for string quartets, *Pribaoutki* (Chansons plaisantes) for voice and eight instruments, *Berceuses du chat* for voice and three clarinets; *Etude* for pianola; *Pastorale,* wordless song with piano; rag-time music and a sonata (1925) for piano, etc.

STRAW AND STRAW MANUFACTURES. Straw is the generic name applied to the dried stems or stalks of certain cereals such as wheat, barley, oats and rye.

The first use of straw was probably as bedding or floor coverings for mankind or as fodder and litter for cattle. The value of straw for cattle was early recognized, for in making conditions of land tenure, it was, and still is, customary to prohibit the removal of the straw residue which, as litter, became the only fertilizing agent. Thatching for primitive shelters and body coverings for man were some of the succeeding utilitarian developments. Straw is now the raw material of many important industries, viz.—mat-making; the stuffing of bedding; the weaving of hats, plaits and baskets; twisting into ropelike bands for tying up sheaves and trusses of corn and hay and for rolling into "skeps" or beehives; for various methods of ornamentation; for the making of pulp for paper and the species of card board known as strawboard and the making of "envelopes" for the protection during transit of glass and earthenware. The two most important of these industries are the making of paper and strawboard and the weaving of plaits and hoods for hat making. For paper and strawboards any kind of straw can be used, the stalks are subjected to a chemical maceration and filtration, until the resultant pulp can be brought through the various necessary rolling mills.

In the plait and hood industry throughout the world, cereals are specially grown and carefully selected for good colour, length, lightness in weight and toughness. Certain soils are necessary for the growth of straw fulfilling these requirements. These are found in Beds., Bucks. and Herts., in England; Tuscany in Italy; on the eastern seaboard of China and in nearly all parts of Japan. These various centres employ different means of cultivation and of treatment of the stalks after growth. In England the wheat crop destined for plait is carefully mown by hand with a sickle or scythe, the stalks when thoroughly ripened are tied up, just below the ears, into small sheaves, the loose leaves at the knots are removed by means of a special comb, leaving only the pipes of the straw which are finally cut up into suitable lengths between the knots. In Tuscany, before the grain is fully ripened, the stalks are pulled up by the roots and spread out to be dried and bleached in the sun. The upper part of the stalk down to the first knot, being exposed to the elements during growth, develops a colour known as "Tuscan" and is termed *punta* or point. This part of the straw is used for making the well-known "Leghorn" hats, as well as for plaits of many designs under the generic name of "Tuscan." The lower portion of the stalk, when denuded of its sheath, is of a pearly white colour and is called the *pedale* or foot. This is lighter in weight than the *punta* and is utilized for hats and plaits of high quality under the name of "Pedal." China and Japan follow these methods as the nature of the straw or the soil may require.

Varieties of Straw Hats.—Straw hats comprise: (1) those made of plaits sewn in overlapping rows either by hand or machine, (2) those woven like a basket called hoods, (3) those, like the "Leghorn" which are made of plaits laid edge to edge. These last have, for fixing the rows of plait together, a fine cord threaded through the loops resulting from each bend of the strand of straw at the turn of the pattern, which when tightened interlocks the rows in such a manner as to conceal the cord entirely, forming when finished practically a flat surface, while the sewn hats, having each row overlapping the next with the stitch taken through, present a fuller and richer appearance. Hoods are woven in various "wattle" and "criss cross" patterns of plain or fanciful nature. All methods commence at the centre of the top of the crown and the starting spiral or knot is termed the "button." In addition to the "Panamas" and "Brazilians," there are the Yedda, Hemp, Raffia, Bowen, Buntal Rush, Java, Bankok and Manila Hoods which, although in the plait and hat trade are called straws are of other vegetable fibres. They are all of exotic growths; the well known "Panama" derives its name from the locality from which it was first exported 300 years ago; the area of its production has since greatly extended, Ecuador and Colombia being now important centres of manufacture. The names of Bankoks, Brazilians, Javas and Manilas announce their source; yeddas and bowens come principally from Sumatra; rush hats are made in vast quantities in China; raffias emanate from the islands of the Caribbean Sea; Hemps of all kinds of patterns in plaits and hoods come from Switzerland, Italy, China and Japan. Hats such as "Panamas" and "Brazilians" have also been made at European centres, viz., St. Albans (England), Dresden (Germany), and Nancy (France), from fibres of exotic origin.

The making of plaits or braids for sewing to shape is of much more recent origin than the weaving of hats or hoods and this development was introduced into Scotland by Mary Queen of Scots in 1552. After the accession of her son, James I., to the English throne, the industry migrated towards the south and settled in the district between Dunstable (Bedfordshire) and Hemel Hempstead (Herts.) in the early days of the 17th century. From that date hats and bonnets were all made or sewn by hand until 1870, when the first hat was machine sewn in Luton (Bedfordshire). Many machines have been invented for the sewing of plait, of which only three varieties are now extensively in use. The 1870 type machine, greatly improved, has a visible stitch similar to that of an ordinary domestic sewing machine: another type, subsequently invented, has a specially designed mechanism by means of which the concealed stitch of handsewing is closely imitated; these produce the overlapping row result, but in the third and latest machine a zig-zag stitch provides for the sewing of plaits edge to edge.

The sulphur and acid processes, for some centuries the only methods of bleaching straws, have been replaced by a process known as "Monopol," by which all tones of white, from paper to ivory, can be obtained. In like manner, the old time logwood fustic, sumac, copperas and other similar dyestuffs have been superseded by aniline and alizarine processes. Hats and hoods are stiffened with gelatine size, and after drying are blocked into the required shape with the acid of damp heat and pressure, either by hand, or by hydraulic or vacuum machines. (H. I.)

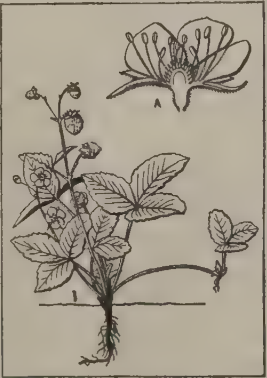


FIG. 1.—WILD STRAWBERRY (FRAGARIA VESCA), IN FLOWER AND FRUIT

A. Longitudinal section through flower (enlarged)

STRAWBERRY, in botany, a species of the genus *Fragaria,* notable for the character of the fruit. The genus consists of about ten species, native of the north temperate regions of both hemispheres, as well as of mountain districts in warmer climes; one species is found in Chile. The tufted character of the plant, and its habit of sending out long slender branches (runners) which produce a new bud at the extremity, are well known. The leaves have usually three leaflets palmately arranged, but the number of leaflets may be increased to five or reduced to one. The flower has the typical structure of members of the family Rosaceae: the so-called fruit is peculiar. The floral axis swells out into a fleshy, dome-shaped or flattened mass in which the carpels or true fruits, commonly called pips or seeds, are more or less embedded but never wholly concealed. A ripe strawberry in fact may be aptly compared to the "fruit" of a rose turned inside out.

The common wild strawberry of Great Britain, which indeed is found throughout Europe and a great part of temperate Asia and North America, is *F. vesca*, and this was the first species brought under cultivation in the early part of the 17th century. Later on other species were introduced, such as *F. elatior*, a European species, the parent stock of the hautbois strawberries, and especially *F. virginiana* from the United States and *F. chiloensis* from Chile. From these species, crossed and recrossed in various manners, have sprung the vast number of different varieties now enumerated in catalogues, whose characteristics are so inextricably blended that the attempt to trace their exact parentage or to follow out their lineage has become impossible. The varieties at present cultivated show wide variations in the size, colour and flavour of the fruit, in season of ripening and in liability to disease.

The larger-fruited sorts are obtained by crossing from *F. chiloensis* and *F. virginiana*, and the smaller alpines from *F. vesca*. The alpine varieties should be raised from seeds; while the other sorts are continued true to their kinds by runners. New varieties are obtained by judicious crossing and seeding.

For further details *see* G. Bunyard, "The History and Development of the Strawberry," *Jour. Roy. Hortic. Soc.* (1914). For cultivation *see* T. W. Sanders, *Encyclopaedia of Gardening* (1912); L. H. Bailey, *Standard Cyclopedia of Horticulture* (1914–27).

STRAWBERRY-TREE (*Arbutus Unedo*), a beautiful ornamental tree of the heath family (Ericaceae, *q.v.*), native to southern Europe and also to south-western Ireland (Killarney), and widely planted in warm countries. It grows from 10 to 30 ft. high and has smooth red bark, which peels in thin plates, and oblong, glossy, dark-green leaves. The white or rose-coloured flowers, arranged in short, drooping clusters, are borne in autumn intermingled with the scarlet granular berries, about ¾ in. across, which ripen only the second season after flowering. (*See* MADROÑO.)

STRAWBOARD: *see* CARDBOARD.

STRAW HATS: *see* HAT MANUFACTURE.

STRAYS, a term used in radio to denote electromagnetic disturbances in reception other than those produced by radio transmitting systems.

STREATHAM, a large residential district in the south of London, England, within the municipal borough of Wandsworth. The name appears to indicate its position on an ancient "street" or highway. According to Domesday Book, Streatham included several manors, two of which, now Tooting and Balham, belonged to the abbot of St. Mary de Bec in Normandy.

STREATOR, a city of La Salle county, Illinois, U.S.A., on the Vermilion river, 90 m. S.W. of Chicago. It is served by the Burlington Route, the Chicago and Alton, the New York Central, the Santa Fé, the Wabash and the Illinois Traction (electric) railways. Pop. 15,779 in 1920 (79% native white); estimated locally at 18,000 in 1928. It is in the heart of the corn belt and the Vermilion coal-field, and there are deposits of clay and shale. The first settler in the immediate vicinity came from Virginia, in 1831. About 1860, after coal had been discovered, a village grew up along the bluff (called Hard Scrabble, from the difficult climb up from the river ford, and later Unionville) and in 1866 the Vermilion Coal Company (whose president was W. L. Streator) began mining on a large scale. The town was planned in 1868, incorporated as a village in 1870, and in 1882, when the population was about 6,000, was chartered as a city.

STREET, GEORGE EDMUND (1824–1881), English architect, was born at Woodford in Essex on June 20, 1824 and died on Dec. 18, 1881. He was the third son of Thomas Street, solicitor. He was educated at Mitcham and at the Camberwell collegiate school. In 1841 he became a pupil of Mr. Owen Carter at Winchester. Afterwards he worked for five years as an "improver" with Sir George Gilbert Scott in London and in 1849 began to practice on his own account. At an early age Street became deeply interested in the principles of Gothic architecture, and studied the finest examples of mediaeval buildings in England and on the Continent. In 1855 he published a well-illustrated work on *The Brick and Marble Architecture of Northern Italy*, and in 1865 a book on *The Gothic Architecture of Spain*.

His most important works were the nave of Bristol Cathedral, the choir of the cathedral of Christ Church in Dublin, and the new courts of justice in London for which in June 1868 Street was appointed sole architect; but the building was not complete at the time of his death. He was elected an associate of the Royal Academy in 1866, and R.A. in 1871; and he was professor of architecture to the Royal Academy. Street was buried in the nave of Westminster Abbey.

See A. E. Street, *Memoir of G. E. Street, R.A.*, 1888.

STREET CRIES. The itinerant vendor has always adopted a distinctive cry to draw attention to his wares, and, as a French writer says, the origin of these cries "se perd dans la nuit des temps." The earliest record that we possess in English is that given in the *New English Dictionary* of a cry of 1393: "Kokes and here knaues crieden hote pyes hote"—a cry which with but slight variation was preserved to the close of the 18th century. The earliest collection of street cries is to be found in the 14th century poem, *London Lackpenny*. The author of this poem is, on John Stow's authority, John Lydgate (1370–1450), a Benedictine monk of the abbey of Bury St. Edmunds. Among the many cries here included are those of "Hot peascods," "Strawberries ripe and cherries in the rise." *Pammelia: Musicke's Miscellanie* was published in 1600–18 and contains a number of cries, but the most important collection of the time is P. Tempest's *The Cryes of Old London* (1668), a work with which Samuel Pepys was familiar. In Smollett's *Humphrey Clinker* it will be recalled that the author protests against "noisy rustics bellowing 'green peas,' " and Herrick long before had introduced stray street cries in his *Hesperides*. The cries of Paris are of very remote origin and *Le Livre des Mestiers* contains examples of the time of Saint Louis; Guillaume de la Villeneuve compiled a famous collection known as *Les Crieries de Paris*. As in London and elsewhere the incunabula of the street cries of Paris are rich in pictorial illustration, and the old collections provide a perfect mirror of the times. Every town possesses its distinctive cries, but, save when there are enthusiasts such as Annibale Carracci (1560–1609), who has preserved those of old Bologna, these are hard to come by.

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STRELITZ, a body of Russian household troops originally raised by the tsar, Ivan the Terrible, in the middle of the 16th century (*Strjeltsi*). They numbered 40,000 to 50,000 infantry, and formed the greater part of the Russian armies in the wars of the 16th and 17th centuries. They were a fierce and ill-disciplined force, individually brave and cruel in war. In 1698 they rose in mutiny for the last time. Crushed in battle by Peter's general, Patrick Gordon, they ceased to exist as a military force, and about 2,000 of them were barbarously tortured and put to death.

STRENGTH OF MATERIALS: *see* MATERIALS, STRENGTH OF.

STRESA, a village of Piedmont, Italy, in the province of Novara, situated on the west side of Lago Maggiore, on the Simplon railway, 10 m. N. of Arona, 673 ft. above sea-level. Pop. (1921), 2,051. It is remarkable for the beauty of its scenery and for its fine villas, and is a favourite health resort.

STRESEMANN, GUSTAV (1878–1929), German statesman, was born in Berlin on May 10, 1878, son of Ernst Stresemann, a wholesale beer merchant. He was educated at the Berlin gymnasium and at the universities of Berlin and Leipzig, where he studied philosophy and political economy, and became prominent as leader of the *Allgemeiner deutscher Burschenbund*. After receiving his doctorate, he entered Saxon industry, first as assistant, afterwards as Syndic. The industry of Saxony was at the time disunited and neglected by the authorities; but Stresemann's energy promoted its union in the *Verband sächsischer Industrieller*, and its advance to the first place in the great *Bund der Industriellen* for all Germany. The *Bund der Industriellen* was a keen antagonist of the *Zentralverband der deutschen Industrie,* the central association of the heavy industry. Stresemann's energy and capacity for organization raised his own association into a position in which it could effectively counter the "heavy industry" and agrarian influences everywhere in Germany. Simultaneously he secured for the finishing industries proper influence in the Saxon Chambers; he himself entered the German Reichstag at the age of 28. His brilliant oratorical gifts and his activity attracted the attention of Bassermann, the leader of the National Liberal party, to which Stresemann belonged. Bassermann and Stresemann were among the leading figures in the pre-war German Reichstag.

War and Revolution.—Stresemann, who became the leader of the National Liberal party in 1917, on Bassermann's death, advocated energetic prosecution of the war, while also urging that Germany should be prepared for peace, if acceptable peace terms were offered her. He was one of the sharpest opponents of Bethmann-Hollweg, whom he reproached with indecision and weakness.

After the outbreak of the revolution and the defeat of Germany, Stresemann tried to unite the forces of Liberalism in Germany, and after the failure of this attempt, founded the German People's party, as successor of the National Liberal party. This party was at first monarchist, but gradually changed to republicanism, as Stresemann himself did. In the Weimar National Assembly Stresemann voted for rejection of the Treaty of Versailles, which he considered intolerable and impossible for Germany to fulfil. The German People's party, led by him, soon, however, entered the Government, left it again a little later, and re-entered it in 1923, after which date the party, through Stresemann, exercised a strong influence over Government policy.

Reconstruction.—When the struggle in the Ruhr (*q.v.*) was at an end and the mark currency in complete collapse; when separatist movements, supported by France, in the Rhineland, Fascist movements in Bavaria and Communist movements in Saxony and Thuringia threatened German unity, Stresemann took office as chancellor and minister of foreign affairs, at the head of the so-called "Grand Coalition," embracing all parties from the Social Democrats to the German People's party. He assumed the responsibility for liquidating the battle in the Ruhr, and attempting to open up negotiations with France. The basis for this was afforded by the Dawes report. In domestic policy, this ensured the stabilization of the currency which Stresemann carried through with the help of Hilferding and afterwards Luther, as ministers of finance; it paved the way for an international loan for Germany to restart her industrial life, and fixed Germany's next payments, and called for the restoration of Germany's economic sovereignty in the Rhineland.

Stresemann resigned his Chancellor's portfolio when the Social Democrats refused to follow him, on account of the most energetic measures which he took against the Communists in Saxony. He retained the portfolio of Foreign Affairs in the succeeding cabinets formed by Marx, Luther, Marx again, and Müller. On signing the agreement based on the Dawes plan in London, Stresemann succeeded in obtaining the evacuation of the Ruhr and of the towns of Düsseldorf, Duisburg and Ruhrort, under certain conditions.

The peace policy which Stresemann—as Briand explicitly admitted—had inaugurated, led eventually to the signature of the Locarno Pact (*q.v.*), the first attempt to find a European solution on a peaceful basis, which also resulted in Germany's entry into the League of Nations. Stresemann's services in the cause of European peace were recognized by the award of the Nobel Prize. Despite many difficulties, he continued undaunted to work for the further development of peace, and was one of the first to declare his readiness to sign the Kellogg Pact.

Stresemann married Käthe Kleefeld, by whom he had two sons. He died at Berlin on Oct. 3, 1929.

His collected speeches and writings have been issued under the title *Stresemanns Reden und Schriften* (2 vols.). *See* the biography (1928) by Rochus von Rheinbaben (Eng. trans. *Stresemann, the Man and the Statesman,* 1929). (R. Fr. v. R.)

STRETTO (It. *Strignere,* to pull close), musical term signifying the device in fugal writing whereby subject and answer are brought closer together and thereby made to overlap, the one beginning before the other is ended. (*See* Fugue.)

STREUVELS, STYN (1871–), pen name of Frank Lateur, Flemish writer, and the nephew of the priest-poet Guido Gezelle. For a long time he worked as a pastry cook at Avelghem in Flanders and then settled down at Ingoyghen, close by, in order to devote himself entirely to literature. Essentially a man of the soil, he nevertheless possessed a delicate artistic sensibility and acquired considerable literary culture. He was the most popular writer of his time in Flanders and enjoyed a great reputation in Holland, although he frequently introduces the Western Flemish dialect into his writings. Many of his novels have been translated. *De Vlaschaard* (1907) is considered his best work.

STRICKLAND, AGNES (1806–1874), English historical writer, was born in 1806, the third daughter of Thomas Strickland, of Reydon Hall, Suffolk. Her first literary efforts were historical romances in verse in the style of Walter Scott. With the assistance of her sister, she wrote *The Lives of the Queens of England* (12 vols. 1840–49) from Matilda of Flanders to Queen Anne. Agnes Strickland was a warm partisan on the side of royalty and the church, but she made industrious study of official records and public documents. Of many historical works her last was the most important—*Lives of the Last Four Stuart Princesses* (1872). In 1871 she obtained a civil-list pension of £100. She died on July 8, 1874.

A *Life* by her sister, Jane Margaret Strickland, appeared in 1887.

STRICKLAND, HUGH EDWIN (1811–53), English naturalist and geologist, born at Righton, Yorkshire, on March 2, 1811, was educated privately and at Oriel college, Oxford, where he studied under Kidd and Buckland. He accompanied William John Hamilton (1805–67) in 1835 through Asia Minor, the Thracian Bosporus and the Island of Zante. In 1836 Strickland brought before the Geological society several papers on the geology of these districts and on the drift deposits in Worcester and Warwick, drawing particular attention to the fluviatile deposits of Cropthorne in which remains of hippopotamus, etc., were found. With Murchison he read an important paper "On the Upper Formations of the New Red Sandstone System in Gloucestershire, Worcestershire and Warwickshire" (*Trans. Geol. Soc.,* 1840). He drew up the report (1842) of a committee appointed by the British Association to consider the rules of zoological nomenclature. He was one of the founders of the Ray society (est. 1844) for the publication of works on natural history which could not be undertaken by scientific societies or by publishers. In 1846 he settled at Oxford, and in 1850 was appointed deputy reader in geology. In 1852 he was elected F.R.S. He was killed accidentally on Sept. 14, 1853.

See Sir William Jardine, Bart., *Memoirs of H. E. Strickland* (1858); W. J. Hamilton, *Researches in Asia Minor, Pontus and Armenia* (1842).

STRIGIDAE: *see* Owl.

STRIKES AND LOCK-OUTS. A "strike" may be defined as a voluntary stoppage of work on the part of a body of workpeople, by common agreement or by order of their society or union, for the purpose of obtaining or resisting a change in the conditions of employment. The term "lock-out" came later into use to denote a stoppage of work in which, instead of the workpeople voluntarily withdrawing their labour, the employers lock their doors, as an act of industrial policy, against workpeople willing to work. In its most strict usage the term "lock-out" applies solely to cases in which employers lock-out their workpeople in order to bring to issue and settlement a state of friction which they regard as intolerable or in order to bring pressure to bear on a section who are on strike or otherwise recalcitrant—pressure calculated to constrain these latter to proceed with their work on the employers' terms.

Clear cases of "lock-out" coming within this narrow definition are not frequent in the history of industrial strife in Great Britain. Of the disputes which have occurred since the World War, those in the engineering industry in 1922, in the boilermaking trade in 1923, in the shipyards in 1924 and in the Rossendale slipper factories in 1927 could perhaps be described as "lock-outs" without any widespread objection being raised, but if the designation "lock-out" be confined to these and kindred cases, and all other disputes be called "strikes," then the number of "lock-outs" must appear as almost negligible beside the number of strikes.

I. GREAT BRITAIN

The following table, based on the official returns collected by the Board of Trade and by the Ministry of Labour, shows the number and importance of the trade disputes in Great Britain (including Northern Ireland) that have come to the knowledge of those departments in each of the years from 1893 to 1928:—

Year	Number of disputes *beginning* in year	Number of workpeople* involved in disputes *beginning* in year	Aggregate duration in working days of *all* disputes *in progress* during year
1893 . . .	599	634,000	30,440,000
1894 . . .	903	322,000	9,510,000
1895 . . .	728	259,000	5,700,000
1896 . . .	906	192,000	3,560,000
1897 . . .	848	229,000	10,330,000
1898 . . .	695	252,000	15,260,000
1899 . . .	710	179,000	2,500,000
1900 . . .	633	185,000	3,090,000
1901 . . .	631	179,000	4,130,000
1902 . . .	432	255,000	3,440,000
1903 . . .	380	116,000	2,320,000
1904 . . .	346	87,000	1,460,000
1905 . . .	349	92,000	2,370,000
1906 . . .	479	218,000	3,020,000
1907 . . .	585	146,000	2,150,000
1908 . . .	389	293,000	10,790,000
1909 . . .	422	297,000	2,690,000
1910 . . .	521	514,000	9,870,000
1911 . . .	872	952,000	10,160,000
1912 . . .	834	1,462,000	40,890,000
1913 . . .	1,459	664,000	9,800,000
1914 . . .	972	447,000	9,880,000
1915 . . .	672	448,000	2,950,000
1916 . . .	532	276,000	2,450,000
1917 . . .	730	872,000	5,650,000
1918 . . .	1,165	1,116,000	5,880,000
1919 . . .	1,352	2,591,000	34,970,000
1920 . . .	1,607	1,932,000	26,570,000
1921 . . .	763	1,801,000	85,870,000
1922 . . .	576	552,000	19,850,000
1923 . . .	628	405,000	10,670,000
1924 . . .	710	613,000	8,420,000
1925 . . .	603	441,000	7,950,000
1926 . . .	323	2,734,000	162,230,000
1927 . . .	308	108,000	1,170,000
1928 . . .	302	124,000	1,390,000

*Workpeople involved in more than one dispute during the year are counted more than once in the totals for the year. The extent of such duplication is not very considerable, except in the case of industries involved in the general strike in May, 1926, and in the coal-mining group, in which about 106,000 workpeople in 1912, 150,000 in 1919, 300,000 in 1920, 100,000 in 1921, and 41,000 in 1926 were involved in more than one dispute.

Fluctuations in Frequency of Disputes.—The most noticeable feature of the table is the immense variation in the figures as between one year and another.

These variations, however, are due mainly—as regards numbers involved and aggregate duration, almost entirely—to the occurrence in some years of quite a small number of great disputes. The year 1926 was an extreme instance of this. The great coal mining dispute of May–December in that year accounted, at the start, for about 1,050,000 workpeople, and for an aggregate duration of over 145 million days; while the general strike early in May accounted for 1,580,000 workpeople (the largest number ever involved in any one stoppage in Great Britain), and for 15 million working days. Apart from these two disputes, the year 1926 was exceptionally free from industrial disturbance, the remaining disputes numbering only 321, with 1[illegible]1,000 workpeople involved, and an aggregate duration of 2,030,000 days—numbers comparable with those for such exceptionally quiet years as 1903–5 and 1927.

Duration of Disputes.—The great majority of industrial disputes are of short duration, and involve relatively small numbers of men. On the average of the years 1910–25, nearly 46% of the disputes lasted less than a week, and more than 66% under a fortnight; while less than 14% lasted six weeks or over. In the same period 48% of the disputes involved under 100 workpeople, and nearly 68% under 250; while less than 11% involved as many as 1,000.

It often happens that disputes involving large numbers are also protracted. Thus, 82% of the total loss of time through disputes in the same period of years arose from the disputes—*less than 2% of the total number*—involving 5,000 workpeople and upwards. This is no doubt partly because a dispute can rarely or never be carried on for a long time unless, on the workpeople's side, it is supported by a powerful union. Conversely, a powerful union rarely or never engages in a dispute unless (i.) the subject matter of dispute is a substantial one, and (ii.) all ordinary measures of settlement have already been exhausted without success, which commonly implies that both parties are at once strong and determined.

The amount of time lost owing to industrial disputes varies enormously, not only from year to year, but also as between the different trades. Strikes and lock-outs are rare in agriculture, in the iron and steel trades, in the boot and shoe trade, and in the chemical industry. On the other hand, the coal mining industry and the engineering and shipbuilding trades have been much harassed by trade disputes, most of them short and involving relatively small numbers, but including also the five greatest disputes (measured by aggregate duration) which the country has ever experienced. These (which were all in the coal mining industry) were the prolonged stoppage of 1893, when nearly 300,000 workpeople in Yorkshire, Lancashire, and the Midlands were out from early in July to the middle of November; the stoppage of 1912, when the whole coal mining industry of the country was brought to a standstill by the demand of the Miners' Federation for the payment of an individual district minimum wage for all underground workers; and the three stoppages of 1920, 1921 and 1926, also on a national scale. These five disputes resulted in the loss of 21 million, 31 million, 16 million, 72 million, and 145 million working days, respectively; a total of 285 million days, or almost exactly the same as the time lost *in the whole of the remaining disputes (numbering nearly 25,000) of the entire period of 35 years covered by the table.* The largest amounts of working days lost outside the coal mining industry have been the 15 million working days lost in the general strike of 1926, and the 13 millions lost in the great engineering dispute of 1922. Industries occupying an intermediate position as regards frequency and extent of industrial disputes are the building trades (where disputes, though rather numerous, have usually been small and local), and the textile trades.

Causes of Disputes.—The causes of disputes are of course very varied, embracing all the matters relating to conditions of employment on which differences may arise between employers and employed. Experience shows, however, that the great bulk of disputes relate to questions of wages, a much smaller proportion to hours of labour, and the balance to a large number of miscellaneous questions, such as the employment of persons or classes obnoxious to the strikers on the ground that they do not belong to their union, or have worked against its interests, or because they are held to have no "right" to the particular occupation on which they are employed, either on account of not having gone through the recognized training or of belonging to another trade. Among this class of strikes are to be included the so-called "demarcation" disputes between two bodies of workmen as to the limits of their trades, which frequently cause suspension of work by both groups, to the great inconvenience of the employer. Strikes are also not uncommon on the question of trade unionism pure and simple—*i.e.*, to obtain or defend freedom to belong to a union, or to act through its agency in negotiations with employers.

This question enters more or less as a factor into a large number of disputes, most usually, however, as a secondary cause or object, so that it does not appear prominently in the tabulation of causes in the official statistics, which is based on principal causes only. Thus the formulated demands of the strikers are usually for improved conditions of work, the question of "recognition" of the trade union only arising incidentally when the parties attempt to negotiate as to these demands. The following table shows the percentages of workpeople *directly* involved in disputes, involving stoppages of work, respecting the undermentioned causes or objects, in 1918–27 in Great Britain and Northern Ireland.

Table Showing Causes of Disputes Involving Stoppages of Work

Year	Wage increases	Wage decreases	Other wage questions	All wage questions	Hours of labour	Employment of particular classes or persons	Other working arrangements, rules, and discipline	Trade unionism	Miscellaneous questions	Total
1918 . .	41·2	3·5	4·3	49·0	17·5	16·7	3·1	11·7	2·0	100·0
1919 . .	43·8	22·6	3·7	70·1	19·2	5·4	2·5	1·1	1·7	100·0
1920 . .	76·0	2·5	3·0	81·5	0·7	9·9	2·5	1·6	3·8	100·0
1921 . .	0·5	94·9	0·9	96·3	0·6	1·3	0·8	0·4	0·6	100·0
1922 . .	0·9	33·0	6·3	40·2	1·3	4·5	51·3	2·0	0·7	100·0
1923 . .	3·1	27·4	12·4	42·9	1·8	6·9	12·4	30·7	5·3	100·0
1924 . .	54·6	14·2	6·8	75·6	0·4	6·2	4·7	3·3	9·8	100·0
1925 . .	9·7	54·2	4·7	68·6	2·2	14·2	5·6	7·7	1·7	100·0
1926 . .	0·3	38·8	0·8	39·9	0·0	0·6	0·3	0·5	58·7	100·0
1927 . .	5·2	20·3	8·9	34·4	14·6	32·5	5·8	6·7	6·0	100·0

Questions of hours of labour, quite insignificant in most years, rise occasionally to importance as in 1916–19 when the great change over to the 47–48 hour week took place, and in 1927 when modifications of those hours were in question.

Results of Disputes.—Statistics may have a fictitious element of unknown amount in that one or both sides to a negotiation may ask for more than they expect to get. A trade union, scenting a demand for a reduction in wages, may put in, as a first tactical move, an application for an increase. If, after a few days' strike, the men were to forego the application and return to work on the old terms the settlement would be apparently a defeat but actually a victory—provided no more were heard of the threatened reduction. The statistics of settlement must be read in the light of such possibilities. They may be summarized as follows:—About 21% of the disputes of the years 1911–27, on the average, ended in favour of the workpeople; 22% ended in favour of the employers; and 57% were compromised. The variations from year to year were not very great, if number of disputes only be considered; but, if the number of workpeople involved be considered, the variations are greater, owing to the preponderating influence of a few large disputes in many years. Thus, the percentage of workpeople directly involved in disputes which ended in favour of the workpeople was 21, on the average; but the annual percentage varied from 1·5 in 1921 to 74·5 in 1912, in both cases owing to disputes on a national scale in the coal mining industry.

The following table gives the percentages of workpeople directly involved in disputes involving stoppages of work, with the results, for Great Britain and North Ireland, 1918–27:—

Table Showing Results of Settlement

Year	In favour of workpeople	In favour of employers	Compromised	Total
1918 . .	23·4	22·1	54·5	100·0
1919 . .	14·0	23·9	62·1	100·0
1920 . .	10·6	10·6	78·8	100·0
1921 . .	1·5	5·6	92·9	100·0
1922 . .	4·4	12·5	83·1	100·0
1923 . .	24·8	23·1	52·1	100·0
1924 . .	9·7	18·0	72·3	100·0
1925 . .	53·1	16·1	30·8	100·0
1926 . .	1·8	94·7	3·5	100·0
1927 .	28·1	30·6	41·3	100·0

It is, of course, to be understood that the figures in the above table only relate to the *immediate* results, as determined by the relative extent to which one or other of the parties succeed in enforcing their demands. The question of the ultimate effect of the stoppages on the welfare of the parties or of the community generally is an entirely different problem.

Methods of Settlement.—The great majority of disputes—involving 57% of the workpeople on the average of the years 1911–27—were settled by direct negotiation between the parties or their representatives; 18% by conciliation; 8% by arbitration; 5% by return to work on the employers' terms without negotiation; less than 1% by replacement of workpeople; and 11% by other methods. Here, again, the variations from year to year were generally small if the number of disputes only be considered, but very wide if the number of workpeople involved be taken into account. Thus, the number of workpeople involved in disputes that were settled by conciliation or arbitration varied from 1·2% to 68·5%; and the number involved in disputes settled by "other" methods from 0·0% to 69·0 per cent. This was a very exceptional case, in 1912, the great coal mining dispute of that year having been settled by legislation.

Table Showing Methods of Settlement

Year	Direct negotiation between the parties or their representatives	Conciliation	Arbitration	Return to work on employers' terms without negotiation	Replacement of workpeople	Closing of works	Other methods	Total
1918	47·1	18·6	16·8	6·7	0·1	0·0	10·7	100·0
1919	70·5	2·6	6·1	11·2	0·1	0·0	9·5	100·0
1920	89·6	5·0	1·9	3·2	0·2	0·0	0·1	100·0
1921	97·1	0·8	0·4	1·6	0·1	0·0	0·0	100·0
1922	93·1	1·8	0·1	4·6	0·2	0·0	0·2	100·0
1923	66·7	11·1	5·9	15·8	0·3	0·0	0·2	100·0
1924	56·7	33·7	3·4	5·9	0·2	0·1	0·0	100·0
1925	45·6	6·5	43·5	2·4	1·5	0·4	0·1	100·0
1926	41·4	0·2	0·0	0·4	0·0	0·0	58·0	100·0
1927	77·3	7·6	5·6	5·8	0·4	0·4	2·9	100·0

Organization of Strikes and Lock-outs.—In the great majority of cases strikes are organized and controlled by trade unions. It does not, however, follow from this that the growth of trade unionism has always fostered and encouraged strikes, there being evidence that in many trades the strengthening of organization has had the effect, not only of restraining ill-considered partial stoppages, but also of preventing more serious dislocations of industry by providing a channel for the expression of grievances and a recognised means of negotiating with employers. It is indeed generally considered that the industrial conditions most favourable to peace are when a powerful trade union is face to face with a representative employers' association, both under the guidance of strong but moderate leaders and neither feeling it beneath its dignity to treat on equal terms with the other.

Whether, however, trade unionism tends generally to encourage or to restrain strikes, the organization and policy of the great majority of trade unions, as at present constituted, are based on the possibility of a collective withdrawal from work in the last resort. Dispute-pay is consequently the one universal form of trade-union benefit, and the strength of a trade union's strike-pay resources are among the factors which determine whether a dispute will be pressed to a stoppage and, if so, how long the stoppage, both sides proving recalcitrant, will last.

Although most strikes are controlled by trade unions, cases are comparatively rare in Great Britain in which the central committee of a trade union takes the initiative and directs its members to cease work. More usually a local strike movement is initiated by the local workmen, and the central committee is generally empowered by the rules to refuse its sanction to a strike and to close it at its discretion, but has no authority to order it. In many unions a ballot is taken of the members of the districts affected before a strike is authorized, and a two-thirds (or even greater) majority, either of members or of branches, in favour of a stoppage may be required before the sanction of the central executive is granted.

When a strike has been authorized by the executive, the conduct of it is frequently entrusted to a "strike committee," appointed *ad hoc*, one reason being that a strike of any considerable dimensions often affects members of several unions, so that the common action necessary in a conflict with employers can only be attained by a committee representing all the societies involved. The financial support of a local or sectional strike imposes but little strain on the resources of a large society, but where a considerable proportion of the members are affected it is usual for a union to replenish its funds by imposing a "levy" or special contribution on members remaining at work. Financial support is often asked and secured from other unions and loans from financial institutions such as the Co-operative Wholesale Bank, have become increasingly a resort of impoverished trade unions during a prolonged and embarrassing dispute.

For an account of the legal powers of combinations of employers and of workpeople in the matter of declaring and conducting strikes and lock-outs the reader should turn to TRADE UNIONS. For an account of the voluntary machinery for the prevention and settlement of trade disputes without recourse to stoppage *see* CONCILIATION AND ARBITRATION. For machinery established by the State for similar purposes *see* COURT OF ARBITRATION.

Important British Trade Disputes.—Space will only permit of the mention of a very few of the most important disputes; and for the same reason, and also owing to the paucity of information for earlier disputes, it has been necessary to restrict reference to disputes occurring since 1888. Scanty records of strikes and lock-outs are indeed extant going back even as far as the year 1765; but in these very early years, and indeed much later, strikes were often demonstrations conducted by desperate and very imperfectly organized men in defiance of the law, and having something of the character (and often some of the personal consequences to the leaders) of a political rising. They are altogether different from the typical strike or lock-out of modern times.

Coal-mining.—In 1893 the coal owners of Yorkshire, Lancashire, and the Midlands demanded a reduction of 25% off the "standard" (equivalent to about 18% off the then current rates of wages), which the Miners' Federation refused to accept. The stoppage began on July 1 and lasted till Nov. 17, when it was settled by the intervention of the Government. The men resumed work at the old rate of wages until Feb. 1, 1894, after which date wages were to be regulated by a conciliation board, consisting of equal numbers of coal owners' and of miners' representatives, with an independent chairman.

A stoppage of the coal mines on a national scale took place in 1912, when the Miners' Federation demanded an individual district minimum wage for all underground workers in mines. It was settled by the passing of the Coal Mines (Minimum Wage) Act, 1912, which virtually gave the men what they demanded.

The coal mining stoppage of 1920 was in support of the men's demand for an advance in wages, not conditional upon output. A temporary advance was given, pending the working out of a permanent scheme, and the men resumed work. Negotiations followed between the Mining Association (representing the coal owners) and the Miners' Federation, but no agreement could be reached, the owners insisting that wages should be regulated on a district, and the men that wages should be regulated on a national basis. The position was also affected by the Government's announcing their intention to decontrol the industry on March 31, 1921, five months earlier than had been expected. A fresh stoppage, which affected all the coal fields, began on April 1, 1921, and a settlement was finally reached on July 1, laying down the lines on which wages were in future to be regulated: the same principles were to be followed in all districts (and the settlement was to that extent national), but the costs and surpluses, on which wages were henceforth to depend, were to be calculated for each district separately.

The agreement of 1921 was revised in 1924, in favour of the men; but a severe slump followed, and the employers gave notice to terminate the agreement as from the end of July, 1925. A stoppage was averted by the Government's granting a subvention until April 30, 1926, to give time for a full inquiry to be made into the state of the industry. A royal commission was appointed, under the chairmanship of Sir Herbert Samuel, which reported on March 6, 1926; they made various proposals for the improvement of the industry, but expressed the opinion that, as a temporary measure, an immediate reduction of wages was necessary. The owners accordingly gave notice of reductions of wages to take effect after April 30, when the subvention ceased; but these were unacceptable to the men, and the stoppage began on May 1. The dispute terminated at various dates in November and December (except in some Midland areas, where an agreement was reached earlier) by the acceptance of the men of district settlements, usually involving considerable reductions of wages and increases in hours of labour.

Engineering and Shipbuilding.—In 1897–98 there was a dispute in the engineering industry, which affected 47,500 men and lasted 29 weeks. It closely followed the formation of the Engineering Employers' Federation, and was an effort to make a stand against what the Federation regarded as encroachments on the employers' freedom of management. The employers were completely successful.

Another great dispute occurred in the engineering industry in 1922, also mainly on the question of management; only one trade union, but that much the largest—the Amalgamated Engineering Union—was concerned. Modified proposals were accepted by the men after a stoppage of about three months.

Most of the strikes and lock-outs in the shipbuilding industry are relatively small, and of short duration, many of them being concerned with demarcation questions; but there were two great disputes, in 1922 and in 1923. That of 1922 affected all the trade unions in the industry, and was directed against a reduction of wages. A modified reduction was accepted after a stoppage of five and a half weeks. The dispute of 1923 was more prolonged, lasting nearly seven months, but it affected only the members of one trade union: this was, however, the principal trade union in the industry, the United Society of Boilermakers and Iron and Steel Shipbuilders. The dispute was occasioned by the refusal of the union to accept an agreement relating to overtime and night-shifting working, which had been signed by the other shipbuilding trade unions. The dispute was eventually compromised, the employers agreeing to discuss with the union the modification of the agreement in certain points.

Other Trades.—Few of the disputes in the remaining trades have approached those mentioned above in magnitude; but the following are, for various reasons, of special interest, and may be briefly mentioned:—

1889. A strike of dock and waterside labourers in London for a rise in time rates of wages from 5d to 6d an hour, the abolition of contract and piecework, and the remedy of other grievances lasted for a month, and resulted in the almost complete victory of the men, largely owing to the support of the public. The strike was carried on by the newly formed Dock Labourers' Union, and was memorable as a demonstration that unskilled labourers could be successfully organized.

1892–93. A dispute in the cotton spinning trade in the Oldham and surrounding districts against a proposed reduction in wages of 5% involved 50,000 workpeople and lasted for twenty weeks. It was terminated by the famous "Brooklands agreement," which provided for a reduction of about 3%, and also contained rules for the settlement of future disputes by conciliation methods.

1895. The last considerable dispute in the boot and shoe industry occurred in this year. At the end of the dispute a series of conciliation and arbitration boards were set up, which have successfully settled all disputes in the industry for more than 30 years, with a few insignificant exceptions.

1911–12. A series of disputes, more or less inter-connected, occurred in the transport trades in this year, seamen, dock and other transport workers, and railway men being affected. There was also a strike, followed by a lock-out, in the cotton weaving industry in Lancashire in these years, which were, indeed, full of industrial disturbance.

1919. There was a three-weeks' strike in the cotton trade of Lancashire and the adjoining counties, both the spinning and the weaving branches being affected. The operatives obtained the advance (of 30% on list prices) which they had asked for, and a reduction in the working hours from 55½ a week to 48 (instead of 46½ as asked).

1921. The cotton operatives resisted a severe reduction in list piece rates; a modified reduction was eventually accepted.

1926. The so-called general strike of this year was called by the general council of the Trades Union congress in support of the coal miners; it was terminated at the end of nine days. The men called out included railway and transport workers, the printing and paper trade unions, some branches of the metal and engineering and of the building trade workers, and some other classes; and it was intimated that other classes of workers would be called out later, if necessary. This has been the only instance so far in Great Britain of a general strike; though there had been a strike of the kind in Dublin in 1913, involving about 20,000 workpeople. One of the principal objects of the Trade Disputes and Trade Unions Act, 1927, was to prevent the recurrence of a general strike; though the Act also limits the right of picketing, forbids civil servants to belong to trade unions having political objects, and requires members of trade unions who desire to support the political funds of their unions to "contract in," instead (as previously) of requiring those who objected to contributing to those funds to "contract out," *i.e.*, apply for exemption.

II. OTHER EUROPEAN COUNTRIES

France.—The average number of industrial disputes in the seven years 1900–06 was 812, with a minimum of 512 and a maximum of 1,314; the average number of workpeople directly involved in these years was 222,800 (minimum, 111,400; maximum, 439,300); and the average aggregate duration in working days, 4,130,000 (minimum, 1,862,000; maximum, 9,445,000).

There was a great increase in 1919 and 1920, years of great industrial disturbance in many countries; and a return in later years to more normal figures, as will be seen from the following table:—

Year	Number of disputes	Number of workpeople directly affected	Aggregate duration in working days
1919	2,053	1,206,000	16,129,000
1920*	1,924	1,488,000	24,564,000
1921	576	454,000	8,092,000
1922	711	307,000	3,386,000
1923†	1,112	366,000	5,292,000
1924†	1,083	275,000	3,863,000

*For the years 1920–24 particulars for Alsace-Lorraine are included.
†Figures relate to strikes only.

A national strike of railway employees on all the French railways in 1910 was brought to an end in little more than a week by the issue of mobilization orders to all the reservists on the railways. In recent years a noticeable feature of the strike statistics in France has been a tendency to strike among employees of public bodies.

Germany.—During the seven years 1901–07 the average number of industrial disputes recorded in Germany was 2,061 (minimum, 1,091; maximum 3,626); and the average number of workpeople directly and indirectly affected 230,700 (minimum, 68,000; maximum 543,000). Statistics of aggregate duration are not available for these years.

The following table gives particulars of the numbers of disputes, numbers of workpeople affected (including agricultural and non-manual workers), and aggregate duration of disputes in Germany in the years 1919–26. Stoppages due to political motives (*e.g.*, the Kapp putsch, and the occupation of the Ruhr) are excluded.

Year	Number of disputes	Number of workpeople directly affected	Aggregate duration in working days
1919	4,068	2,144,000	35,132,000
1920	4,392	1,562,000	17,703,000
1921	4,788	1,540,000	26,316,000
1922	5,201	1,969,000	28,894,000
1923	2,162	1,779,000	14,584,000
1924	2,012	1,634,000	36,360,000
1925	1,766	758,000	17,114,000
1926	365	91,000	1,405,000

It may be mentioned, that there have been several instances of general strikes, elsewhere almost unknown, in the three Scandinavian countries (Norway, Sweden, and Denmark).

III. BRITISH DOMINIONS

Australia and New Zealand.—These dominions have endeavoured in various ways, and for a long series of years, to prevent strikes and lock-outs by direct legislative action and by the provision of wages boards and other devices for the settlement of threatened disputes. These measures, however, have by no means wholly put a stop to disputes in Australia, as will be seen from the table below.

The following table shows the numbers of disputes, numbers of workpeople involved, and aggregate duration in working days in Australia in each of the years 1919 to 1926. As in many other countries, the years 1919–21 were years of great industrial disturbance; the year 1919 alone accounted for over six million working days lost.

Year	Number of disputes	Number of workpeople affected	Aggregate duration in working days
1919	460	158,000	6,308,000
1920	554	156,000	1,872,000
1921	624	165,000	957,000
1922	445	116,000	859,000
1923	274	76,000	1,146,000
1924	504	152,000	919,000
1925	499	177,000	1,129,000
1926	360	113,000	1,310,000

Canada.—Under the Lemieux Act (the Industrial Disputes Investigation Act, 1907) strikes and lock-outs are unlawful, under heavy penalties, in public utility industries (railways, coal mines, etc.) before or during a reference of the dispute to a board of conciliation.

The following table shows the number of disputes, number of workpeople involved, and aggregate duration in Canada during the years 1919 to 1926:—

Year	Number of disputes	Number of workpeople affected	Aggregate duration in working days
1919	298	134,000	3,942,000
1920	285	52,000	887,000
1921	145	23,000	956,000
1922	85	41,000	1,975,000
1923	91	33,000	768,000
1924	73	32,000	1,770,000
1925	83	26,000	1,744,000
1926	77	24,000	297,000

It will be seen that, as in many other countries, the figures for 1919 are much higher than those for the other years of the period.

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THE UNITED STATES

The first strike in American history took place in 1786 when the journeymen printers of Philadelphia quit work to enforce their demand for a minimum wage of $6 a week. There are records of industrial disturbances before this time but the parties involved in these early disputes were masters and the authorities of some of the colonial towns. The disputes arose over price fixing activities of the municipal authorities. There are no records of labour disputes in the modern sense of the term prior to 1786 due to the fact that a distinct cleavage between the interests of the labouring man and the employer is an essential characteristic of a labour dispute, and until the latter part of the 18th century the functions of employer and labourer were ordinarily undifferentiated. With the expansion of markets during the 18th century and the accompanying growth of distinct classes of labourers and employers, the strike became the customary means by which workers safeguarded their standard of living against encroachments of employers.

Prior to 1827 there was no labour movement in America and the few industrial disputes of which there is record were conducted on a small scale and with little or no organization. Rising prices in the '20s brought on a number of strikes, principally to secure higher wages but also in a few instances for the ten-hour day. From 1827 to 1832, politics occupied the attention of labour and there were few strikes, but after 1832 the political movement suffered an eclipse and strikes became more numerous as interest in organized labour revived. From 1833 to 1837 there were 173 strikes, but the panic of 1837 put an end to organized labour and there followed a long period of depression during which there were few strikes.

After the Civil War unionism revived, and following the trend of the times, took on a national character. Industrial disputes likewise began to take place on a nation-wide scale in contrast to the local outbursts of isolated unions that were the characteristic labour disputes of the period before the Civil War. The first great industrial dispute of nation-wide importance occurred in 1877 during a period of intense business depression. The workers on the Pennsylvania and the Baltimore and Ohio railroads struck in protest against a wage reduction, and although the men were unorganized, the strike spread like wildfire over the roads. Several lives were lost and millions of dollars worth of property was destroyed before the strike came to an unsuccessful conclusion for the workers.

An important strike occurred in 1885 when the shop employees on the Gould railways struck. The Knights of Labor, to which the strikers belonged, brought the strike to a successful close, thus gaining great prestige in the American labour movement. In 1886, however, the Knights were unsuccessful in another strike on the Gould roads. This year was outstanding for an epidemic of strikes and lockouts on the issue of the eight-hour day, most of which were unsuccessfully conducted by the Knights of Labor. In connection with these eight-hour strikes a tragic occurrence took place in Chicago. A meeting was held to protest against police activities in the strike and was addressed by anarchists who were advocates of violence. A bomb, thrown in the course of the meeting, killed 15 policemen. Public sentiment throughout the country was alienated from the strikers in their struggle for the eight-hour day although there was no connection between the anarchists and the union organizations. The widespread failure of the Knights to win in the disputes of 1886 was a major factor in the decline of this organization. The American Federation of Labor came to the front with the decline of the Knights of Labor and its policy of organizing the skilled workers on craft lines has been reflected in the nature of industrial disputes since that time. There have been no attempts at general strikes under the leadership of the American Federation of Labor.

After 1887 there was a lull in industrial conflict which was broken in 1890 by a movement for the eight-hour day sponsored by the American Federation of Labor. The carpenters were chosen to make the first attack for the shorter day and their strikes throughout the country in May, 1890, met with a large degree of success for their organization.

The panic of 1893 brought on numerous labour disturbances and it is estimated that in 1894 as many as 750,000 workers were involved. The most important strikes of this period were the miners' strike and the Pullman strike both of which came in 1894. About 125,000 miners struck against wage reductions and held out for three months before going back to work without securing their demands.

The Pullman strike was one of the most interesting episodes in American labour history. The American Railway Union, of which Eugene V. Debs was the founder, declared a sympathetic strike on June 26, 1894, in support of the employees of the Pullman Company, and refused to handle Pullman cars. A great deal of violence and destruction of property took place in Chicago and Federal troops were sent there against the protest of the governor of Illinois. It was in this strike that the injunction first became an important aid to employers as a means of defeating strikes. The officers of the American Railway Union were imprisoned for violating an injunction which the railroads had secured. By the middle of July the strike had practically ended in defeat for the union.

In 1897 the United Mine Workers were again involved in an extensive strike. Although at this time the union membership was not over 10,000 men, at least 100,000 obeyed the strike call and the whole bituminous industry was tied up with the exception of West Virginia. After a three months' strike the union won a thorough-going victory over the operators. The settlement conceded the miners a 20% increase in wages, the eight-hour day, and union recognition.

The strong hold that the United Mine Workers' Union has had on the so-called central competitive field dates from this victory. With the revival of prosperity after 1898 a renewal of interest in trade unions occurred and the number of organized workers increased rapidly until 1905. During this period there was a large increase in the number of strikes as well as in the number of workers involved, and in general the disputes may be characterized as offensive moves on the part of workers to secure better conditions in contrast to the defensive strikes of the depressed '90s.

The strike of 150,000 anthracite miners in 1902 was the most important strike of this period. The miners demanded a reduction of hours, increase of wages, and recognition of the union. After five months the country faced a serious coal shortage and President Roosevelt intervened to secure a settlement. The strike ended when the workers and the employers agreed to accept arbitration by a board appointed by the President. The miners won a 10%

increase in wages, and a shorter working day but their union was not recognized. In this period the left wing of the American labour movement achieved some prominence in carrying on strikes. In 1903 and 1904 the radical Western Federation of Miners carried on an unsuccessful strike to secure the eight-hour day, and a few years later the Industrial Workers of the World were successful in their New England textile strikes, but defeats in Paterson, N.J., in 1912 and 1913 destroyed their prestige among workers as a power in industrial conflict.

Depression followed the prosperity of the turn of the century and after 1905 American labour was on the defensive until the World War period.

When the United States entered the World War in 1917 the American Federation of Labor discouraged strikes in the essential industries. A number did occur, however, and these were mediated by Government committees. When the war was over, the War Labor Adjustment boards were dissolved and workers, who had been prevented from striking by the promise of peaceful settlement, felt that the government and employers had broken faith. In Sept. 1919, the steel strike began as a result of the united action of 24 international unions. Approximately 365,000 men left their jobs, but gradually returned to work, and by Jan. 1920, the remaining 100,000 men returned and the mill owners had won a sweeping victory.

In Aug. 1919, although forbidden by the officers of the union, 250,000 railway shopmen went on strike because of the delay of the Wage Adjustment Board to reach a decision on the demands of the men for increased pay. After six days the strike was called off and the men returned to work.

In Nov. 1919, 435,000 bituminous coal miners struck for wage increases and shorter hours. In March, 1920, an agreement was reached providing for a 27% increase in wages. In Sept., 1919, 93% of the Boston policemen struck for the right to organize and to affiliate with the American Federation of Labor. Their places were filled with other men.

After the break in the prosperity of the post-war period there were general wage reductions which resulted in numerous defensive strikes. The most important strikes of this period were the coal strike and the Railroad Shopmen's strike of 1922. The coal strike affected both bituminous and anthracite industries, and involved 600,000 workers. The outcome of the strike was a success for the workers.

On July 1, 1922, a strike of 500,000 railway shopmen began. The unions involved had refused to accept a decision of the Railroad Labor Board reducing wages, which together with certain grievances against the railroads, was the cause of the strike. In September a sweeping injunction was obtained by Attorney General Daugherty which hindered materially the activities of the strikers. The strike gradually ended later in the year with both sides claiming a victory.

In 1923 a very marked decline in the extent of industrial disputes set in throughout the country. This decline may be accounted for in a large measure by the high level of real wages prevailing in the United States since 1923 because of falling prices and a generally stable level of wages.

The anthracite coal region has been the scene of two large strikes in recent years. In 1923 after a strike of three weeks the workers secured a 10% wage increase, and in 1925 after striking for 170 days the workers and operators agreed to continue their old trade agreement.

In 1926 one of the principal disputes occurred in Passaic, N.J., when the textile workers carried on a strike which ended after a year with gains for the workers. Some 40,000 cloak and suit workers in New York City struck in July, 1926, and remained out until later in the year when an agreement was reached with the employers.

One of the most extensive strikes in recent years took place when 200,000 bituminous coal miners struck on April 1, 1927, because of the employers' failure to renew the agreement that had been in force for several years. The union refused to negotiate with the employers except on a national basis but in 1928 this stand was abandoned and the union negotiated with the employers by districts, taking in some cases a wage cut. The bituminous coal industry is one of the least prosperous of American industries due to over-expansion and excessive competition, and probably will continue to be the source of bitter labour disputes unless it undergoes an extensive re-organization.

With the exception of the coal strike which continued into 1928 there were no important nation-wide strikes in 1927 and 1928. There were, however, several large strikes in various cities. In 1927 6,000 teamsters struck in New York City and secured a wage increase. The plumbers in Brooklyn carried on a strike for two months and returned to work under an agreement to arbitrate the question of a wage raise.

In July, 1927, the building trades workers of Baltimore were involved in an important jurisdictional dispute. Late in Aug. 1927, 350 theatres closed in Chicago because of a dispute with the moving picture machine operators' union. An unusual strike occurred in Aug. 1927, in Henderson, N.C., when 800 unorganized textile workers struck to enforce wage demands.

The year 1928 saw a continuation of the same general industrial situation that had existed for the previous five years and the industrial disputes of 1928 reflected the condition of the country.

Generally speaking in 1928 unions were on the aggressive for wage increases and shorter hours, although there were important exceptions to this general rule. The mine-workers due to the condition of the industry were on the defensive, and the strike of 25,000 textile workers in New Bedford, Mass., ended in a 5% wage cut for the workers.

STATISTICS OF INDUSTRIAL DISPUTES IN THE UNITED STATES

The following table was prepared from material appearing in the publications of the United States Department of Labor. No statistics for the period 1905–16 were published. The figures for the number of employees involved in disputes from 1916 to 1928 represent only the employees involved in the portion of the industrial disputes from 1916 to 1928 reported by the Bureau of Labor Statistics with the consequence that the actual number of employees involved during this period was considerably larger than the number given in the table. Since 1916 no distinction has been made between strikes and lock-outs, these being combined under the general heading of industrial disputes. In this article the same procedure has been followed.

Number of Industrial Disputes in the United States and the Number of Employees Involved (1881–1928)

Year	Number of industrial disputes	Number of employees involved
1881	477	101,725
1890	1,897	305,133
1895	1,255	298,496
1900	1,839	446,218
1901	3,012	412,537
1902	3,240	583,447
1903	3,648	644,014
1904	2,419	420,662
1905	2,186	244,811
1916	3,789	1,599,917
1917	4,450	1,227,254
1918	3,353	1,239,989
1919	3,630	4,160,348
1920	3,411	1,463,054
1921	2,385	1,099,247
1922	1,112	1,608,321
1923	1,553	744,948
1924	1,249	654,453
1925	1,301	428,416
1926	1,035	329,592
1927	734	349,434
1928	576	342,341

Principal Causes and Results of Industrial Disputes.—The following tables were prepared from material published in the July 1928, *Monthly Labor Review*, p. 87, and show the principal causes and results of industrial disputes in the United States by years from 1916 to 1927:

Principal Causes of Disputes Beginning in Each Year in the United States (1916–27)

Cause of dispute	Number of disputes beginning in											
	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927
Increase of wages	1,301	1,571	1,397	1,115	1,429	120	156	445	255	277	260	142
Decrease of wages	35	36	36	86	147	896	261	49	125	117	52	57
Increase of wages and decrease of hours	481	378	256	578	269	34	16	58	30	29	39	43
Decrease of hours	113	132	79	117	62	294	22	16	18	7	19	20
Increase of hours	7	18	6	25	8	18	12	5	5	6	4	3
Recognition of union	404	333	241	522	308	191	137	153	152	109	117	119
General conditions	68	116	93	123	116	83	72	80	79	89	66	47
Discharge of employees	144	246	192	163	170	45	44	79	54	74	61	50
Sympathy	33	71	35	108	67	36	33	31	22	39	29	23
Jurisdictions	19	21	16	16	20	10	10	13	23	59	17	13

Results of Disputes Ending in Each Year in the United States (1916–27)

Result	Number of disputes ending in											
	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927
In favor of employers	748	395	465	687	677	701	248	368	283	253	226	169
In favor of employees	749	631	627	627	472	256	259	403	354	349	288	235
Compromise	777	720	691	797	448	291	105	168	138	138	147	129
Employees returned pending arbitration	73	137	204	50	61	80	16	46	45	51	36	29
Not reported	101	191	211	59	214	198	113	160	139	198	83	77

For further statistics on industrial disputes in the United States from 1881 to 1905 *see* the *21st Annual Report* of the Commission of Labor (1906). A convenient summary of this material will be found in Groat, *Organized Labor in America,* chapter x. For further statistics on disputes since 1916 *see* the *Monthly Labor Review.* For a thorough discussion of industrial disputes in the U.S. down to 1898 see *History of Labour in the United States* by Commons and Associates. For the period since 1898 see *History of Trade Unionism in the United States* by Perlman.

(J. R. Co.)

STRINDBERG, JOHAN AUGUST (1849–1912), Swedish dramatist, novelist and poet, born in Stockholm Jan. 22, 1849, grew up under poverty-stricken and unhappy conditions, and after a short period at Uppsala university, became a school teacher; then a wealthy doctor interested himself in him and undertook to complete his education in medicine. Strindberg first found his feet as a dramatist. He wrote *Hermione* (1869), an ambitious tragedy in verse; and a one-act piece, *In Rom* (1870) was performed. For a year or two he struggled as a journalist in Stockholm, until in 1874 he was appointed librarian in the Royal Library. In these years he completed his first great play, *Mäster Olof* (*Master Olof,* 1874), with the Swedish reformer Olaus Petri, as its central figure, and *Röda Rummet* (*The Red Room,* 1879), a satiric novel suggested by *The Pickwick Papers.* Strindberg then wrote the dramas *Gillets hemlighet* (*The Secret of the Guild,* 1880), *Lycko-Pers resa* (*Lucky Peter's Travels,* 1880), and *Herr Bengts hustru* (*Sir Bengt's Wife,* 1882). In 1882–83 followed the splendid stories of *Svenska öden och äventyr* (*Swedish Fates and Adventures*), which established his fame. In 1875 he met Siri (Sigrid) Wrangel, the wife of an officer, and became entangled in a fateful passion, which after her divorce in 1877, ended in marriage. After a year or two, his love turned to suspicious hatred and the first signs showed themselves of persecution mania. He had described his early life in the autobiography, *Tjänstekvinnans son* (*The Son of a Bondswoman,* 1886); and his unhappy marriage is the theme of the revolting and self-lacerating *En dåres försvarstal* (*A Fool's Defence,* 1893). His relations to Siri Wrangel colour all his imaginative work in this period. In the early 'eighties he lived for a time in Paris, and Switzerland, where his literary activity ranged from lyric poetry and satire to studies of the French peasant, and the masterly novels of *Utopier i verkligheten* (*Realised Utopias,* 1885). With the stories and sketches of *Giftas* (*Married,* 1884–86) he launched an attack on marriage which involved him in a prosecution, resulting, however, in acquittal. The plays *Fadren* (*The Father,* 1887) and *Fröken Julie* (*Lady Julia,* 1888) open a new phase in Strindberg's dramatic work, and form a landmark of importance in the history of European realism. Similar plays followed, most of which turn round the author's own marital tragedy. But in those years he also wrote his greatest contributions to Swedish fiction, the masterly novels *Hemsöborna* (*The People of Hemsö,* 1887), and *I Havsbandet* (*In the Outer Skerries,* 1890). A very dark period followed. His marriage was dissolved in 1891; his misery was accentuated by money difficulties, and for a time he hovered on the brink of insanity. A second marriage with an Austrian lady, Frida Uhl was even more disastrous than the first.

The dark experiences of these terrible years found their precipitate in *Inferno* (1897), *Legender* (1898), and the great allegorical drama in three parts, *Till Damascus* (*To Damascus,* (1898, 1904); to this period belong, too, *Advent* (1899) and the effective play *Brott och brott* (*Crimes and Crimes,* 1899). When reconvalescence set in, Strindberg returned to the historical drama and now produced a long series of works of power and originality, the finest being perhaps *Gustav Vasa* (1899) and *Gustav Adolf* (1900); he also wrote a number of symbolic poetic plays, notably *Ett Drömspel* (*A Dream Play,* 1902). In 1901 appeared the engaging drama *Påsk* (*Easter*) and the masterly realistic tragedy *Dödsdansen* (*The Dance of Death*), the greatest of his harrowing marriage dramas. For the *théâtre intime* which he established in Stockholm, he also wrote many short pieces, prominent among them *Spöksonaten* (*The Ghost Sonata,* 1907). Of the prose works of his last period may be mentioned *Fagervik och Skamsund* (*Fairhaven and Foulsound,* 1902) and *Taklagsöl* (*The Festival of the Finished House,* 1906), which affords a glimpse into Strindberg's third marriage with the actress Harriet Bosse. In 1903 appeared the last volume of his autobiographical writings, *Ensam* (*Alone*), a book of tragic pathos; and in 1907–08 what is perhaps the most significant work of his last period, *En blåbok* (*A Blue Book*), of which further volumes were published after his death. Strindberg died in Stockholm on May 14, 1912. He is Sweden's greatest modern writer, and has exerted a deep and lasting influence on the European novel and drama.

Bibliography.—The standard edition of Strindberg's *Samlade Skrifter* is that edited by J. Landquist, 55 vols. (Stockholm, 1912–21). Most of his works have been translated into English and there is a complete German edition by E. Schering; the chief works have, of course, appeared also in French. The Anglo-Swedish Foundation has begun (1929) the publication of a new translation of his dramas. The chief biographies are by N. Erdmann, Stockholm, 1920, and E. Hedén, Stockholm, 1921; there is an English life by Miss L. Lind of Hageby, London, 1913. The specialist literature on Strindberg in Swedish, English, French and German is already large. Here may be mentioned as the most important of recent books, Martin Lamm, *Strindbergs dramer,* 2 vols., Stockholm, 1924–26.

STRINGED MUSICAL INSTRUMENTS may be divided into five different classes, according to the method whereby the strings are set in vibration.

1. Strings Plucked by Fingers or Plectrum.—Twanging the strings by the fingers is the most primitive method, probably suggested by the feeble note given out by the tense string of the hunter's bow. The *nanga* of the ancient Egyptians, of which specimens are preserved in the British Museum, is the only link as yet discovered between the bow and the harp.

The next step observed is the device of stretching the strings partly over a soundboard and partly *à vide,* as in the cithara, the lyre, the rotta, the crwth, etc. In this stage the strings were made to bridge an open space for greater convenience in twanging them with both hands. The gradual closing up of this open space marked the steps in the transition from cithara to fiddle.

When the principle of stopping strings by pressing them against a fingerboard in order to obtain several sounds from each had been discovered and applied by adding a neck to the body, a new subdivision was created in this class of instruments. This principle involved a very great advance in technique, and produced the two great families of guitar and lute. The addition of a keyboard to the psaltery, created another new class of instruments, of which the principal members were the clavicymbalum, the virginal, spinet and the harpsichord.

2. Strings Struck by Hammers or Tangents.—The earliest known instrument thus played was the Assyrian dulcimer, or *pisantir.* In this, as in the psaltery, the strings were stretched over a rectangular or trapezoid sound-chest and were struck by sticks or hammers. The dulcimer has survived in the *cembalo* or *cimbalom* of the Hungarian gipsies. The addition of a keyboard produced the clavichord, and later the pianoforte.

3. Strings Set in Vibration by Friction of a Bow.—Although used with various other instruments, such as the Oriental rebab and its European successor the rebec, with the oval vielle, the guitar or troubadour-fiddle and the viols, it is with the effect of the bow on the perfected type represented by the violin family that we are mostly concerned. The strings in this case are all of the same length, difference in pitch being secured by thickness and tension. The fingers, by pressing the strings, produce a variety of notes from each string at will by shortening the vibrating section as the position of the fingers shift in the direction of the bridge. To this class belong also the Welsh crwth and the tromba marina.

4. Strings Set in Vibration by Friction of a Wheel.—This class is small, being represented mainly by the organistrum, and the hurdy-gurdy and a few sostenente keyboard instruments. In these instruments the rosined wheel performs mechanically the function of the bow, setting the strings in vibration as it revolves. A row of ten or 12 keys controlling wooden tangents performs the function of the fingers in stopping the strings.

5. Strings Set in Vibration by the Wind.—An example is the aeolian harp. Here the eight strings of different thickness, but tuned strictly in unison and left slack, are set in vibration by a current of air passing obliquely across them causing the strings to divide into aliquot parts, thus producing various harmonics.

In regard to the structural features of stringed instruments the construction of the sound-chest divides those played by hand into two distinct classes, viz., those with the box-form type, consisting of back and belly (or sound board), joined by ribs of equal width, and those with a vaulted back to which is attached directly a flat sound board, without the intervention of ribs.

STRIPE (Chevron—"A charge or device consisting of a bar bent like two meeting rafters."—Heraldry).

(1) **Rank Stripes.**—In the fighting services of practically every country the rank of non-commissioned officers is indicated by the wearing of a certain number of chevrons on the tunic.

In July 1802 a General Order was issued stating that in future British non-commissioned officers would wear as an indication of rank, instead of epaulets and shoulder knots, the following chevrons on their right arms, viz.:—Serjeant-Majors and Quartermaster-Serjeants 4 bars; all other Serjeants 3 bars; Corporals 2 bars. In 1862 a crown over the 3 bar chevron was introduced to distinguish Colour-Serjeants. In 1881 the 4 bars were abolished for Serjeant-Majors and a crown substituted. When the appointment of Lance-Corporal was introduced this was indicated by 1 bar. At the present time (1929) stripes indicate the following ranks or appointments:—1 bar, Lance-Corporal; 2 bars, Corporal; 3 bars, Lance-Serjeant and Serjeant. In the Foot Guards Lance-Corporals wear 2 bars. Although stripes were originally worn on the right arm only they were later worn on both arms for a time in full-dress, but at present they are worn only on the right arm. In service dress they are worn on both arms above the elbow. Rank chevrons are **V** shaped.

Rank chevrons are worn in the following armies as indicated:—

United States Army. Master Serjeant	3, and an arc of 3 bars.
Technical Serjeant . . .	3, ,, ,, ,, ,, 2 ,,
First Serjeant	3, ,, ,, ,, ,, 2 ,, with a lozenge in the centre.
Staff Serjeant	3, and an arc of 1 bar.
Serjeant	3
Corporal	2
Private, first class . . .	1

The chevrons are made of olive drab material on a dark blue ground.

French Army. Serjeant-Major .	2 together in silver below the elbow.
Quartermaster-Serjeant . .	2, one above and one below the elbow, in silver.
Serjeant	1 below the elbow in silver.
Quartermaster-Corporal . .	1 above ,, ,, ,, ,, and 2 below the elbow in red material.
Corporal	2 below the elbow in red material.
Private, first class . . .	1 ,, ,, ,, ,, ,, ,, worn diagonally on the sleeve.
German Army. Obergefreiter (Senior Lance-Corporal) . .	3 silver chevrons.
Gefreiter (Junior Lance-Corporal)	2 ,, ,,
Oberschütze (Senior Private) . Oberreiter (Trooper) . . Oberkanonier, etc. (Gunner, etc.)	1 ,, chevron.
Belgian Army, ∧ shaped, below elbow. 1st Serjeant-Major or 1st Maréchal des logis Chief .	2 thick and 2 thin.
Serjeant-Major or Maréchal des logis Chief . .	2 ,, ,, 1 ,,
1st Serjeant or 1st Maréchal des logis Chief .	1 ,, ,, 1 ,,
Serjeant or Maréchal des logis . . .	1 ,, ,, 1 ,,
Caporal or brigadier . . .	2 horizontal stripes in red wool.

(2) **Good Conduct Badges** are chevrons, **Λ** shaped, worn in the British service on the left sleeve below the elbow to indicate periods of good conduct, viz.:—1 bar for two years, 2 bars for five years, 3 bars for twelve years, 4 bars for eighteen years, 5 bars for twenty-three years and 6 bars for 28 years. An additional bar is given for every 5 years' service. Good conduct badges are only worn by privates and lance corporals (and equivalent ranks).

(3) **Wound Stripes or Gold Stripes,** were introduced into the British service by Army Order 249 of 1916 as a distinction to be worn by all ranks who had been wounded at any time during the World War. The stripe was worn perpendicularly on the left sleeve below the elbow and was made of gold Russia braid, two inches in length. A stripe was worn for each occasion on which the individual was wounded, the second and subsequent stripes being half an inch from each other. The wearing of these stripes has now been discontinued in the British service. They are, however, still worn in the U.S.A. forces, where they are made of gold lace or bullion **V** shaped and are worn on the right sleeve.

(4) **War Service Chevrons.**—In the British service these were introduced by Army Order 4 of 1918 and were small worsted chevrons, **Λ** shaped, worn on the right sleeve below the elbow. A red chevron was worn by all ranks who served overseas during 1914 and a blue chevron for each complete year for those who served overseas after 1914. The wearing of these chevrons was discontinued in 1922 by Army Order 434. In the U.S.A. forces they are still worn and consist of a **V** shaped chevron worn on the left sleeve. They are made of gold lace, bullion or sky blue cloth. When worn in conjunction with "Service Stripes" they are worn above the stripes. A chevron was granted

for each six months' service in the European zone during the World War.

(5) **Service Stripes.**—In the U.S.A. all enlisted men of the Regular Army, National Guard or Organised Reserves wear a stripe of olive drab material on a dark blue ground for every period of 3 years' service in the Federal Service. For service in the National Guard not in Federal Service similar stripes are worn but on a buff ground. These stripes are worn diagonally on the left sleeve of the service coat. (T. J. E.)

STRODE, RALPH (*fl.* 1350–1400), English schoolman, was probably a native of the West Midlands. He was a fellow of Merton College, Oxford, before 1360, and famous as a teacher of logic and philosophy and a writer on educational subjects. He belonged, like Thomas Aquinas and Bonaventura, to that "School of the Middle" which mediated between realists and nominalists. Besides his *Logica,* which has not survived, he wrote *Consequentiae,* a treatise on the syllogism, and *Obligationes* or *Scholastica militia,* a series of "formal exercises in scholastic dialectics." He had some not unfriendly controversy with his colleague John Wyclif, against whom he defended the possession of wealth by the clergy, and whose doctrine of predestination he attacked. Strode is also associated with John Gower in Chaucer's dedication of *Troylus* and *Cryseyde,* and Strode himself, according to the 15th-century *Vetus catalogus* of fellows of Merton, was a "poeta nobilis." Leland and Bale confirm this testimony, and Professor I. Gollancz has suggested the identification of the *Phantasma Radulphi* attributed to Strode in the *Vetus catalogus* with the beautiful 14th-century elegiac poem *The Pearl.* If this holds good, Strode wrote also *Cleanness, Patience,* and *Sir Gawayne and the Green Knight.* From 1375 to 1385 this Strode or another of the same name was common sergeant of the city of London; he died in 1387.

STRODE, WILLIAM (1598–1645), English parliamentarian, second son of Sir William Strode, of Newnham, Devonshire, was returned to parliament in 1624 for Beeralston, and represented the borough in all succeeding parliaments till his death. He from the first threw himself into opposition to Charles I. and took a leading part in the scene of March 2, 1629, when the Speaker, Sir John Finch, was held down in the chair. (*See* HOLLES, DENZIL.) Prosecuted before the Star Chamber, he refused "to answer anything done in the House of Parliament but in that House." On May 7, a fresh warrant was issued, and a month later, to prevent his release on bail, he was sent by Charles with two of his fellow members to the Tower. Refusing to give a bond for his good behaviour, he was sentenced to imprisonment during the king's pleasure, and was kept in confinement in various prisons for eleven years. In January 1640, in accordance with the king's new policy of moderation, he was liberated; and on April 13, took his seat in the Short Parliament, with a mind embittered by the sense of his wrongs. In the Long Parliament, which met on Nov. 3, 1640, he was the first to propose the control by parliament over ministerial appointments, the militia and its own duration; supported the Grand Remonstrance of Nov. 7, 1641; and displayed a violent zeal in pursuing the prosecution of Strafford. He was included among the five members impeached by Charles of high treason on Jan. 3, 1642. He opposed all suggestions of compromise with Charles, urged on the preparations for war, and on Oct. 23, was present at the battle of Edgehill. In the prosecution of Laud he showed the same relentless zeal as he had in that of Strafford. Strode died on Nov. 28, 1645.

STROMNESS, a burgh of barony, parish and seaport, in the island of Pomona, county of Orkney, Scotland. Pop. (1921), 1665. It is situated on the side of a well-sheltered bay, 14 m. by steamer W. of Kirkwall. Many of the houses are within tidal limits and furnished with quays and jetties.

STRONG, EUGENIE (*née* **SELLERS**), English archaeologist, married in 1897 the late S. A. Strong, librarian to the House of Lords. She was educated in France and at Girton college, Cambridge, of which she became the first fellow in 1910. She lectured on Greek art and archaeology in London, Rome and Dublin, and in 1913 delivered the Norton lectures for the Archaeological Institute of America. In 1904 she became librarian to the duke of Devonshire, in succession to her husband, and in 1909 was appointed assistant director of the British School of Archaeology in Rome, a post which she held until 1925.

Her publications include *Roman Sculpture from Augustus and Constantine* (1907; new ed. in Italian, 1923); *Apotheosis and After Life* (1915); *Art in Rome* (1927). She is also the English editor of G. Schuchardt's *Schliemann's Excavations,* Furtwängler's *Masterpieces of Greek Sculpture* and F. Wickhoff's *Roman Art.*

STRONG ROOMS: *see* SAFES, STRONG ROOMS and VAULTS.

STRONTIANITE, a mineral consisting of strontium carbonate $SrCO_3$. It takes its name from Strontian in Argyllshire, where it appears to have been known as far back as 1764, but it was not recognized as a distinct mineral until later, when the examination of it led to the discovery of the element strontium. It crystallizes in the orthorhombic system and is isomorphous with aragonite and witherite. Distinctly developed crystals are, however, of rare occurrence; they are usually acicular with acute pyramid-planes and are repeatedly twinned on the prism. Radiating, fibrous or granular aggregates are more common. The colour is white, pale green or yellowish brown. The hardness is 3·5 and the specific gravity 3·7. The mineral occurs in metalliferous veins in the lead mines of Strontian in Argyllshire, Pateley Bridge in Yorkshire, Bräunsdorf near Freiberg in Saxony, abundantly in veins in calcareous marl near Münster and Hamm in Westphalia and in limestone at Schoharie, N.Y. It is used for producing red fire in pyrotechny and for refining sugar.

STRONTIUM, a metallic chemical element (symbol Sr. atomic weight 87·63, atomic number 38), belonging to the alkaline earth group. It is found in small quantities very widely distributed in various rocks and soils, and in mineral waters; its chief sources are the minerals strontianite, celestine and barytocelestine. The metal was detected in the mineral strontianite, found at Strontian, in Argyllshire, by Cruikshank in 1787, and by Crawford in 1790; and the discovery was confirmed by Hope in 1792 and by Klaproth in 1793.

The metal was isolated (possibly not quite free from mercury) in 1808 by Sir H. Davy, who electrolysed a mixture of the moist hydroxide or chloride with mercuric oxide, using a mercury cathode. It has been obtained in a state of purity by A. Guntz and Roederer by heating the hydride in a vacuum to 1,000° C. It may be obtained in the form of sticks by the "contact cathode" method, in which a cooled iron rod, acting as a cathode, just touches the surface of a fused mixture of potassium and strontium chlorides and is raised as the strontium collects on it. Few, if any, of the amalgams are chemical individuals; the richest in strontium contains 52% and distils unchanged. Strontium is a silver-white ductile metal (of sp.gr. 2·54–2·63) which melts at 800°. It oxidizes rapidly when exposed to air, and burns when heated in air, oxygen, chlorine, bromine or sulphur vapour. With dry ammonia at −60° the metal forms strontium ammonium, which slowly decomposes in a vacuum at 20° giving $Sr(NH_3)_2$; excess of ammonia gives a dark blue solution, and evaporation gives bronze crystals of $Sr(NH_3)_6$. With carbon monoxide the metal gives $Sr(CO)_2$; with oxygen it forms the monoxide and peroxide.

The *hydride,* SrH_2, obtained by Guntz on heating strontium amalgam in a current of hydrogen, is a white solid, which readily decomposes water in the cold and behaves as a strong reducing agent. The *monoxide* or strontia, SrO, is formed by strongly heating the nitrate, or commercially from the hydroxide which is produced by heating the sulphide or carbonate in superheated steam (at about 500–600° C). It is a white amorphous powder which resembles lime in its general character. By heating the amorphous form in the electric furnace H. Moissan succeeded in obtaining a crystalline variety. The amorphous form readily slakes with water, and the aqueous solution yields a crystalline hydrated hydroxide. It is used in the extraction of sugar from molasses, since it combines with the sugar to form a soluble saccharate, which is removed and then decomposed by carbon dioxide. A hydrated *peroxide,* approximating in composition to $SrO_2{\cdot}8H_2O$, is formed as a crystalline precipitate when alkali is added to an aqueous solution of a strontium salt containing hydrogen peroxide. If all the solutions are above 50° and very concentrated, the anhydrous peroxide results.

Strontium fluoride, SrF_2, is obtained by the action of hydrofluoric acid on the carbonate, or by the addition of potassium fluoride to strontium chloride solution. *Strontium chloride*, $SrCl_2{\cdot}6H_2O$, is obtained by dissolving the carbonate in hydrochloric acid, or, commercially, by fusing the carbonate with calcium chloride and extracting the melt with water. It crystallizes in small colourless needles and is easily soluble in water; the concentrated aqueous solution dissolves bromine and iodine readily. By concentrating the aqueous solution between 90–130° C, or by passing hydrogen chloride into a saturated aqueous solution, a second hydrated form of composition, $SrCl_2{\cdot}2H_2O$, corresponding with dihydrated barium and radium chlorides, is obtained. The anhydrous chloride is formed by heating the hydrated chloride in a current of hydrogen chloride.

Strontium sulphide, SrS, is formed when the carbonate is heated to redness in a stream of sulphuretted hydrogen. It phosphoresces very slightly when pure. *Strontium sulphate*, $SrSO_4$, found in the mineral kingdom as celestine, is formed when sulphuric acid or a soluble sulphate is added to a solution of a strontium salt. It is a colourless, amorphous solid, which is almost insoluble in water, its solubility diminishing with increasing temperature; it is appreciably soluble in concentrated sulphuric acid. When boiled with alkaline carbonates it is converted into strontium carbonate.

Strontium nitride, Sr_3N_2, is formed when strontium amalgam is heated to redness in a stream of nitrogen or by igniting the oxide with magnesium. It is readily decomposed by water, with liberation of ammonia. *Strontium nitrate*, $Sr(NO_3)_2$, is obtained by dissolving the carbonate in dilute nitric acid. It crystallizes from water (in which it is very soluble) in monoclinic prisms which approximate in composition to $Sr(NO_3)_2{\cdot}4H_2O$. It is used in pyrotechny for the manufacture of red-fire.

Strontium carbide, SrC_2, is obtained by heating strontium carbonate with carbon in the electric furnace. It resembles calcium carbide, decomposing rapidly with water, giving acetylene. *Strontium carbonate*, $SrCO_3$, found in the mineral kingdom as strontianite, is formed when a solution of a carbonate is added to one of a strontium salt. It loses carbon dioxide when heated above 1,250° C.

Strontium salts may be recognized by the characteristic crimson colour they impart to the flame of the Bunsen burner and by the precipitation of the insoluble sulphate. Strontium salts are only very feebly toxic.

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STROPHANTHUS, a genus of plants of the family Apocynaceae, deriving its name from the long twisted thread-like segments of the corolla, which in one species attain a length of 12 to 14 inches. The genus comprises about 28 species, mainly tropical African, extending into South Africa, with a few species in Asia, from Farther India to the Philippines and China. Several of the African species furnish the natives with the principal ingredient in their arrow poisons—*S. hispidus* and *S. kombe* being probably most frequently employed.

Both *S. hispidus* and *S. kombe* have hairy seeds with a slender thread-like appendage, terminating in a feathery tuft of long silken hairs, the seeds of the former being coated with short appressed brown hairs, and those of the latter with white hairs; but in the species used at Delagoa bay and called "umtsuli" the thread-like appendage of the seed is absent. The natives pound the seeds into an oily mass, which assumes a red colour, portions of this mass being smeared on the arrow immediately behind the barb.

Under the name of *strophanti semina*, the dried ripe seeds of *Strophanthus*, freed from awns, are official in the British and many other pharmacopeias. The seeds must be mature. They are about $\frac{3}{5}$ in. long, $\frac{1}{6}$ in. broad, greenish fawn, covered with flattened silky hairs, and oval-acuminate in shape. They are almost odourless, but have an intensely bitter taste. The chief constituent is a white microcrystalline glucoside, known as strophanthin, freely soluble in water and alcohol, but not in chloroform or ether, and melting at about 173° C. It constitutes about 50% of the mature cotyledons of the mature seed. The resin is contained in the husk, and occurs in the alcoholic tincture of strophanthus.

Pharmacology.—The drug has no external actions. Taken internally it tends, after the repetition of large doses, to produce some gastric irritation. As ordinarily administered, the drug acts on the heart before influencing any other organ or tissue. It is almost certain that strophanthus acts directly on no other cardiac structure than the muscle-fibre. No action can certainly be demonstrated either upon the vagus nerves or upon the intracardiac nervous ganglia. The muscular force is increased in a very marked degree. A secondary consequence of this is that the diastole is prolonged, and the pulse thus rendered less frequent. If the heart is beating irregularly the drug tends to make it more regular. In fatal cases of strophanthus poisoning death is brought about by the arrest of the heart in systole, *i.e.* in a state of tetanic spasm from over-stimulation. Strophanthus markedly raises the blood-pressure, but this action is almost entirely due to the increased force of the heart.

STROPHE, a term in versification which properly means a turn, as from one foot to another, or from one side of a chorus to the other (Gr. *στροφή*, "a turn"). Hence, the song of a chorus during one turn or figure of a dance, and thus a collection of various prosodical periods combined into a structural unit. When the strophe is answered by another unit of identical scansion (called an antistrophe) and accompanied by a third of somewhat different structure (epode), the three form a period.

STROSSMAYER, JOSEPH GEORGE [Josip Juraj Strossmajer] (1815–1905), Croatian bishop and politician, was born at Esseg in Croatia-Slavonia on Feb. 4, 1815. He became lecturer on theology at Djakovo, chaplain to the Austrian emperor, and director of the Augustinian body at Rome. In 1849 he was consecrated bishop of Djakovo, with the official title "Bishop of Bosnia, Slavonia and Sirmium." He fostered the growth of Slavonic nationalism in Croatia-Slavonia, in Dalmatia, and among the Slovenes of south Austria, aiding the Ban Jellačić in his campaigns against Hungary (1848–49), and subsequently becoming a recognized leader of the opposition to Hungarian predominance. (*See* Croatia-Slavonia.) Besides being foremost among the founders of the South Slavonic Academy in 1867, and of Agram University in 1874, he helped to reorganize the whole educational system of Dalmatia and Croatia-Slavonia. He built a palace and cathedral at Djakovo, founded a seminary for the Bosnian Croats, presented the South Slavonic Academy with a gallery of valuable pictures, and published collections of national songs and tales. He also aided Augustin Theiner, then librarian at the Vatican, to compile his *Vetera monumenta Slavorum meridionalium historiam illustrantia* (Rome, 1863). Strossmayer died on April 10, 1905. He was a count of the Holy Roman Empire and a bishop of the pontifical throne.

STROUD, market town, urban district, Stroud parliamentary division, Gloucestershire, England, $102\frac{1}{2}$ m. W. of London. Pop. (1921) 8,543. It is served by the G.W. and L.M.S. railways. It lies in a narrow through-valley of the Cotswolds traversed by canals from Thames to Severn. The town hall is Elizabethan. Stroud is the principal seat of the west of England cloth manufacture. Stroud has also silk-mills, dyeworks, breweries and foundries. During 1832–85 Stroud returned two members to parliament; it was merged in the Stroud division of Gloucestershire.

STROUDSBURG, a borough of eastern Pennsylvania, U.S.A., the county seat of Monroe county; on Broadhead creek, opposite East Stroudsburg (*q.v.*). It is served by the Delaware Valley, the Erie, the Lackawanna, the New York, Susquehanna and Western and the Pennsylvania railways. Pop. (1920) 5,278 (94% native white). Stroudsburg is a summer resort three miles W. of the Delaware Water Gap and 15 m. from the heart of the Pocono mountains. It has various manufacturing industries. A number of colonial houses still stand, notably the Jacob Stroud mansion (1760) which served as a refuge at the time of the Wyoming Massacre. The borough was laid out in 1806.

STROZZI, the name of an ancient and noble Florentine family, which was already famous in the 14th century. Palla Strozzi (1372–1462) founded the first public library in Florence in the monastery of Santa Trinita. Filippo Strozzi il Vecchio

(1426–1491), son of Matteo and of Alessandra Macinghi, began to build the beautiful Strozzi palace in Florence. Another Filippo Strozzi (1488–1538), who, although married to a Medici, opposed the hegemony of that house and was one of the leaders of the rising of 1527. On the final overthrow of the republic in 1530 Alessandro de' Medici attempted to win over Filippo Strozzi, but Strozzi had no faith in the tyrant and retired to Venice. After the murder of Alessandro he undertook the leadership of a band of republican exiles with the object of re-entering the city (1537); but having been defeated and captured and put to the torture, he committed suicide. His son Leone (1515–1554) was a distinguished admiral in the service of France and fought against the Medici; he died of a wound received while attacking Sarlino. The Strozzi acquired by marriage the titles of princes of Forano, dukes of Bagnolo, etc. The Strozzi palace, which belonged to the family until 1907, was bequeathed by will to the Italian nation.

See A. Bardi, *Filippo Strozzi* (Florence, 1894); B. Niccolini, *Filippo Strozzi* (Florence); C. Guasti, *Le Carte Strozziane* (Florence, 1884–91),

STRUCTURAL ENGINEERING. The term structural engineering came into accepted use in America during the 19th century, in relation to the particular branch of civil engineering which was concerned with bridge building. At a later date the term came to be used more frequently in connection with the great development of steel-framed and reinforced concrete buildings in that country, and it is mainly in this connection that the term has been accepted and used throughout the world.

From the brief survey in this article of the development of structural practice, it will be seen that the most fundamental change has not been in the use of mild steel, or, in fact, in the use of any relatively new material, but in the intelligent application in the design of structures of a rapidly extending knowledge of mechanics and of the scientific use of constructional materials. Hence there is a general tendency to give a wider significance to the term structural engineering and to set no arbitrary limits either to the materials employed or to the nature of the structures in which they are embodied.

Structural engineering embraces the design and construction of all those vital structural parts of buildings, and other substantial erections, in which a knowledge of the strength and nature of the materials used and of the relevant principles of the science of mechanics are the controlling factors. *See* also the articles on ARCHITECTURE and BRIDGES: CONSTRUCTION.

Early Development of Structural Practice.—While the more modern developments of structural engineering have been largely coincident with and dependent upon parallel developments in the production and use of iron, steel and Portland cement, the development of the science of mechanics and of the theory of elasticity have occupied a much longer period of time. Until the middle of the 18th century constructional practice of all kinds had been chiefly governed by the common traditions accepted in the various crafts. This practice was subject to the losses, faults and checks to which knowledge so acquired and held is peculiarly liable. The high state of development of the science of stereotomy or jointing of stone work should, however, be noted, particularly as applying to stone arches, vaults and domes. It arose out of the construction needs of the great cathedrals of the Middle Ages. The great era of bridge building, which may be said to have been initiated by the erection of the second bridge over the Thames at London by the French engineer Labelye in 1749, and by the successful completion of William Edwards' third bridge at Pontypridd in 1755, continued for the remainder of that century, and may be credited with the establishment of a new era in constructive ability and knowledge. At later dates notable bridges were erected by Robert Mylne, Telford and Rennie, which carried this aspect of structural design to an advanced stage.

Use of Cast Iron.—In England in 1755, the use of cast iron in construction had been advocated by Smeaton, and by the end of the century much experience had been acquired in the production of a uniform and reliable material and in the possibilities of its use in buildings. The most striking use of the metal probably occurred in the construction of arched bridges, where cast-iron voussoirs were employed in the place of stone; the first bridge of this kind was completed at Coalbrookdale in 1776. (Much confidence was shown in this type of bridge construction and Rennie prepared designs for a cast-iron bridge of 450 ft. span over the Menai straits.) At a still later date the cast-iron units were made in longer sections and bolted together, so that they were called upon to resist tensile forces and the sections of the ribs approximated to cast-iron beams of curved outline.

Meanwhile, the use of cast-iron in the construction of factory buildings in the north of England was developed, first in columns to support timber beams, and later in the substitution of cast-iron beams for timber. At the commencement of the 19th century, a building was designed by Boulton and Watt and erected in Manchester, in which cast-iron beams were supported on cast-iron columns, while the floors consisted of brick arches supported on the bottom flanges of the beams and brought to a level surface by rough concrete. Buildings of this type were erected with little change for a long period. The principles underlying this form of construction were at first little understood, but such men as Fairbairn, Tredgold and Hodgkinson assisted in the establishment of sound principles; their work was based upon extensive experiments, mainly upon the use of cast-iron in beams, and their published results proved of great benefit to architects and builders.

Use of Wrought Iron and Steel.—The great improvements in the manufacture of wrought iron, which followed upon the introduction and development of the puddling furnace and the rolling mill by Henry Cort towards the end of the 18th century, led to its increased use in construction, while the investigations into the strength of cast-iron referred to above probably stimulated the more effective use of wrought iron, the nature of which approximated more closely to the ideal elastic material conceived by the mathematicians and physicists. Only the simplest sections were rolled in the solid, beams.

In 1847 Ferdinand Zores produced a small rolled joist or I-section, the form being decided upon after consultation with French builders and iron manufacturers. Larger rolled sections were on view at the Paris exhibition in 1855 and these I-sections had been advocated by Fairbairn in England. The early small rolled joists were largely used in France as the basis of fire-resisting floor construction, but while they were obviously of value in other forms of construction, the I-section came very slowly into general use. The first steel-joist section to be produced in England was rolled by Dorman and Long in 1855. The Harper building in New York built in 1854 was the first one to have wrought-iron beams set in masonry walls as lateral supports.

Cheap and reliable mild steel became available through the introduction of the Bessemer and Siemens-Martin processes of production but prejudice and early difficulties in manufacture delayed its use. As late as 1877 in England Board of Trade Regulations prohibited the use of mild steel in bridge construction. In the construction of the Forth bridge (1880–90) mild steel was, however, employed and the success of this venture constitutes a remarkable tribute to the skill of the structural engineers at that date and a testimony to the fitness and reliability of this material for bridge work and general constructional use. The extended use of steel for structural purposes was assisted and guided by the introduction of standard forms and dimensions, and by uniform specifications. The American Society of Civil Engineers, founded in 1852, in co-operation with the steel manufacturers contributed immensely to the development of standard formulae. In 1894 the Carnegie-Phipps company of Pittsburgh published a handbook of standard shapes with information and formulae as to their structural properties. These remained standard for years and were basic for many subsequent handbooks published. In American cities, where skyscraper construction started, building laws were passed giving effect to the conclusions of these early developments. In England specifications were issued by the British Engineering Standards Association (formed in 1904), and the passing of the London County Council (General Powers) Act of 1909, provided the first authoritative regulations for the control of the design of steel-framed buildings.

Development of Framed Construction.—In the construction of various kinds of framed structures iron was being used to a considerable extent by the middle of the 19th century; thus the technique of this form of construction was being steadily developed. In some of the larger structures pin joints were used, but these were gradually discarded in England and the simpler riveted joint adopted. Of this latter type of construction Tueller's lattice girder bridge (1868) consisting of 300 ft. spans over the Mersey at Runcorn is a good example.

At a somewhat earlier period, similar developments in framed construction were taking place in America, where road bridges were being erected to meet a great demand. The majority of these were constructed in timber alone, or in timber and iron, but the well known forms of Howe truss (1830) and Pratt truss (1844) which were developed in this connection represented substantial progress in the design of framed structures. At a later date, the development of the wire rope by Robling, applied in the construction of the great suspension bridge at Brooklyn, indirectly influenced the introduction and perfection of the lift or elevator, which became, and is now, so vital an equipment of all tall buildings.

While a considerable amount of iron was used in the construction of buildings until well into the latter half of the 19th century, the construction of normal types was based on the assumption that the walls constituted the chief supports for transmitting structural loads to the foundation; also, since the thicknesses of these walls were regulated by building by-laws—which were based upon tradition and custom rather than upon scientific conclusion—the height to which buildings could be economically carried was limited, owing to the thick walls necessary to conform with the bylaws. Moreover high building possessed no great advantage without lifts. The first passenger elevator, a "vertical screw railway," was installed in 1859, by Otis Tufts in the Fifth Avenue Hotel in New York. In 1866 the first suspended elevator operated by a steam hoist was installed in the St. James Hotel in the same city.

The Crystal Palace buildings, erected by Paxton for the 1851 Exhibition in Hyde Park, are not usually claimed as one of the early examples of iron-framed buildings, yet the structure is remarkable in having foreshadowed and established a principle adopted in the modern steel building, in which the walls do not transmit any important portion of the structural load to the foundation. It was, however, the developments which took place in America at a later date which were to influence most markedly the progress of this form of construction throughout the world. In the year 1883, during a period of unusual building activity in Chicago and following an extensive fire in that city, W. L. B. Jenney designed a building of 10 storeys that is the forerunner of all high buildings. Afterwards two storeys were added, making the building 12 storeys, proving the soundness of the original calculations. This building, the Home Insurance building, is the first of all skyscrapers. It was finished in 1885. While it is true that L. S. Buffington, a young architect in Minneapolis, had thought of steel skeleton structures as early as 1880, it remained for Mr. Jenney to put the problem to practical test. There is, however, some controversy regarding who should get credit for the first skeleton construction building.

Skeleton Construction.—The Home Insurance building was designed with relatively thin outer walls, the dead load of which is placed on a framework of iron concealed inside the masonry and used to transmit the weight to the foundation. The framework was made of cast iron column and wrought iron I-beams, the beams being bolted to the columns with angle iron brackets. At the suggestion of the Carnegie-Phipps Steel company, rolled Bessemer steel beams, then being first produced, were used above the fifth floor. Cast-iron columns were used to the top since plates and angles of steel, of which the later steel columns were built up, had not yet been rolled. The term skeleton construction was later applied to all buildings of this type. Besides the development of the steel framework, the elevators, the use of Portland cement, another factor of great importance in the creating of skyscrapers was the invention of hollow tile in 1871 by Balthaser Kreisher, which solved both the dead-weight and the fire protection problem

The advantages to be derived from the erection of high buildings on city sites were rapidly recognized both by the land-owner and the building-owner; site values were enormously increased and much greater accommodation became available on a restricted area. The adoption of skeleton construction also led to speedier erection, since, on the completion of the steel framing, the building of walls and the construction of the floors could proceed simultaneously on several floor levels.

As confidence in the type of building increased, higher and yet higher structures were erected, and since most of them were relatively slender and were frequently built on sites that afforded poor foundations, the use of piles and of the caisson—already adopted by the bridge builder to ensure sound foundations—increased and developed. Improved practice in the construction of foundations became fundamentally important in the further growth of this type of building, and many ingenious and effective developments occurred, including combined foundations for two or more columns, and also cantilevered foundations, by means of which the actual foundation construction for the external or boundary columns could be kept within the limits of the site. (*See* article on FOUNDATIONS.)

Protection from Fire.—Early experience showed the very complete destruction by fire of iron and steel buildings in which the distortion of the framework, under the effects of excessive heat, resulted in the collapse of the metal framework and walls. The importance of fire protection is now generally recognized and the vital parts of steel buildings are required to be protected by terra-cotta, hollow tile, cement concrete or other fire-resisting materials. In America a definite limit of height is generally set by the building regulations for the control of non-fireproof buildings, but if adequate and ample fire-protection of the structural fabric is provided in the permanent construction, no arbitrary limit is set to the height in some American cities; in others there are height limitations. It is necessary, however, to provide, for all high buildings efficient warning, fire-checking and fire-fighting equipment, such as stand-pipes and extinguishers, especially at heights beyond the scope of the local fire-fighting equipment. The work of the various Fire Assurance companies and, more recently, the effective research and investigations of the National Board of Fire Underwriters, has influenced fire-protection, assisted in the improvements of constructional methods, and helped to render these improvements rapidly effective. In Great Britain, structural practice and consequent building developments have been somewhat different from those of America. Very high buildings have not been favoured for a variety of reasons which are referred to elsewhere in this article. One of the arguments that was used in the past against high buildings was the difficulty of dealing with fires at great heights. Experience in America, however, has proved that adequate provisions can be made to meet such emergencies.

Wind Pressure.—There are obvious dangers associated with tall structures, which arise chiefly from the effects of wind pressure upon the exposed elevated faces. Stability of the structures as a whole is now generally obtained by a combination in the building of rigidity and weight. While the steel frame in itself is sufficiently rigid to reduce distortion under wind pressure to a negligible amount, in all calculations the rigidity of the walls is taken into consideration, as it is a considerable factor in resisting distortion. The necessity for maintaining a rigid form of frame which would resist distortion under side pressure has led to the development of the braced structure and of the structure with rigid connections. Both these types demand of the designer a knowledge of the most advanced sections of mechanics and structural engineering. Much experimental research upon problems associated with tall structures has been carried out in the universities of America and by American engineers, from which satisfactory bases of design have been developed or theories verified. The progress of framed construction in tall buildings has enabled such a high degree of achievement to be reached, that careful experiments upon one of the tallest buildings recently erected in America have fully demonstrated that, even in the strongest gales, the little vibration that occurs is of no consequence in such structures.

Electric welding, to replace riveting, is still in the experimental state. While no additional strength or rigidity is necessary than is provided by the riveted structure, two objects are being sought: the elimination of noise and the saving in steel that would result from not needing such heavy angles at the connections.

Corrosion.—During the later development of skeleton construction considerable attention was given to the dangers which might arise from the corrosion of important parts of these steel structures. In the earlier days of steel construction applied to buildings, insufficient care was given to the protection of hidden and inaccessible parts, and connections and members were often so designed and fabricated that protection was difficult to apply. A few failures have occurred owing to corrosion, but the recent demolition of some of the earliest tall buildings in America has demonstrated that, with reasonable care, the life of the ordinary type of steel-framed building may be practically indefinite if the work is properly done. At the same time the investigation has led to the recognition of the value of concrete as a suitable and effective encasing material for the protection of steel. Reliable and durable protective paints have been produced and are now in wide use for the treatment of steel framework to be enclosed in masonry. They should be freely applied in at least two coats to all parts where actual encasing in solid concrete is not specified. Some hopes are entertained that a solution of the problem of corrosion will be found in the production of non-corrosive steel, having the necessary structural properties and yet economical in production.

Building Regulations.—The extent to which the adoption of suitable building regulations has assisted in the development of efficient and economical methods of construction has varied in different countries. In Great Britain, the type of local by-law which has generally been in force has lagged seriously behind the best accepted modern practice and has often acted as a deterrent to such development. In relation to the construction of walls the regulations have had a restrictive effect since they have compelled the erection of exceptionally thick walls. In relation to other parts of buildings such as roofs, floors and columns these by-laws are usually inadequate and arbitrary and, while they may be of a character to prevent the erection of unsafe structures, they have not tended to encourage the adoption of better forms of construction.

The first and the most outstanding regulations to govern steel building construction in Great Britain were embodied in the London County Council (General Powers) Act of 1909, and are usually referred to as the L.C.C. Regulations for Steel-Framed Buildings. These regulations, while containing some peculiar features and restrictions, had a marked effect upon the development of this form of construction and there has since been a steady increase in the number of buildings erected in accordance with them. At present, practically all large buildings erected in London, apart from reinforced concrete structures, are designed and erected as steel-framed buildings.

In consequence of the manner in which the L.C.C. regulations were framed, they applied only to new buildings in which the main structure was to be of steel, while buildings in which steel was combined structurally with other materials were still subject to the older regulations. This lack of co-ordination has tended to discourage forms of composite construction which, for smaller buildings would often have produced more economical results. Under the London County Council (General Powers) Act 1926 efforts are being made to remove these and other anomalies.

In the United States a much closer relation has been established between regulations and practice, and many thorough revisions of local building codes, particularly in their effect on steel construction, have been undertaken during the last twenty years in American cities. The general methods of procedure and supervision adopted by authorities in the United States are more elastic in practice than in Great Britain, so that the regulations do not tend so much to discourage the best available methods offered by the engineers and contractors; the system in vogue is indeed equivalent to a continual revision of the regulations, thus encouraging constant progress and improvement.

In this connection the investigations carried out by the Bureau of Standards in Washington, D.C., and by various professional bodies have proved most valuable, the results of such investigations—conducted under practical and exhaustive conditions—being incorporated in the various building codes when approved and accepted by the responsible and representative professional institutions.

Reinforced Concrete.—The adoption and development of construction in reinforced concrete has followed the lines common to steel work, since the theoretical basis is almost identical, and the production of suitable specifications and regulations has been the product of similar efforts. Reinforced concrete buildings are usually of the framed type of construction, consisting of pillars and beams, as in steel work, but with the wall and floor panels continuous between columns and beams, so that the concrete enclosing the reinforcing steel is continuous and the structure is monolithic in character. All the intersections of beams and columns are thus rigid connections and the rigidity of such structures is one of their main features. In recent years the study of elasticity has been closely followed in its application to reinforced work, where the straining of one member is definitely communicated through the rigid continuation to the adjoining members. Hence the designer of reinforced concrete must have an unusually thorough structural training if he is to comprehend and provide successfully for all the variations of stress to which a reinforced structure is subject. The development of the theory of indeterminate structures involving rigid connections has been a natural consequence. A later type of construction dispenses with beams and uses slabs and mushroom-headed pillars.

Reinforced concrete reached an established position as a constructional method in England when a joint committee, under the auspices of the Royal Institute of British Architects, considered and reported on the subject, first in 1907 and later in 1911. The report gave advice and guidance upon this form of construction in the absence of local regulations. As early as 1900 American engineers had developed the technique of reinforced concrete to a high degree.

In 1915 the London County Council, using the authority vested in them under the clauses of the L.C.C. (General Powers) Act 1909, made regulations for the control of buildings erected in reinforced concrete. While, in view of later developments and scientific investigation, these regulations are seen to be faulty, they were accepted at the time as a real help to the architect, builder and engineer, because at that time there was little general recognition of the more intricate problems involved in its use. The regulations include data for the practical design of beams, slabs, columns, foundations and walls, and a specification of materials and minimum strengths under test. These regulations now are in need of revision, because of the great advance in knowledge concerning this work. In the United States various changes have been made in the early rules with the result that more adequate requirements are in force.

Owing to the experience gained in actual design and construction and to the greatly extended investigations which have been conducted into the properties of this new material, reinforced concrete appears not only low in maintenance cost, but is of satisfactory permanence. In addition it possesses fire-resisting qualities. Contradictory data, however, indicate that more knowledge of the action of concrete under various conditions is necessary before definite conclusions can be drawn. Owing mainly, perhaps, to the severely classical character of the normal architectural training, concrete cannot be said to have attained the same pre-eminence as a material for architectural expression as it has in construction. However, some interesting, though perhaps exceptional, schemes have been produced by the so-called "modernist" architects and structural designers. (*See* also CONCRETE and REINFORCED CONCRETE.)

Structural Engineer and Architect.—It is recognized that structural engineering developed in its initial stages as a specialized branch of civil engineering, and its most prominent developments took place in connection with those pioneering ventures of mankind in the furtherance of which the skill and ability of the civil engineer is of paramount importance. Later developments, however, especially in countries where industrial and commercial conditions are now more stable, have resulted in establishing conditions in which the work of the structural engineer is, in nature and quality, much more closely related to that of the architect. It follows, therefore, that as a knowledge of the theory and practice of structural engineering becomes more established and widespread, it will become more difficult to distinguish clearly between the work of the architect and that of the structural engineer in regard to the design and construction of tall fireproof buildings.

There are at present, in all countries, numbers of architects who have prepared themselves to undertake responsibility both for architectural design and structural engineering in relation to all the forms of building in which they practise, the combination being most frequently found in Continental countries. In Great Britain, where the private architectural practice still predominates, the employment of a structural engineer as a consultant, or as a specialist, appears to be the normal procedure. In view of the general recognition of the advantages of specialization, and of the difficulties inherent in scientific construction, there is little doubt that the structural specialist will remain a distinct and important person among those who are responsible for the design of future buildings.

Building Skyscrapers in the United States.—The great demand for tall buildings that started at the end of the last century produced a new form of organization to handle their construction. In the past the work was done on a divided contract where work was parcelled out to various contractors who worked under the supervision of the architect who had designed the building. Then, due to the magnitude and complication of the work and the overburdening of the architect, the general contractor appeared, who was prepared to undertake the building of a skyscraper under a general contract in which he agreed to deliver the completed building on a given date. The contractor became a promoter, a financier, a buyer of materials, a large employer of labour, and principally an organizer who could combine all building trades and functions under a centralized management. The architect usually, therefore, became responsible only for architectural and structural design.

(F. E. D.; J. L. M.; W. A. St.)

See Col. W. A. Starrett, *Skyscrapers* (1928).

STRUENSEE, JOHAN FREDERICK (1731–1772), Danish political philosopher, was born at Halle in 1731. His father, subsequently superintendent-general of Schleswig-Holstein, was a rigid pietist; but young Struensee, who settled down in the 'sixties as a doctor at Altona, revolted against the narrowness of his father's creed, became a fanatical propagandist of the doctrines of the encyclopaedists. He became court physician to Christian VII. Struensee rapidly gained authority in affairs.

For a time Struensee kept himself discreetly in the background, but he soon grew impatient of his puppets. He dismissed the heads of departments, and abolished the Norwegian stadholderships. Henceforth the cabinet, with himself as its motive power, was to be the one supreme authority in the state. He then began to reform the administration and the law without any regard to national customs and predilections. Between March 29, 1771, and Jan. 16, 1772—the ten months during which he held absolute sway—he issued no fewer than 1069 cabinet orders, or more than three a day. In order to be sure of obedience he dismissed wholesale without pension or compensation the staffs of all the public departments, substituting nominees of his own.

The general ill will against Struensee, which had been smouldering all through the autumn of 1771, led to a conspiracy against him, headed by Rantzau-Ascheburg and others, in the name of the queen-dowager Juliana Maria. On Jan. 17, 1772 Struensee, Brandt, the unhappy king's keeper, and the queen were arrested, and "the liberation of the king," who was driven round Copenhagen by his deliverers in a gold carriage, was received with universal rejoicing. On April 25 Struensee and Brandt were condemned first to lose their right hands and then to be beheaded; their bodies were afterwards to be drawn and quartered. The sentences were carried out on April 28, Brandt suffering first.

See Élie Salomon François Reverdil, *Struensee et la cour de Copenhague 1760–1772* (Paris, 1858); Karl Wittich, *Struensee* (Leipzig, 1879); Peter Edward Holm, *Danmark-Norges Historie*, vol. iv. (Copenhagen, 1897–1905); Gustave Bascle De Lagrèze, *La Reine Caroline-Mathilde et le Comte Struensee* (Paris, 1887); Robert Nisbet Bain, *Scandinavia*, cap. xv. (Cambridge, 1905); William Henry Wilkins, *A Queen of Tears* (London, 1904); Georg Friedrich von Jenssen-Tusch, *Die Verschwörung gegen die Königin Karoline Mathilde und die Grafen Struensee und Brandt* (Leipzig, 1864).

STRUTHERS, a village of Mahoning county, Ohio, U.S.A., on the Mahoning river, 5 m. S.E. of Youngstown; served by the Pennsylvania and the Pittsburgh and Lake Erie railways. Pop. (1920) 5,847 (25% foreign-born white). Struthers is a residential and industrial suburb of Youngstown, with large steel and iron works and various other manufacturing plants.

STRUTHIONIDAE: *see* OSTRICH.

STRUTT, JEDEDIAH (1726–1797), British inventor and manufacturer, was born at South Normanton, Derbyshire, on July 28, 1726. He was a farmer, as his father had been before him. His brother-in-law, William Woollatt, brought to his notice the unsuccessful efforts to produce ribbed as well as plain goods on the stocking frame, and he invented Strutt's Derby ribbing machine. Patents were taken out by Strutt and Woollatt in 1758 and 1759. Strutt then started a factory with Woollatt at Derby, and in 1762 took in Samuel Need as a partner. In 1768 Richard Arkwright (*q.v.*) consulted Need as to the possibilities of his cotton-spinning frame which led to Arkwright, Strutt and Need starting their first cotton mill at Nottingham, with horse power.

Later works were erected at Cromford and, about 1780, after Strutt dissolved partnership with Arkwright, he built himself the mills at Belper and Milford. Shortly before this Strutt had made the discovery, which revolutionized the manufacture of calico, that cotton could be used throughout in its making. To house the machinery for this new invention the first fire-proof mill in England was built at Derby.

STRUVE, FRIEDRICH GEORG WILHELM (1793–1864), German astronomer, was born at Altona on April 15, 1793. In 1808 he entered the university of Dorpat (Yuriev). He remained at Dorpat, occupied with researches on double stars and geodesy till 1839, when he removed to superintend the construction of the new central observatory at Pulkowa, afterwards becoming director. He retired in 1861 and died at St. Petersburg on Nov. 23, 1864.

Struve's name is best known by his extensive observations of double stars; his publications on this branch of astronomy are *Catalogus novus stellarum duplicium* (1827); his principal work, *Stellarum duplicium et multiplicium mensurae micrometricae* (St. Petersburg, 1837); and *Stellarum fixarum imprimis duplicium et multiplicium positiones mediae* (1852). At Pulkowa, in 1840, he obtained a parallax of $\frac{1}{4}''$ for α Lyrae; this was one of the first measurements of stellar parallax. For the rest of his life Struve was chiefly occupied in working out the results of former years' work and in the completion of geodetic operations. He had commenced them with a survey of Livonia (1816–1819), which was followed by the measurement of an arc of meridian of more than $3\frac{1}{2}°$ in the Baltic provinces of Russia (*Beschreibung der Breitengradmessung in den Ostseeprovinzen Russlands*, 2 vols., 4to, Dorpat, 1831). This work was afterwards extended by Struve and General Tenner into a measurement of a meridianal arc from the north coast of Norway to Ismail on the Danube (*Arc du méridien de 25° 20′ entre le Danube et la Mer Glaciale*, 2 vols. and 1 vol. plates, 4to, St. Petersburg, 1857–1860). (*See* GEODESY; EARTH, FIGURE OF.)

STRYCHNINE, $C_{21}H_{22}N_2O_2$, an alkaloid discovered in 1818 in St. Ignatius's beans (*Strychnos Ignatii*); it also occurs in other species of *Strychnos*, *e.g.*, *S. Nux vomica*, *S. colubrina*, *S. Tieuté*, and is generally accompanied by brucine, $C_{23}H_{26}N_2O_4\cdot4H_2O$. Strychnine crystallizes from alcohol in colourless prisms, practically insoluble in water, and with difficulty soluble in the common organic solvents. Its taste is exceptionally bitter. It has an alkaline reaction, and is a tertiary monacid base.

In Medicine.—The British Pharmacopoeia dose of *strychnine* is $\frac{1}{60}$ to $\frac{1}{15}$ gr. Easton's Syrup is *syrupus ferri phosphatis cum quinina et strychnina*, containing $\frac{1}{32}$ gr. of strychnine in each fluid drachm. *Strychninae hydrochloridum* is also used; it is much more soluble than strychnine. From it is prepared *liquor strychninae hydrochloridi*, containing 1gr. of hydrochloride in 110 minims. The United States pharmacopoeia also contains *strychninae nitras* and *strychninae sulphas*. Strychnine is incompatible with *liquor arsenicalis* and potassium iodide.

As regards its physiological action, strychnine enters the blood as such, being freely absorbed from mucous surfaces or when given hypodermically. Internally it acts as a bitter, increasing the secretion of gastric juice and intestinal peristalsis. The specific effects of the drug, however, are upon the central nervous system. It excites the motor areas of the spinal cord and increases their reflex irritability. Small doses increase the sensibility of touch, sight and hearing; large doses cause twitching of the muscles and difficulty in swallowing; while in overdoses violent convulsions are produced. The cerebral convolutions remain unaffected, but the important centres of the medulla oblongata are stimulated. Not only is the respiratory centre stimulated but the cardiac centre is acted upon both directly by the drug and indirectly for a time by the enormous rise in blood pressure due to the contraction of the arterioles all over the body. Ordinary doses have no effect upon the temperature but in overdose the temperature rises during a convulsion. Strychnine is eliminated by the kidneys as strychnine and strychnic acid. It is excreted very slowly and therefore accumulates in the system.

In collapse following severe haemorrhage and arrest of the heart or respiration during chloroform narcosis an intramuscular injection of $\frac{1}{12}$gr. of the hydrochloride may stimulate the cardiac action. In acute opium poisoning strychnine is very valuable. It is a physiological antagonist of chloral hydrate, morphine and physostigmine, and may be given in poisoning by these drugs.

Toxicology.—The symptoms of strychnine poisoning usually appear within twenty minutes of the ingestion of a poisonous dose, starting with stiffness at the back of the neck, twitching of the muscles and a feeling of impending suffocation. The patient is then seized with violent tetanic convulsions. After a minute the muscles relax, and the patient sinks back exhausted, consciousness being preserved throughout. Tetanus (*q.v.*) resembles strychnine poisoning, but the development of the symptoms in tetanus is usually much slower, death rarely occurring within 24 hours.

The treatment of strychnine poisoning is immediate evacuation of the stomach by stomach-pump or emetic, chloroform being administered to allay the spasms. Chloral and potassium bromide may be given as physiological antidotes.

STRYJ, a town of Poland in the province of Stanislawów. Pop. (1921) 27,300. An important railway junction and a centre for the oilfields and the agricultural area of the province. Mineral gas is produced in the neighbourhood. The town is situated on the Stryj river, a tributary of the Dniester. The town was once the capital of a Polish lieutenancy (Starostwo).

STRYPE, JOHN (1643–1737), English historian and biographer, was born in Houndsditch, London, on Nov. 1, 1643. He was the son of John Strype, or van Stryp, a member of a Flemish family settled in Strype's Yard in Petticoat Lane, as a merchant and silk throwster. The younger John was educated at St. Paul's School, and at Jesus college, and Catherine Hall, Cambridge. In 1670 he became perpetual curate of Theydon Bois, Essex, and subsequently received the curacy of Leyton and a sinecure living in Sussex. He was lecturer at Hackney from 1689 till 1724. He died at Hackney on Dec. 11, 1737. He was buried in the church at Leyton.

The most important of Strype's works are the *Memorials of Thomas Cranmer, Archbishop of Canterbury, 1694* (ed. for the Eccl. Hist. Soc., in 3 vols., Oxford, 1848–1854; and in 2 vols. with notes by P. E. Barnes, London, 1853); *Life of the learned Sir Thomas Smith* (1698); *Life and Acts of John Aylmer, Lord Bishop of London* (1701); *Life of the learned Sir John Cheke, with his Treatise on Superstition* (1705); *Annals of the Reformation in England* (4 vols.; vol. i. 1709 [reprinted 1725], vol. ii. 1725, vol. iii. 1728, vol. iv. 1731; 2nd ed., 1735, 4 vols.; 3rd ed., 1736–1738, 4 vols.); *Life and Acts of Edmund Grindal, Archbishop of Canterbury* (1710), *of Matthew Parker, Archbishop of Canterbury* (1711), and *of John Whitgift, Archbishop of Canterbury* (1718); *An Accurate Edition of Stow's Survey of London* (1720), a valuable edition of Stow, although its interference with the original text is a method of editing which can scarcely be reckoned fair to the original author; and *Ecclesiastical Memorials* (3 vols., 1721; 3 vols., 1733). His *Historical and Biographical Works* were reprinted in 19 vols. at the Clarendon Press, Oxford, between 1812 (*Cranmer*) and 1824 (*Annals*).

STRZYGOWSKI, JOSEF (1862–), Austrian scholar, was born at Bial, near Bielitz, on March 7, 1862. In 1892 he became a professor at Graz, and in 1909 was appointed professor of art at the University of Vienna. He wrote numerous works on art, dealing especially with oriental influences on Western art (*see* BYZANTINE ART; ROMAN ART). His works include: *Byzantische Denkmäler*, 1–3 (1891–93); *Hellenistische und Koptische Kunst in Alexandria* (1902); *Koptische Kunst* (1903); *Die bildende Kunst der Gegenwart* (1907); *Ursprung der Christlichen Kirchenkunst* (1920, Swedish and English trans.); and he edited *Early North European Church Art and Wood Architecture* (1925).

STSHERBATSKY, FEDOR IPPOLITOVICH (1867–), Russian orientalist, was born at St. Petersburg (Leningrad) on Sept. 19 (old style), 1867, of a family of old nobility. He was educated at Tsarskoye Selo, and studied philology at St. Petersburg, Vienna and Bonn. In 1904 he became professor of Indian literature at St. Petersburg. The years 1910–11 were spent in British India for scientific research. His knowledge of Tibetan languages and of Buddhism enabled him to enter into friendly relations with the leading Buddhist priests. He was invited to meet the Dalai Lhama, with whom he had several interviews without any interpreter. His thorough understanding of Buddhism makes his work, *The Theory of Knowledge and Logic according to the Later Buddhists* (1899), a most valuable book (German trans., 1924). He has published many Sanskrit mss. in the *Bibliotheca Buddica* of the Academy of Sciences. In 1923 the Royal Asiatic Society published his work, *The Central Conception of Buddhism*, and in 1926 was published *The Conception of Nirvana*.

STUART, ARABELLA (1575–1615), daughter of Charles Stuart, earl of Lennox, younger brother of Lord Darnley and of Elizabeth, daughter of Sir William Cavendish and "Bess of Hardwick," was (by strict pedigree) next in succession to James VI. of Scotland to the thrones of England and Scotland, after Queen Elizabeth. She became the centre of the intrigues of those who refused to accept James as Elizabeth's successor. Suitors for her hand included Henry IV. of France, the earl of Northumberland, and Esmé Stuart, duke of Lennox. In 1590 a scheme was formed of marrying her to Ranuccio, eldest son of the duke of Parma, who was descended from John of Gaunt, and of raising her with Spanish support to the throne. She was regarded with suspicion by Elizabeth and closely guarded at Hardwick by the dowager countess of Shrewsbury. In 1602 the queen's suspicions were increased by the discovery of a plot to marry Arabella to Edward, eldest son of Lord Beauchamp, who as grandson of Edward Seymour, earl of Hertford, and of Lady Catherine Grey, was heir to the throne after Elizabeth according to Henry VIII.'s will. According to other accounts the intended husband was Thomas Seymour, a younger son of the earl of Hertford. Arabella planned an escape from Hardwick with the aid of her chaplain Starkey, who after its failure committed suicide. In December she wrote secretly to Lord Hertford proposing her marriage with his grandson, but the latter immediately informed the council. In February 1603 another attempt at escape failed, and she was then transferred to the care of the earl of Kent at Wrest House. Arabella was received at the court of James I. and treated with favour, and she showed her fidelity to James by revealing a communication made to her by the conspirators in the Main and Bye Plots, in which her name had been used without her sanction. Every effort, however, was made to prevent her marriage. In December 1609 her plan to escape with Sir George Douglas to Scotland, apparently with a view of arranging a marriage with Stephen Bogdan, pretender to Moldavia, was discovered, and she was arrested. She was, however, granted a pension of £1,600 a year by James. In 1610 she was married secretly in despite of the King's prohibition to William Seymour, younger brother of Edward, and grandson of Lord Hertford. They were imprisoned, Arabella at Lambeth and her husband in the Tower. In 1611 she was placed in charge of the bishop of Durham. She escaped on June 3, 1611, and succeeded in boarding a ship bound for Calais. Her husband had also effected his escape and was sailing towards the French coast. Arabella was captured and brought back to the Tower, where she spent the rest of her unhappy career. She sank into melancholy, and, according to some accounts, insanity, and died on or about Sept. 25, 1615. She was buried in the tomb of Mary Queen of Scots in Henry VII.'s chapel in Westminster Abbey.

See also *The Life and Letters of Arabella Stuart*, by E. T. Bradley (1889), which supersedes the *Life* by E. Cooper (1866); and *Lives* by M. Lefuse (1913), and B. C. Bradley (1913).

STUART, GILBERT (1755–1828), American artist, was born at North Kingstown (R.I.) on Dec. 3, 1755. He studied at Newport (R.I.) with Cosmo Alexander, and went with him to Scotland, but returned to America after Alexander's death, and obtained many portrait commissions. In 1775 he went to England, and became a pupil of Benjamin West in 1778. His work, however, shows none of the influence of West, and after four years Stuart set up a studio for himself in London. He painted George III. and the future George IV., and in Paris he painted Louis XVI., and his success was no less great in Ireland. After five years he left Ireland for his native land in order to paint Gen. Washington, who was said to be the only person in whose presence Stuart found himself embarrassed. His first portrait Stuart felt was a failure; but Washington sat to him again, the result being the "Athenaeum" head on an unfinished canvas, showing the left side of the face. This remains the accepted likeness of Washington, of whom he also painted a full-length for Lord Lansdowne; of each of these portraits he executed many replicas. Among his portraits are those of Presidents Washington, John Adams, Thomas Jefferson, James Madison, James Monroe and John Quincy Adams, and John Jay, Governor Winthrop, Generals Gates and Knox, Bishop White, Chief Justice Shippen, John Singleton Copley, Sir Joshua Reynolds, Benjamin West, Lords Clinton, Lyndhurst, and Inchiquin, Sir Edward Thornton, Mme. Patterson-Bonaparte and Horace Binney. Stuart's original colouring and technique, and his insight into character, make him not only one of the few great American artists, but one of the greatest portrait-painters of his time. He settled at Boston in 1805, and died there on July 27, 1828.

See George C. Mason, *Life and Works of Gilbert Stuart* (1879).

STUART, JAMES EWELL BROWN (1833–1864), American soldier, was born in Virginia on Feb. 6, 1833 and entered West Point military academy in 1850. In 1859 Stuart, while staying in Washington on official business, was sent to assist Col. R. E. Lee in the suppression of the John Brown raid on Harper's ferry. Two years later when Virginia seceded from the Union Stuart resigned his commission in the United States army to share in the defence of his State. He had resigned as a lieutenant but he was at once made a colonel. With the scantiest of formal training his regiment was mustered into the Confederate army, and assigned to Joseph Johnston's force in the Shenandoah valley. At the first battle of Bull Run, Stuart distinguished himself by his personal bravery. Later in the year 1861 he was promoted brigadier-general and placed in command of the cavalry brigade of the Army of Northern Virginia. Just before the Seven Days' battle (*q.v.*) he was sent out by Lee to locate the right flank of McClellan's army, and not only successfully achieved his mission, but rode right round McClellan's rear to deliver his report to Lee at Richmond. In the next campaign he had the good fortune, in his raid against Gen. Pope's communications, not only to burn a great quantity of stores, but also to bring off the headquarters' staff document of the enemy, from which Lee was able to discover the strength and positions of his opponents in detail. Stuart, now a major-general and commander of the Cavalry Corps, was present at the second battle of Bull Run, and during the Maryland campaign he brilliantly defended one of the passes of South mountain (Crampton's gap), thus enabling Lee to concentrate his disseminated army in time to meet McClellan's attack. At Fredericksburg Stuart's cavalry were as usual in the flank of the army, and his horse artillery rendered valuable service in checking Franklin's attack on "Stonewall" Jackson's Corps. At Chancellorsville Stuart was specially appointed by Lee to take over command of the II. Army Corps after Jackson had been wounded. The next campaign, Gettysburg, was preceded by the cavalry battle of Brandy station, in which for the first time the Federal Cavalry showed themselves worthy opponents for Stuart and his men. The march to the Potomac was screened by the Cavalry Corps, which held the various approaches on the right flank of the army, but at the crisis of the campaign Stuart was absent on a raid, and although he attempted to rejoin Lee during the battle, he was met and checked some miles from the field. Very shortly after the opening of the campaign of 1864 Stuart's corps was drawn away from Lee's army by the Union cavalry under Sheridan, and part of it was defeated at Yellow Tavern on May 10, and Stuart himself was killed.

See *Life* by H. B. McClellan (1885).

STUART, JOHN M'DUALL (1818–1866), South Australian explorer, was born at Dysart in Fifeshire, Scotland, in 1818, and arrived in the colony about 1839. He accompanied Captain Sturt's 1844–1845 expedition as draughtsman, and between 1858 and 1862 he made six expeditions into the interior, the last of which brought him on July 25 to the shores of the Indian Ocean at Van Diemen's Gulf, at the mouth of the Adelaide River. He died June 5, 1866.

STUBBS, WILLIAM (1825–1901), English historian and bishop of Oxford, son of William Morley Stubbs, solicitor, of Knaresborough, Yorkshire, was born on June 21, 1825, and was educated at the Ripon Grammar school and at Christ Church, Oxford, where he graduated in 1848, with a first class in classics and a third in mathematics. He was elected a fellow of Trinity college in the same year, was ordained priest in 1850, and held the college living of Navestock, Essex, from 1850 to 1866. In 1862 he was appointed librarian at Lambeth, and in 1866 regius professor of modern history at Oxford. He held this chair till 1884. Many of his lectures were published in book form, including *Seventeen Lectures on the Study of Mediaeval and Modern History, etc.* (1886, 3rd ed. 1900); *Lectures on European History* (1906); *Germany in the Early Middle Ages* (1908); and *Germany in the later Middle Ages* (1908). Stubbs aimed at the organization of a school of history in Oxford after the German model, but his lectures were thinly attended and he gave up the idea.

As a historian Stubbs was eminent alike in ecclesiastical history, as an editor of texts and as the historian of the English Constitution. In 1858 he published his *Registrum sacrum anglicanum*, which sets forth episcopal succession in England, and he edited with A. W. Haddan, vol. iii. of *Councils and Ecclesiastical Documents covering the History of the Anglo-Saxon Church* (1878). He edited for the Rolls series 19 volumes of editions of the chronicles, among the most notable of which are the *Gesta Regum* of William of Malmesbury (1867); the *Gesta regis Henrici II.* (1867); Roger Hoveden's *Chronica* (4 vols., 1868–71); the *Memorials of St. Dunstan* (1874); *The Historical Works of Ralph Diceto* (1878) and *The Historical Works of Gervase of Canterbury* (1879–90). The prefaces to these volumes contain some brilliant sketches of character.

His most famous work is his *Constitutional History of England* (3 vols., 1873, 75, 78, French trans. 1907), preceded by the *Select Charters, and other Illustrations of English Constitutional History from the Earliest Times to the Reign of Edward I.*, in 1870. The appearance of the *Constitutional History*, which traces the development of the English Constitution from the Teutonic invasions of Britain till 1485, is a landmark in the study of mediaeval English history, and has not been superseded.

In character Bishop Stubbs was modest, kind and sympathetic, ever ready to help and encourage serious students, generous in his judgment of the works of others, a most cheery companion, full of wit and humour. His wit was often used as a weapon of defence, for he did not suffer fools gladly. He died on April 22, 1901. In 1859 he had married Catherine, daughter of John Dollar, of Navestock, and had a numerous family.

See *Letters of William Stubbs, Bishop of Oxford*, edit. W. H. Hutton (1904).

STUCCO, a kind of plaster used for the covering of walls, or for decorative or ornamental features such as cornices, mouldings, etc., or for ceilings. The stucco used as an exterior covering for brick or stone work is coarse; a finer kind is used for decorative purposes. (*See* PLASTER-WORK.)

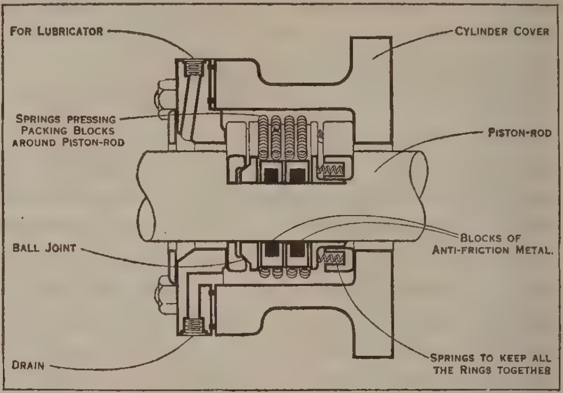
STUCLEY (or STUKELY), **THOMAS** (*c.* 1525–1578), English adventurer, son of Sir Hugh Stucley, of Affleton, near Ilfracombe, a knight of the body to King Henry VIII., was supposed to have been an illegitimate son of the king. He was a standard-bearer at Boulogne from 1547 to 1550, entered the service of the duke of Somerset, and after his master's arrest in 1551 a warrant was issued against him, but he escaped to France, and served in the French army. He was sent by Montmorency with a letter of recommendation from Henry II. of France to Edward VI. On his arrival he proceeded on Sept. 16, 1552 to reveal the French plans for the capture of Calais and for a descent upon England, which had, according to his account, been the object of his mission to England. Stucley was imprisoned in the Tower for some months. A prosecution for debt on his release in August 1553 compelled him to become a soldier of fortune once more, but he returned to England in December 1554 in the train of Philibert, duke of Savoy. He married an heiress, Anne Curtis, but in a few months had to return to the duke of Savoy's service. From 1558 onwards he seems to have been engaged in buccaneering, and although Elizabeth was compelled to disavow Stucley, who surrendered in 1565, his prosecution was merely formal.

Stucley was then engaged by Sir Henry Sidney in Ireland, then by Fénelon, the French Ambassador in London, and then by Philip II. of Spain, but he fell into disgrace at Madrid. But he commanded three galleys, under Don John of Austria at the battle of Lepanto, and exploits restored him to favour at Madrid. On March 2, 1572 he was at Seville, offering to hold the narrow seas against the English with a fleet of twenty ships. In four years (1570–1574) he is said to have received over 27,000 ducats from Philip II. Wearied by the Spanish king's delays he sought assistance from Gregory XIII., who aspired to make his illegitimate son, Giacomo Buoncompagno, king of Ireland. He set sail from Civita Vecchia in March 1578, but put into Lisbon, where he was to meet his confederate, James Fitzmaurice Fitzgerald, and to secure better ships before sailing for Ireland. There he was turned from his purpose by King Sebastian, with whom he sailed for Morocco. He commanded the centre in the battle of Alcazar on Aug. 4, 1578, and was killed.

There is a detailed biography of Stucley, based chiefly on the English, Venetian and Spanish state papers, in R. Simpson's edition of the 1605 play (*School of Shakespeare*, 1878, vol. i.), where the Stucley ballads are also printed.

STUDEBAKER CORPORATION, THE, incorporated Feb. 14, 1911, at that time acquiring the assets of the Studebaker Brothers Manufacturing Company, formed in 1868, and the Everitt-Metzger-Flanders Company, organized in 1908. The Studebaker Brothers Manufacturing Company succeeded the firm of H. and C. Studebaker, established in 1852. Beginning with net assets of $23,000,000 in 1911, the corporation has increased its assets as at June 30, 1928, to $105,000,000. Capital stock outstanding 1928: preferred $7,305,000, $100 par value; common $75,000,000, no par value. (H. E. DA.)

STUFFING-BOX is a device to prevent leakage by a piston or ram or spindle as it passes into a cylinder sustaining pressure. This applies to steam-engines, air-compressors, some kinds of pumps, hydraulic machinery, many stop-valves, throttle-valves, and water fittings. The main element in each instance is the gland, which is forced along by a thread, or by two or more screws pressing its flange. A chamber surrounding the rod or spindle contains the stuffing or packing, and this becomes compressed around the rod to form a non-leaking joint. Big glands have the nuts of the bolts driven in unison by a gear to produce equable tightening all around the circle. A packing commonly used is hemp, though to withstand heat asbestos mixtures are chiefly employed, and are charged with graphite so as to give a constant lubricating effect. Metallic packings have largely superseded any kind of fabrics, the stuffing-box containing an arrangement of white-metal pads, with springs to compress them around the rod; the steam pressure further assists in making a tight joint. The drawing shows the Lancaster and Tonge packing, in which the encircling springs can be unhooked and twisted to tighten the grip.


For Lubricator
Cylinder Cover
Springs pressing Packing Blocks around Piston-rod
Piston-rod
Ball Joint
Blocks of Anti-friction Metal.
Drain
Springs to keep all the Rings together

SECTION OF LANCASTER STUFFING-BOX SHOWING METALLIC PACKING WHICH PRESSES ANTI-FRICTION BLOCKS AROUND THE PISTON-ROD AND PREVENTS THE ESCAPE OF STEAM

STUFFINGS OR FORCEMEATS. These are used principally to give extra flavour to certain flesh foods and vegetables; to bring out the flavour of others; and as additions to some dish such as jugged hare, in the form of forcemeat balls or quenelles. Bread, crumpled, moistened and seasoned, is the foundation of many forcemeats. A simple American formula is 2 cups dry bread crumbs to ½ cup hot water, ½ teaspoon salt, ¼ teaspoon pepper, sometimes varied by the substitution of milk or stock (especially chicken stock) for water. A plain English recipe calls for 4 oz. bread scraps to half the amount of suet, one egg, salt, pepper and some form of seasoning, *e.g.*, parsley or mixed herbs. Either recipe may be elaborated by adding chopped onion, sage, nutmeg or ground nuts. Chestnut, mushroom, oyster and potato forcemeats are good for poultry, minced giblets being often added. Fruit stuffings are especially good for strong-flavoured birds like duck and goose.

STUKELEY, WILLIAM (1687–1765), English antiquary, was born at Holbeach, Lincolnshire, on Nov. 7, 1687. His principal work, an elaborate account of Stonehenge, appeared in 1740, and he wrote copiously on other supposed Druid remains, becoming familiarly known as the "Arch-Druid." He died in London on March 3, 1765.

STUMPF, CARL (1848–), German psychologist and philosopher, was born at Wiesentheid, Bavaria, April 21, 1848. He studied first at Würzburg under Brentano, and later at Göttingen under Lotze. He was greatly influenced in his philosophy and psychology by these two men, and has remained loyal to them. He was appointed to the chair of philosophy at Würzburg (1873), Prague (1879), Halle (1884), Munich (1889) and finally Berlin (1894) where he was professor of philosophy and director of the psychological laboratory. In 1900 he founded the phonogram-archivs, which consist of a collection of phonograph records of primitive music. In 1907–8 he was rector of Berlin university. In 1921 he reached the age limit, and retired from active teaching.

His chief publications include: *Ueber den psychologischen Ursprung der Raumvorstellung* (1873); *Tonpsychologie* (1883–90); "Ueber den Begriff der mathematischen Wahrscheinlichkeit," *Sitz. bayr. Ak.* (1892); *Ueber Leib und Seele* (1897); *Beiträge zur Akustik und Musikwissenschaft* (1898–1924); "Ueber den Begriff der Gemütsbewegung," *Z. f. Psychol.* (1899); "Erscheinungen und psychische Funktionen," *Abh. pr. Ak.* (1906); "Zur Einteilung der Wissenschaften," *Abh. pr. Ak.* (1906); "Ueber Gefühlsempfindungen," *Z. f. Psychol.* (1907); *Die Wiedergeburt der Philosophie* (1908); *Philosophische Reden und Vorträge* (1910); *Die Anfänge der Musik* (1911); "Apologie der Gefühlsempfindungen," *Z. f. Psychol.* (1916); "Die Struktur der Vokale," *Sitz. pr. Ak.* (1918); *Die Sprachlaute: experimentellphonetische Untersuchungen* (1926). *See* also B. Rand, *The Classical Psychologists* (1912); and Stumpf's autobiography in R. Schmidt, *Die Philosophie der Gegenwart in Selbstdarstellungen* (1924).

(H. S. L.)

STUMPF, JOHANN (1500–1576), writer on Swiss history and topography, was born at Bruchsal (near Carlsruhe) in 1500 and died at Zürich in 1576. He studied theology at Strasbourg and Heidelberg, and in 1522 was ordained priest at Basel and assigned to the parish of Bubikon (in Canton Zürich). He soon, however, adopted the Protestant faith, and he remained at Bubikon (most of his parishioners following him) as Protestant pastor till 1543. Thereafter he removed to Stammheim, but retired in 1561 and spent the rest of his days at Zürich. The chief result of his historical studies and travels was his *Gemeiner loblicher Eydgnossenschaft Stetten, Landen, und Volckeren Chronikwirdiger Thaaten Beschreybung* (1548). He also wrote on the Council of Constance (1541) and on the emperor Henry IV. (1556).

STUPA, in architecture, a specific type of Buddhist religious building, consisting of a solid mass of masonry, built above a receptacle containing a sacred relic. In India it is commonly called a tope (*q.v.*). Although the origin of the stupa was probably the more primitive tumulus, or mound of earth over a grave, its development in historic times was toward greater and greater height and richness of treatment. Outside of Tibet and China, a profile generally conical and of great height was developed, as in the famous gilded example in the centre of the Shwe Dagon, in Rangoon. The Tibetan form, developed to a great degree of beauty and richness in China, has a bulbous silhouette, wider near the top than at the bottom.

STURDEE, SIR FREDERICK CHARLES DOVETON (1859–1925), British sailor, was born at Charlton, Kent, on June 9, 1859, and entered the navy in 1871. He was promoted lieutenant (1880), commander (1893), captain (1899), rear-admiral (1908), vice-admiral (1913), admiral (1917) and admiral of the fleet (1921). He saw service in Egypt (1882) and in Samoa (1899), when he was in command of the Anglo-American force. He was assistant director of naval intelligence to the Admiralty (1900–02) and chief of staff, Mediterranean Fleet (1905–07) and Channel Fleet (1907). In 1910 he became rear-admiral of the first battle squadron, and commanded the 2nd cruiser squadron (1912–13). During the World War Sturdee was made chief of the war staff in Nov. 1914. As commander-in-chief in the south Atlantic and Pacific, he led the squadron which won the battle of the Falkland islands (Dec. 8, 1914), and he was in command of the 4th battle squadron when it took part in the battle of Jutland. He was created K.C.B. in 1913, K.C.M.G. in 1916, and a baronetcy was conferred on him in 1916, with the title "of the Falkland islands." From 1918–21 he was commander-in-chief at the Nore. He died on May 7, 1925.

STURDZA or Sturza, the name of an ancient Rumanian family, of unknown origin, which probably came from Trebizond and settled in Moldavia. The Sturdza family has been long and intimately associated with the Government first of Moldavia and afterwards of Rumania. Its members belong to two main divisions, which trace their descent respectively from John (Ioan) or from Alexander (Sandu), the sons of Kirak Sturdza, who lived in the 17th century, the founder of the family.

1. To the first division belongs Michael [Michail] Sturdza (1795–1884), prince of Moldavia from 1834 to 1849. A man of liberal education, he established the first high school, a kind of university, in Jassy. He brought scholars from foreign countries to act as teachers, and gave a very powerful stimulus to the educational development of the country. In 1844 he decreed the emancipation of the gypsies. Until then the gypsies had been treated as slaves and owned by the Church or by private landowners; they had been bought and sold in the open market. Michael Sturdza also attempted the secularization of monastic establishments, which was carried out by Prince Cuza in 1864, and the utilization of their endowments for national purposes. Under his rule the internal development of Moldavia made immense progress; roads were built, industry developed, and Michael is still gratefully remembered by the people.

See *Michel Stourdza et son administration* (Brussels, 1834); *Michel Stourdza, ancien prince regnant de Moldavie* (1874); A. A. C. Sturdza, *Règne de Michel Sturdza, prince de Moldavie 1834–1849* (1907).

2. Gregory [Grigorie] Sturdza (1821–1901), son of the above, was educated in France and Germany, became a general in the Ottoman army under the name of Muklis Pasha, and afterwards attained the same rank in the Moldavian army. He was a candidate for the Moldavian throne in 1859, and subsequently a prominent member of the Russophil party in the Rumanian parliament. He wrote *Lois fondamentales de l'univers* (Paris 1891).

3. John [Ioan] Sturdza, prince of Moldavia (1822–1828), was the most famous descendant of Alexander Sturdza. Immediately after the Greek revolution, Prince John Sturdza took an active part in subduing the roving bands of Greek Hetairists in Moldavia; he transformed the Greek elementary schools into Rumanian schools and laid the foundation for that scientific national development which Prince Michael Sturdza continued after 1834. In 1828 the Russians entered the country and took Prince John prisoner. He died in exile.

4. Demetrius [Dimitrie] Sturdza (1833–1914), Rumanian statesman, was born in 1833 at Jassy, and educated there at the Academia Michaileana. He continued his studies in Germany, took part in the political movements of the time, and was private secretary to Prince Cuza. Demetrius afterwards turned against Cuza, joined John Bratianu, and became a member of the so-called Liberal Government. In 1899 he was elected leader of the party in succession to Bratianu and was four times prime minister. He died at Bucharest on Oct. 21, 1914. (M. G.)

STURE, STEN, commonly called the Younger (1492–1520), succeeded his father Srante (d. 1512) as regent of Sweden. His regency was wrecked by the feud between the Sture and Trolle families, and his own personal feud with Gustaf Trolle, who invoked the aid of Christian II. of Denmark. The war with Denmark was begun in 1516 and resumed in 1518, and in 1520 culminated in the battle near Börgerund on Lake Aarunden (Jan. 19). At the very beginning Sture was hit by a bullet and his peasant levies fled to the wild mountainous regions of Tiveden where they made a last desperate but unsuccessful stand. The mortally-wounded regent took to his sledge and posted towards Stockholm, but expired on the ice of Lake Mälar two days later.

STURGE, JOSEPH (1793–1859), English philanthropist and politician, was the son of a farmer in Gloucestershire, and settled in 1822 in Birmingham, where he died on May 14, 1859. His life was given to agitation for the abolition of slavery, then to the betterment of the conditions of the liberated slaves, and lastly to the cause of peace and arbitration. He was one of the founders in 1855 of the *Morning Star,* a paper established in the peace interest; a Quaker; and a friend of the Chartists.

See Henry Richard, *Memoirs of Joseph Sturge* (London, 1864); John (Viscount) Morley, *Life of Richard Cobden* (London, 1881).

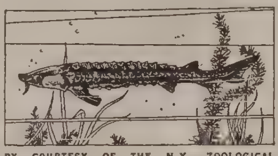
STURGEON (*Acipenser*), a small group of fishes, of which some 20 species are known, from European, Asiatic and North American rivers. The distinguishing characters of this group are dealt with in the article Fish. Most of them pass a great part of the year in the sea, but periodically ascend large rivers, some in spring to deposit their spawn, others later in the season for some purpose unknown; a few are confined to fresh water. None occur in the tropics or the southern hemisphere. By a decree of Edward II., English sturgeons are the property of the king.

Sturgeons are found in the greatest abundance in the rivers of southern Russia, more than 10,000 fish being sometimes caught at a single fishing-station in the fortnight of the up-stream migration, and in the fresh waters of North America. In Russia the fisheries are of immense value. Early in summer the fish migrate into the rivers or towards the shores of fresh-water lakes in large shoals for breeding purposes. The ova are small and numerous. The growth of the young is rapid. After the sturgeon attains maturity, growth continues for some years, but slowly. Some attain great age, and von Baer stated that observations made in Russia indicate that the Hausen (*A. huso*) may attain an age of between 200 and 300 years. Sturgeons ranging from 8 to 11 ft. in length are by no means scarce, and some species grow to a much larger size. Sturgeons are ground-feeders. The more important species are:

1. The common sturgeon of Europe (*A. sturio*) occurs on all

the coasts of Europe, but is absent from the Black sea. It is not rare on the coasts of North America. It reaches a length of 12 ft., but is always caught singly, or in pairs. The form of its snout varies with age (as in the other species), being much more blunt and abbreviated in old than in young examples. There are 11–13 bony shields along the back and 29–31 along the body.

2. *A. güldenstädtii* is one of the most valuable species of the rivers of Russia; it inhabits the Siberian rivers also, eastwards as far as Lake Baikal. It attains the same size as the common sturgeon, and abounds in the rivers of the Black and Caspian seas.



BY COURTESY OF THE N.Y. ZOOLOGICAL SOCIETY

THE COMMON STURGEON (ACIPENSER STURIO)

3. *A. stellatus* occurs in abundance in the rivers of the Black sea and of the Sea of Azov. It has a long and pointed snout, like the sterlet, but simple barbels without fringes. Though growing only to about half the size of the preceding species it is of no less value, its flesh being more highly esteemed and its caviare and isinglass fetching a higher price.

4. The sturgeon of the great lakes of North America (*A. rubicundus*) has been made the object of a large industry at various places on Lakes Michigan and Erie. The sturgeons of the lakes are unable to migrate to the sea, but those below the Falls of Niagara are great wanderers.

5. *A. huso* is recognized by the absence of osseous scutes on the snout and by its flattened, tape-like barbels. It is one of the largest species, reaching the length of 24 ft., and a weight of 2,000lb. It inhabits the Caspian and Black seas, and the Sea of Azov. Its flesh, caviare and air-bladder are of less value than those of the smaller kinds.

6. The sterlet (*A. ruthenus*) is one of the smaller species, which inhabits both the Black and Caspian seas.

The family *Acipenseridae* includes one other genus, *Scaphirhynchus,* the shovel-head or shovel-nosed sturgeon, distinguished by the long, broad and flat snout, the suppression of the spiracles, and the union of the longitudinal rows of scales posteriorly. All the species are confined to fresh water. One of them is common in the Mississippi and other rivers of North America, the other three occur in the larger rivers of eastern Asia.

STURGEON BAY, a city of north-eastern Wisconsin, U.S.A., on the narrow peninsula (here 8 m. wide) between Green bay and the main body of Lake Michigan; a port of entry and the county seat of Door county. It lies on Sturgeon bay (an inlet of Green bay, connected with Lake Michigan by a ship-canal) and is served by the Green Bay and Western Railroad and lake steamers. Pop. 4,553 in 1920 (87% native white). The peninsula is a region of great natural beauty, with many hotels and summer homes. The city is a summer resort and trading centre. The annual cherry crop amounts to over 10,000,000 bushels. Commercial fishing is an important industry. There is a State fish hatchery near by. The city was incorporated in 1883.

STURGIS, RUSSELL (1836–1909), American architect and art critic, was born in Baltimore county, Maryland, on Oct. 16, 1836. He graduated from the Free Academy in New York (now the College of the City of New York) in 1856. He studied architecture under Leopold Eidlitz and then for two years in Munich. In 1862 he returned to the United States. He designed the Yale University chapel and the Farnham and Durfee dormitories at Yale, the Flower Hospital, New York, the Farmers' and Mechanics' Bank, Albany, and many other buildings. After 1880 he did comparatively little professional work. He was in Europe in 1880–84. For a short time after his return he was secretary of the New York municipal civil service board. He was president of the Architectural League of New York in 1889–93, was first president of the Fine Arts Federation in 1895–97, and was a member of the National Society of Mural Painters, the National Sculpture Society, the National Academy of Design, and the New York chapter of the American Institute of Architects. He lectured on art at Columbia University, the Metropolitan Museum of Art in New York, the Peabody Institute of Baltimore and the Art Institute of Chicago. He edited *A Dictionary of Architecture and Building* (3 vols., 1901–02) and the English version of Wilhelm Lüebke's *Outlines of the History of Art* (2 vols., 1904), and he wrote *European Architecture* (1896), *How to Judge Architecture* (1903), *The Appreciation of Sculpture* (1904), *The Appreciation of Pictures* (1905), *A Study of the Artist's Way of Working in the Various Handicrafts and Arts of Design* (2 vols., 1905) and an unfinished *History of Architecture* (1906 et seq.). During his last years he was nearly blind. He died in New York Feb. 11, 1909.

STURGIS, a city of Michigan, U.S.A. The population was 5,995 in 1920 (95% native white). It is in a rich agricultural region, and has a large number of diversified manufacturing industries. The city has a commission-management.

STÜRGKH, CARL, Count (1859–1916), Austrian politician, was born at Graz on Oct. 30, 1859, of an ancient Styrian family. In 1891, he entered the Reichsrat as representative of the constitutional landed proprietors, achieving some prominence as a keen opponent of universal suffrage. He was from Feb. 10, 1909 to Nov. 3, 1911 minister of education, and a zealous advocate of the humanistic education traditional in the *gymnasia.* On Nov. 3 he became prime minister, and formed a cabinet without regard to nationality. Owing to the incessant parliamentary obstruction, however, Stürgkh prorogued parliament indefinitely on March 16, 1914, with an announcement that "Parliaments were only means to an end, and where they failed, other means must be employed." So on the outbreak of the World War Austria was without a parliament, and the decisions lay with its few rulers alone. Stürgkh was one of the committee of five ministers who decided on the ultimatum to Serbia. He refused to convoke parliament, and it was as a protest against this that the Social Democrat, Friedrich Adler (*q.v.*) assassinated him in a Viennese restaurant on Oct. 21, 1916 (*see* Austria).

STURM, JACQUES CHARLES FRANÇOIS (1803–1855), French mathematician, of German extraction, was born at Geneva on Sept. 29, 1803, and spent most of his life in Paris. In 1829 he discovered the theorem regarding the determination of the number of real roots of a numerical equation included between given limits, which bears his name. (*See* Equation.) He was chosen a member of the Académie des Sciences in 1836, became professor in the École Polytechnique in 1840, and finally succeeded Poisson in the chair of mechanics in the Faculté des Sciences in Paris. He died in Paris on Dec. 18, 1855.

His works, *Cours d'analyse de l'école polytechnique* (1857–68) and *Cours de Mécanique de l'école polytechnique* (1861), were published posthumously.

STÜRMER, BORIS VLADIMIROVICH (1849–1917), Russian politician, was of German origin. His father was captain of a fire brigade at Tula. He studied at the University of St. Petersburg (Leningrad). He started his career in the chamberlain's department of the imperial court. When in 1892 the Government rejected the candidate nominated to the presidency of the executive board of the Tver zemstvo, Stürmer, whose name was on the list of the Tver gentry, was appointed to this office. It was the first case of a president being appointed instead of elected. In 1894 Stürmer was appointed governor of the Novgorod, and later of the Yaroslavl province. In Jan. 1916, he was made prime minister. He was opposed in liberal and patriotic circles. Accusations of connections with Germany were brought to the Duma by Milyukov and resulted in Stürmer's resignation in Nov. 1916. After Sazonov's dismissal Stürmer took the portfolio of foreign affairs. He was arrested after the revolution, and died in prison in Sept. 1917.

STURM VON STURMECK, JACOB (1489–1553), German statesman and reformer, was born at Strasbourg on Aug. 10, 1489. He was educated at the universities of Heidelberg and Freiburg, and about 1517 he entered the service of Henry of Wittelsbach, provost of Strasbourg (d. 1552). He soon became an adherent of the reformed doctrines, and a member of the town council in 1524. He was responsible for the policy of Strasbourg during the Peasants' War; represented the city at the diet of Speyer in 1526 and at subsequent diets. He took part in the conference at Marburg in 1529; but when the attempts to close the breach between Lutherans and Zwinglians failed, he presented the *Confessio tetrapolitana* to the Augsburg diet of 1530. As the representative of Strasbourg Sturm signed the "protest" which was presented to the diet of Spires in 1529, being thus one of the original "Protestants." Owing largely to his influence Strasbourg joined the league of Schmalkalden in 1531. In Feb. 1547 the citizens were compelled to submit to Charles V. Sturm obtained for his native city some modification of the *Interim* issued from Augsburg in May 1548. He died at Strasbourg on Oct. 30, 1553.

See H. Baumgarten, *Jakob Sturm* (Strasbourg, 1876); A. Baum, *Magistrat und Reformation in Strassburg bis 1529* (Strasbourg, 1887).

STURNIDAE: *see* STARLING.

ŠTURSA, JAN (1880–1925), the leader of the modern school of Czech sculpture, was born at Nové Město in Moravia. In 1899 he entered the Academy of Fine Arts at Prague as a pupil of Myslbek. His early works manifest the influence of the symbolic literature of that period, but by 1905–7 he had already attained an individual expression in such works as "Puberty" (1905), "The Melancholy Girl" (1906) and "Primavera" (1907). A journey to Italy in 1907 was the opening of a new epoch in his creative work. His admiration for femininity is manifested in "Eve" (1908, State Gallery, Munich), "Hetaira" (1909), "Messalina" and the monumental representation of the dancer "Sulamith Rahu" (1911), now in the gallery at Venice. He interpreted the opposite feminine type of intellectuality in the monument to Hana Kvapilova (1912), the Czech actress. During the same period Štursa produced the group of statuary for the pylons of the Hlavka Bridge at Prague. In 1916 he was appointed professor at the Academy of Fine Arts in Prague, and in this period of his artistic maturity he created the "Wounded Man." He produced a number of portrait busts, the most noteworthy being "President Masaryk." He died in Prague on April 28, 1925.

STURT, CHARLES (d. 1869), English explorer, was born in England. Having landed in Australia with his regiment (the 39th), he started on a first expedition (1828) discovering the Darling river; while a second made known the existence of Lake Alexandrina. From his third journey (1844–1845), in which terrible hardships had to be endured, he returned quite blind, and he never altogether recovered his sight. He was appointed surveyor-general of South Australia in 1833, and subsequently chief secretary until 1856 when responsible government was introduced. Sturt died at Cheltenham, England, on June 16, 1869.

STURZO, LUIGI (1870–), Italian priest and political organizer. Born at Caltagirone, Sicily, on Nov. 26, 1870, he showed ability in creating diocesan committees, co-operation unions, etc., and guiding the masses in the direction of Christian democracy. On the outbreak of the World War, he came to Rome as secretary of the Azione cattolica. After the armistice he was chosen political secretary of the *Partito Popolare italiano*, founded early in 1919. The general tendency of the party was Christian Socialist, and Don Sturzo advocated social reforms of a radical nature, especially in agriculture, as the majority of the party's adherents were peasants; unlike the Socialists, he demanded the expropriation of the land with compensation for the landlords at the expense of the taxpayers, collaboration of capital and labour and a patriotic foreign policy; an extremist wing was led by Sig. Miglioli.

At the elections of Nov. 1919, the *Partito Popolare* secured 101 seats, and became a dominant force in Italian politics. When Sig. Bonomi was trying to form a cabinet after the fall of Giolitti in Feb. 1922, it was Don Sturzo who dictated its composition. In the early days of Fascism Don Sturzo did not oppose it, although there were frequent affrays between the black-shirted *squadre* and the Migliolini. After the march on Rome he allowed several Popolari to enter the cabinet, but his half-hearted support of the Mussolini Government resulted in their withdrawal, and Don Sturzo and his party definitely joined the opposition. A section of the party broke away and constituted the *Centro nazionale cattolico*. The Vatican issued an admonition to priests not to mix in party politics and hinted that he would be well advised to leave Italy. He consequently went to England and France. In 1925 he published *Pensiero antifascista*, and in 1927 *Italy and Fascism* in English. (L. V.)

STUTTGART, capital of Württemberg. Pop. including suburbs (1925) 337,199. Stuttgart seems to have originated in a stud (*Stuten Garten*) of the early counts of Württemberg, and is first mentioned in a document of 1229. In the early history of Württemberg it was overshadowed by Cannstatt. Indeed, even at the beginning of the 19th century it did not contain 20,000 inhabitants, and its real advance began with Kings Frederick and William I. Few of its principal buildings are older than the 19th century. They illustrate the revival of the Renaissance style. Of the churches in the city the most interesting are the Stiftskirche, with two towers, a fine specimen of 15th-century Gothic; the Leonhardskirche, also a Gothic building of the 15th century; and the Hospitalkirche, restored in 1841, the cloisters of which contain the tomb of Johann Reuchlin. A large proportion of the most prominent buildings are clustered round the Schlossplatz. Among these are the new palace, a structure of the 18th century, finished in 1807; the old palace, a 16th-century building; and the so-called Akademie, formerly the seat of the Karlschule, where Schiller received part of his education, and now containing a library. On or near the Schlossplatz also are the new courts of justice; and the central railway station.

The art collections of Stuttgart are numerous and valuable. The museum of art comprises a picture gallery, a collection of casts of Thorvaldsen's works and a cabinet of engravings. The library contains many thousands of printed volumes and manuscripts, including one of the largest collections of Bibles in the world. The technical high school, which since 1899 has possessed the right to confer the degree of doctor of engineering, practically enjoys academic status and so does the veterinary high school.

Stuttgart is the centre of the publishing trade of south Germany. Its other manufactures include machinery, pianos and other musical instruments, cotton goods, linen, gloves, rubber, jewellery, chocolate, lamps, cigars, furniture, leather, paper, colours and chemicals. A large banking and exchange business is done here. Stuttgart contains a garrison. Cannstatt, incorporated with Stuttgart in 1903, attracts visitors owing to its beautiful situation and its saline and chalybeate springs.

STUYVESANT, PETER (1592–1672), Dutch colonial governor, was born in Scherpenzeel, in Southern Friesland, in 1592. He studied at Franeker, entered the military service in the West Indies about 1625, and was director of the West India Company's colony of Curaçao 1634–44. In April, 1644 he attacked the Portuguese island of Saint Martin and was wounded; he had to return to Holland, and there one of his legs was amputated. Thereafter he wore a wooden leg ornamented with silver bands. In May, 1645, he was selected by the West India Company to supersede William Kieft as director of New Netherland. He arrived in New Amsterdam (later New York) on May 11, 1647, and was received with great enthusiasm. In response to the demand for self-government, in Sept., 1647, he and the council appointed—after the manner then followed in Holland—from 18 representatives chosen by the people a board of 9 to confer with him and the council whenever he thought it expedient to ask their advice.

The leading burghers were, however, soon alienated by his violent and despotic methods, by his defence of Kieft, and by his devotion to the interests of the company; the nine men became the centre of municipal discontent, and a bitter quarrel ensued. In 1650 the states-general suggested a representative government to go into effect in 1653, but the company opposed it; in 1653, however, there was established the first municipal government for the city of New Amsterdam modelled after that of the cities of Holland. Stuyvesant also aroused opposition through his efforts to increase the revenues of the company, to improve the system of defence, and to prevent the sale of liquor and firearms to the Indians, and through his persecution of Lutherans and Quakers, to which the company finally put an end. In 1650, he came to an agreement with the commissioners of the united colonies of New England at Hartford upon the boundary between New Netherland and Connecticut, involving the sacrifice of a large amount of territory. On Long Island, during Stuyvesant's rule, Dutch influence was gradually undermined by John Underhill. Stuyvesant's dealings with the Swedes were more successful. With a force of 700 men he sailed into the Delaware in 1655, captured Ft. Casimir (Newcastle)—which Stuyvesant had built in 1651 and which the Swedes had taken in 1654—and overthrew the Swedish authority in that region. He also vigorously suppressed Indian uprisings in 1655, 1658 and 1663.

In March, 1664, Charles II. granted to his brother, the duke of York, the territory between the Connecticut river and Delaware bay, and Col. Richard Nicolls with a fleet of 4 ships and about 300 or 400 men was sent out to take possession. Misled by instructions from Holland that the expedition was directed wholly against New England, Stuyvesant made no preparation for defence until just before the fleet arrived. As the burghers refused to support him, Stuyvesant was compelled to surrender the town and fort on Sept. 8. He returned to Holland in 1665 and was made a scapegoat by the West India Company for all its failings in New Amsterdam; he went back to New York again after the treaty of Breda in 1667, having secured the right of free trade between Holland and New York. He spent the remainder of his life on his farm called the Bouwerie, from which the present "Bowery" in New York city takes its name. He died in Feb. 1672, and was buried in a chapel, on the site of which in 1799 was erected St. Mark's church.

See Bayard Tuckerman, *Peter Stuyvesant* (1893), in the "Makers of America" Series; and Mrs. Schuyler Van Rensselaer, *History of the City of New York in the Seventeenth Century* (1909).

STYLE. It is desirable to insist at the outset on the dangers of a heresy which found audacious expression towards the close of the 19th century, namely, that style is superior to thought and independent of it. Against this may be set at once one of the splendid apophthegms of Buffon, "Les idées seules forment le fond du style." Before there can be style there must be thought, clearness of knowledge, precise experience, sanity of reasoning power. A confusion between form and matter has often confused this branch of our theme. Even Flaubert, than whom no man ever gave closer attention to the question of style, seems to dislocate them. For him the *form* was the work itself: "As in living creatures, the blood, nourishing the body, determines its very contour and external aspect, just so the *matter*, the basis, of a work of art imposes, necessarily, the unique, the just expression, the measure, the rhythm, the *form* in all its characteristics." This ingenious definition seems to strain language beyond its natural limits. If the adventures of an ordinary young man in Paris be the *matter* of *L'Education sentimentale* it is not easy to admit that they "imposed, necessarily," such a "unique" treatment of them as Flaubert so superlatively gave. They might have been recounted with feebler rhythm by an inferior novelist, with bad rhythm by a bad novelist and with no rhythm at all by a police-news reporter. What makes that book a masterpiece is not the basis of adventure, but the superstructure of expression. The expression, however, could not have been built up on no basis at all, and would have fallen short of Flaubert's aim if it had risen on an inadequate basis. The perfect union is that between adequate matter and an adequate form. We will borrow from the history of English literature an example which may serve to illuminate this point. Locke has no appreciable style; he has only thoughts. Berkeley has thoughts which are as valuable as those of Locke, and he has an exquisite style as well. From the artist's point of view, therefore, we are justified in giving the higher place to Berkeley, but in doing this we must not deny the importance of Locke. If we compare him with some pseudo-philosopher, whose style is highly ornamental but whose thoughts are valueless, we see that Locke greatly prevails. Yet we need not pretend that he rises to an equal height with Berkeley, in whom the basis is no less solid, and where the superstructure of style adds an emotional and aesthetic importance to which Locke's plain speech is a stranger. At the same time, an abstract style, such as that of Pascal, may often give extreme pleasure, in spite of its absence of ornament, by its precise and pure definition of ideas and by the just mental impression it supplies of its writer's power and placidity of mind. But whether in the abstract or concrete style, what Rossetti called "fundamental brain-work" must always have a leading place.

When full justice has been done to the necessity of thought as the basis of style, it remains true that what is visible, so to speak, to the naked eye, what can be analysed and described, is an artistic arrangement of words. Language is so used as to awaken impressions, and these are roused in a way peculiar to the genius of the individual who brings them forth. The personal aspect of style is therefore indispensable, and is not to be ignored even by those who are most rigid in their objection to mere ornament. Ornament in itself is no more style than facts, as such, are thought. In an excellent style there is an effect upon our senses of the mental force of the man who employs it. D'Alembert said of Fontenelle that he had the style of his thought, like all good authors. In the words of Schopenhauer, style is the physiognomy of the soul: in the Renaissance phrase, it is *mentis character*. All these attempts at epigrammatic definition tend to show the sense that language ought to be, and even unconsciously is, the mental picture of the man who writes.

To attain this, however, the writer must be sincere, original and highly trained. He must be highly trained, because, without the exercise of clearness of knowledge, precise experience and the habit of expression, he will not be able to produce his soul in language. Nor can anyone who desires to write consistently and well, afford to neglect the laborious discipline which excellence entails. He must never rest until he has attained a consummate adaptation of his language to his subject, of his words to his emotion. This is the most difficult aim which the writer can put before him. Perfection is impossible, and yet he must never desist from pursuing perfection.

> "If all the pens that ever poets held
> Had fed the feeling of their masters' thoughts,
> And every sweetness that inspired their hearts,
> Their minds, and muses, on admirèd themes—
> If all the heavenly quintessence they 'still
> From their immortal flowers of poesy,
> Wherein, as in a mirror, we perceive
> The highest reaches of a human wit—
> If these had made one poem's period,
> And all combined in beauty's worthiness,
> Yet should there hover in their restless heads
> One thought, one grace, one wonder, at the least.
> Which into words no virtue can digest."
> —Marlowe, *Tamburlaine the Great*.

Flaubert believed that every thought or grace or wonder had one word or phrase exactly adapted to express it, and could be "digested" by no other without loss of clearness and beauty. It was the passion of his life, and the despair of it, to search for this unique phrase in each individual case. Perhaps in this research after style he went too far, losing something of that simplicity and inevitability which is the charm of natural writing. The greatest writing is that which in its magnificent spontaneity carries the reader with it in its flight; that which detains him to admire itself can never rise above the second place. Forgetfulness of self, absence of conceit and affectation, simplicity in the sense not of thinness or poorness but of genuineness—these are elements essential to the cultivation of a noble style. Here again, thought must be the basis, not vanity or the desire to astonish. We do not escape by our ingenuities from the firm principle of Horace, "scribendi recte sapere est et principium et fons."

Of the errors of style which are the consequences of bad taste, it is difficult to speak except in an entirely empirical spirit, because of the absence of any absolute standard of beauty by which artistic products can be judged. That kind of writing which in its own age is extravagantly cultivated and admired may, in the next age, be as violently repudiated; this does not preclude the possibility of its recovering critical if not popular favour. Perhaps the most remarkable instance of this is the revolt against Ciceronian prose which occurred almost simultaneously in several nations toward the middle of the 16th century and in England is best represented by Lyly in his celebrated *Euphues*. Montaigne in France and Castiglione in Italy, by their easiness and brightness, their use of vivid imagery and their graceful illumination, marked the universal revulsion against the Ciceronian stiffness. Each of these new manners of writing fell almost immediately into desuetude, and the precise and classic mode of writing in another form came into vogue (Addison, Bossuet, Vico, Johnson). In the 19th century admiration of the ornamental writers of the 16th and 17th centuries revived. A facility in bringing up before the memory incessant analogous metaphors is the property, not merely of certain men, but of certain ages; it flourished in the age of Marino and was welcomed again in that of Meredith. A vivid, concrete style, full of colour and images, is not to be condemned because it is not an abstract style, scholastic and systematic. It is to be judged on its own merits and by its own laws. It may be good or bad; it is not bad merely because it is metaphorical and ornate. The amazing errors which lie strewn along the shore of criticism bear witness to the lack of sympathy which has not perceived this axiom and has wrecked the credit of dogmatists. Yet that particular species of affectation which encourages untruth, affectation, parade for the mere purpose of producing an effect, must be wrong, even though Cicero be guilty of it.

See Walter Pater, *An Essay on Style* (1889); Walter Raleigh, *Style* (1897); Antoine Albalat, *La Formation du style par l'assimilation des auteurs* (1901) and *Le Travail du Style* (1904); Remy de Gourmont, *Le Problème du style* (1902); J. Middleton Murry, *The Problem of Style* (1922); H. W. Fowler, *A Dictionary of Modern English Usage* (1926). (E. G.; X.)

For style in architecture, etc., *see* PERIODS OF ART.

STYLOBATE, in architecture, the upper step of a Greek temple on which the columns rest; also applied to all three steps.

STYLOPS, the name of a genus of insects belonging to the order Strepsiptera allied to the beetles. The order is distributed over most parts of the world, but numbers less than 200 species. The males are minute, black or brown insects with branched antennae and vestigial mouth-parts: the fore wings are reduced to club-like scales but the hind wings are large and fan-like. They are seldom seen and lead a very brief life. The females are degenerate sac-like parasites that live partly protruding from the bodies of certain bees, wasps or leafhoppers and their allies. The young larvae are very minute and known as triungulins which hatch within the parent and probably escape on to flowers, etc. when they await the presence of a host. On finding the latter they bore their way into the body, change into legless maggots and pupate there, the males alone subsequently emerging. The presence of these parasites induces structural or other changes in their hosts including the acquisition of characters pertaining to the opposite sex (parasitic castration).

STYRENE or **STYROLENE,** also known as phenylethylene or vinylbenzene, is a hydrocarbon occurring with crude xylene in coal-tar naphtha. It is a yellow oily liquid of aromatic odour, boiling at 146° C, and with specific gravity 0·912. It is also obtained to the extent of 1 to 4% from liquid storax (styrax) and is used in medicine and in perfumery. Storax balsam (Oriental sweet gum) is derived from exudations of *Styrax Officinalis,* a shrub growing in the Levant and Greece. It is known in liquid and solid form soluble in ether or hot alcohol, it is employed in perfumery and in ointment form as a detergent. The semi-liquid balsam from *Liquidambar orientale* is obtained from Asia Minor and contains more than 25% of cinnamic acid. American storax is derived from *Liquidambar styraciflora,* found in Honduras, Louisiana, Florida and Mexico.

Styrene, $C_6H_5{\cdot}CH{:}CH$, is obtained from storax by distillation with water, by heating cinnamic acid with lime, or by the action of aluminium chloride on benzene and vinyl bromide.

Phenylacetylene, $C_6H_5{\cdot}C{:}CH$, a pungent liquid boiling at 139° C, results when α-bromostyrene or acetophenone chloride is heated to 130°. It yields copper and silver derivatives and is transformed into acetophenone by successive treatment with concentrated sulphuric acid and water. (G. T. M.)

STYRIA, a province of Austria covering 6,323 sq.m., lies within the Eastern Alps and is distinguished for its scenery and mineral wealth. Geographically it is divided into Upper Styria, the mountain and basin lands of the upper courses of the Enns and Mur-Mürz, and Lower Styria, the region of the middle Mur and the headwaters of the Raab. Upper Styria north of the Enns comprises detached groups of mountains which continue eastward, the huge limestone belt of the Salzburg Alps, generally exceeding 7,000 ft. in height.

Despite the mountainous character little of the soil is unproductive, only 8% of the area being classed as barren land. Forests cover 54% of its productive area, cultivated land 20% and the remainder is good grassland. In Upper Styria cultivation favours the fertile glacial moraines and alluvial fens of the stream terraces and basins, rye, oats and buckwheat being the most common cereals though wheat, barley and maize are also grown. In addition potatoes, flax, hemp and root crops are important. Lower Styria under more favourable conditions of soil and climate produces wine, fruit and hops. Cattle breeding is a flourishing activity supported by the breeding of draught horses in the marshy basins, pigs and poultry thrive in Lower Styria while sheep are on the increase everywhere; large numbers of game of various kinds are also to be found on the highlands.

The Erzberg iron mines have been worked since the Roman period and yield nearly the whole of the Austrian production. Styria supplies some 50% of Austrian lignite production. In addition there are important deposits of magnesite, *e.g.*, at Trieben, while other mineral resources include graphite, aluminium, salt, marble and building stone. The Tertiary basin of Leoben and Donauwitz, near coal and iron supplies, is the centre of the iron and steel industry; Graz (*q.v.*), the administrative, religious and intellectual capital, is also the commercial centre of the province. In the Styrian Salzkammergut around Aussee, near Graz at the spas of Gleichenberg and Tobelbad and in the Semmering district of Mürzzuschlag, an increasing revenue is derived from tourists. Styria is richly endowed with water power, notably in the valleys of the Enns, Mur and Mürz.

The population in 1923 was 977,350, equivalent to 155 persons per sq.m., but it is very unevenly distributed. In the more remote highland region of Upper Styria isolated houses or small villages are the rule, the inhabitants of villages and districts being often united in co-operative agricultural groups. Settlements in the valleys are small and strung like beads along the river courses. They are markets for the neighbouring mountain valleys and often busy manufacturing centres, but apart from Graz few towns exceed 10,000 inhabitants. The population is mainly German in speech with Slovene intermixture in the south-east, and Roman Catholic in faith. Despite a mountainous situation, the early fame of its metallic wealth attracted notice, from Roman times onwards, and it has been traversed by most of the migratory peoples of whom the Slavs left the strongest imprint. Under Charlemagne it became part of the duchy of Carinthia, obtained separate existence as the mark of Styria in 1056 and passed to the Habsburgs in the late 13th century. It is on the route from Vienna to Italy via the Semmering pass.

See also AUSTRIA and K. Köchl, *Steirisch Land und Leute* (Graz, 1923, etc.). (W. S. L.)

STYX, a stream near Nonacris in Arcadia, Paus., viii. 17, 6 ff., where see Frazer's commentary; the modern Mavro Nero (Black Water). It was thought to be virulently poisonous and capable of dissolving any vessel it was put in, save one made from the hoof of a horse. From the time of Homer, Styx (The Hateful) is one of the rivers of the underworld, generally its boundary, and the gods, if they swear by it, dare not break their oath. In Hesiod (*Theogonia,* 383 ff.), the nymph Styx, daughter of Ocean, with her children (Power, Might, Victory, and other abstractions) helps Zeus against the Titans, and is therefore honoured by him. If a god does break the oath, he is insensible for a year and then banished for nine years; mortals on occasion might take this oath, and in either case it would seem to have involved drinking the water (Hesiod, *op. cit.,* 783 ff.; Herodotus, vi., 74). We may suppose that the oath was really an ordeal; the water was a magical poison, perhaps originally fatal only to perjurers.

SUAKIN, a seaport of the Anglo-Egyptian Sudan on the Red Sea. It is a coralline islet connected with the suburb of El-Kef on the mainland by a causeway and a viaduct. Access is gained to the harbour through a winding and dangerous passage over 2 m. long, terminating in a deep oval-shaped basin several acres in extent, and completely sheltered from all winds. Suakin is to some extent superseded by Port Sudan (*q.v.*), a harbour 36 m. to the north. The custom-house and government offices present an imposing frontage to the sea, and the principal houses are of white coral stone three storeys high. Here, as at Massawa, traders were attracted by an island site which protected them from the Arabs. The mainland belonged in the middle ages to the Beja (*q.v.*), but in 1330 Ibn Batuta found a son of the amir of Mecca reigning in Suakin over the Beja, who were his mother's kin. Makrizi says that the chief inhabitants were nominal Muslims and were called Hadarib. The amir of the Hadarib was still sovereign of the mainland at the time of J. L. Burckhardt's visit (1814), though the island had been seized in 1517 by the Turks under Selim the Great. Mohammed Ali after the conquest of the Sudan leased Suakin from Turkey. This lease lapsed with the pasha's death, but in 1865 Ismail Pasha reacquired the port for Egypt. It has always been the place of embarcation for Sudan pilgrims to Mecca. Legitimate commerce, rapidly growing before the revolt of the mahdi (1881), was greatly crippled during the continuance of the dervish power, though the town itself never fell into their hands. Pearl fishing is an important industry and cotton is cultivated in the neighbourhood.

The port is connected by railway with Berber by submarine cables with Suez and Aden and with Jidda, which lies 200 m. northeast on the opposite coast of the Red Sea.

SUARDI, BARTOLOMMEO (*c.* 1455–*c.* 1536), Italian painter and architect, frequently called Bramantino, was born in Milan, the son of Alberta Suardi. He executed paintings containing portraits of celebrated personages for the Vatican. In 1508 he was engaged in Rome. Bramante d'Urbino taught him architecture, and had his assistance in the execution of the interior of the church of San Satiro, Milan. In 1525 Bramantino was appointed architect to the court by Duke Francis (II.) Sforza.

Bartolommeo Suardi has been confused with a certain Bramantino da Milano, of whom Vasari makes frequent mention. The Bramantino of Vasari, if he existed at all, worked for Pope Nicolas V. between 1450 and 1455.

See A. della Croce, *Le Rovine di Roma* (Milan, 1875) (from the Sketch book of Suardi in the Ambrosiana Library at Milan).

SUAREZ, FRANCISCO (1548–1617), Spanish theologian and philosopher, was born at Granada on Jan. 5, 1548, and educated at Salamanca. Influenced by the Jesuit John Ramirez he entered the Society of Jesus in 1564, and after teaching philosophy at Segovia, taught theology at Valladolid, at Alcala, at Salamanca, and at Rome successively. After taking his doctorate at Evora, he was named by Philip II. principal professor of theology at Coimbra. Suarez may be considered almost the last eminent representative of scholasticism. In philosophical doctrine he adhered to a moderate Thomism. On the question of universals he endeavoured to steer a middle course between the pantheistically inclined realism of Duns Scotus and the extreme nominalism of William of Occam. In theology, Suarez attached himself to the doctrine of Luis Molina, the celebrated Jesuit professor of Evora, and endeavoured to reconcile his view with the more orthodox doctrines of the efficacy of grace and special election. This mediatizing system was known by the name of "congruism."

Suarez is probably more important, however, as a philosophical jurist than as a theologian or metaphysician. In his extensive work *Tractatus de legibus ac deo legislatore* (reprinted, London, 1679) he is to some extent the precursor of Grotius and Samuel Pufendorf. Grotius speaks of him in terms of high respect. Suarez refutes the divine right of kings—doctrines popular in England and to some extent on the Continent.

In 1613, at the instigation of Pope Paul V., Suarez wrote a treatise dedicated to the Christian princes of Europe, entitled *Defensio catholicae fidei contra anglicanae sectae errores*. This was directed against the oath of allegiance which James I. extracted from his subjects. James caused it to be burned by the common hangman, and forbade its perusal under the severest penalties, complaining bitterly at the same time to Philip III. that he should harbour in his dominions a declared enemy of the throne and majesty of kings. Suarez lived a very humble and simple life. He died after a few days' illness on Sept. 25, 1617 at Lisbon.

The collected works of Suarez have been printed at Mainz and Lyons (1630), at Venice (1740–51), at Besançon (1856–62) and in the collection of the Abbé Migne. His life has been written by Deschamps (*Vita Fr. Suaresii*, Perpignan, 1671). The chief modern authorities are K. Werner's *Franz Suarez u. die Scholastik der letzten Jahrhunderte* (Regensburg, 1861), and Stöckl's *Geschichte der Philosophie des Mittelalters*, iii. 643 *seq.*

SUB-ATOMIC ENERGY: *see* ATOM; ELECTRICITY: *Electrons;* NUCLEUS; RADIOACTIVITY.

SUBCONSCIOUS, in psychology, means anything that is neither in the focus nor in the margin of consciousness (that is, does not receive attention, and so cannot be recognized in the actual experience of the moment), but which nevertheless must be assumed to be influencing us in some way, as a disposition, etc. *See* ABNORMAL PSYCHOLOGY, PSYCHOLOGY, with bibliographies.

SUB-DOMINANT, in music, the 4th degree of the diatonic scale, as F in the scale of C. (HARMONY; INTERVAL.)

SUBIACO (anc. *Sublaqueum*), a town of Italy, picturesquely situated on the Anio, 1,339 ft. above sea-level. Pop. (1921) 8,218 (town), 9,108 (commune). It was so called from its position under the three artificial lakes constructed in the gorge of the Anio in connection with the aqueduct of the Anio Novus, which had its intake at the lower end of the lowest of them (the *Simbruina stagna* of Tacitus). On the banks of this lake Nero constructed a villa, in the remains of which was found the beautiful headless statue of a youth kneeling, now in the Museo delle Terme at Rome. The lakes ceased to exist, the last dam being washed away in 1305. In 494 St. Benedict retired as a hermit to a cave (Sacro Speco) above the lakes of the Anio. In 505, probably, he founded the first of his twelve monasteries. The church dedicated to S. Scholastica, S. Benedict's sister, was erected in 981. In 1053 it was restored and a campanile built, which still exists; and in the middle of the 13th century the church was rebuilt in the Gothic style. Other buildings grew up round it; the cloister on the right is a fine Romanesque arcaded court with twisted columns and Cosmatesque (13th cent.) mosaics, the south side by Lorenzo Cosmati, the other three sides by his sons (*c.* 1227–1243). *See* BENEDICTINES.

Arnold Pannartz and Conrad Schweinheim, two German ecclesiastics, set up here the first printing press in Italy, issuing an edition of Donatus (1464), followed by one of Cicero (1465) and of Lactantius (1465). Copies of the Lactantius, of the Augustine of 1467, printed not here but in Rome, and of other rare *incunabula* are preserved here. Still more interesting is the monastery of the Sacro Speco, higher up the hill. The Grotta dei Pastori has frescoes of the 9th century, while the Sacro Speco, or cave of St. Benedict, contains frescoes of the 13th, and so does the lower church, the latter having been in part repainted in the latter half of that century by an unknown master Conxolus. The upper church contains scenes from the life of Christ by a Sienese master of the end of the 14th century, to whom is also attributable a remarkable fresco of the triumph of death and some 15th-century work, and in the chapel of S. Gregory a portrait of St. Francis of Assisi (who was perhaps here in 1218), probably painted before 1228, as it lacks the halo and the stigmata. The whole group of buildings is constructed against the rocky sides of the gorge, part of it on massive substructions. The town contains various buildings constructed by Pius VI., who as cardinal was commendatory abbot of Subiaco. It is crowned by a mediaeval castle constructed originally by Gregory VII.

See P. Egidi, G. Giovannoni, F. Hermanin, V. Federici, *I Monasteri di Subiaco* (Rome, 1904); A. Colasanti, *L'Aniene* (Bergamo, 1906). (T. A.)

SUBJECT: *see* TERM, JUDGMENT and LOGIC.

SUBJECTIVISM, a philosophical term, applied in general to all theories which lay stress on the purely mental sides of experience, opposed to objectivism. In the narrowest sense subjectivism goes to the logical extreme of denying that mind can know objects at all (*cf.* SOLIPSISM: IDEALISM).

SUBLEYRAS, PIERRE (1699–1749), French painter, was born at Uzès (Gard) in 1699. He gained the *grand prix* and went to Italy in 1728. His first important work was "Christ's Visit to the House of Simon the Pharisee" (Louvre, engraved by Subleyras himself), ordered by the canons of Asti, which made his reputation and procured his admission into the Academy of St. Luke. Cardinal Valenti Gonzaga next obtained for him the order for "Saint Basil and the Emperor Valens" (small study in Louvre), which was executed in mosaic for St. Peter's. Benedict XIV. and all the princes of Rome sat to him, and the pope himself commanded two great paintings—the "Marriage of St. Catherine" and the "Ecstasy of St. Camilla"—which he placed in his private apartments. Subleyras shows greater individuality in his curious genre pictures, which he produced in considerable numbers (Louvre). In his illustrations of La Fontaine and Boccaccio his true relation to the modern era comes out; and his drawings from nature are often admirable. (*See* one of a man draped in a heavy cloak in the British Museum.) He died in Rome on May 28, 1749. His wife was a celebrated miniature painter, Maria Felice Thibaldi.

SUBLIMINAL SELF. The phrase owes its wide currency to the writings of F. W. H. Myers, especially to his posthumous work *Human Personality and its survival of Bodily Death.* In the stricter usage the phrase stands for an hypothesis which seemed to its author to bring almost all the strange facts he observed under one scheme of explanation. But the phrase "Subliminal Self" is now often used by those who do not fully accept Myers's hypothesis, as a convenient heading to which to refer all the facts of many different kinds that seem to imply subconscious or unconscious mental operations. It is the stricter sense that here concerns us.

In the speculations of Schopenhauer and of Eduard von Hartmann, the "Unconscious" played a great part as a metaphysical principle explanatory of the phenomena of the life and mind of both men and animals. But with these exceptions, the philosophers and psychologists of the 19th century showed themselves in the main reluctant to admit the propriety of any conception of unconscious or subconscious mental states or operations. The predominant tendency was to regard as the issue of "automatic" nervous action or of "unconscious cerebration" whatever bodily movements seemed to take place independently of the consciousness and volition of the subject, even if those movements seemed to be of an intelligent and purposeful character. This attitude towards the subconscious is still maintained by some of the more strictly orthodox scientists: but it is now very widely accepted that we must recognize in some sense the reality of subconsciousness or of subliminal pyschical process. The conception of a *limen* (threshold) of consciousness, separating subconscious or subliminal psychical process from supraliminal or conscious psychical process, figured prominently in the works of G. T. Fechner, the father of psycho-physics, and by him was made widely familiar. In the last half century, there has been accumulated a mass of observations which establish the reality of processes which express themselves in purposeful actions and which bear all the marks from which we are accustomed to infer conscious cognition and volition, but of which nevertheless the subject or normal personality has no personal knowledge.

Among the commonest and most striking of such manifestations is the "automatic writing" which a considerable proportion of normal persons are capable of producing. A person who has this power may sit absorbed in reading or in conversation, while his hand produces written words or sentences, of which he knows nothing until he afterwards reads them. In some cases the matter so written states facts previously known to the subject but which he is unable to recollect by any voluntary effort. And in rare cases the matter written seems to imply knowledge or capacities which the subject was not believed to possess either by himself or by his friends. Other actions, including connected speech, may be produced in a similar fashion, and in the last case the subject hears and understands the words uttered from his own mouth in the same way only as those from the mouth of another person. "Table-tilting," "planchette-writing," and the various similar modes of spelling out by the aid of a code intelligible replies to questions, which have long been current in spiritistic circles and which, by those who practise them, are often regarded as the operations of disembodied intelligences, seem to belong to the same class of process. In extreme cases the manifestations of such subconscious or (better) co-conscious operations are so frequent, exhibit so much continuity and express so clearly a train of thought, purpose and memory, that they compel us to infer an organized personality of which they are the expression; such are the cases of double or multiple consciousness or personality. Very similar manifestations of a "co-consciousness" may be produced in a considerable proportion of apparently normal persons by means of post-hypnotic suggestion; as when suggestions are made during hypnosis, which afterwards the subject carries out without being aware of the actions, or of the signals in response to which he acts, and without any awareness or remembrance of the nature of the suggestions made to him. The more sober-minded of the investigators of these phenomena have sought to display all such cases as instances of division of the normal personality, and as explicable by the principle of cerebral dissociation (*see* HYPNOTISM); the more adventurous, concentrating their attention on the more extreme instances, regard all such manifestations as instances of the possession and control (partial or complete) of the organism of one person by the spirit or soul of another, generally a deceased person. Myers's hypothesis of the subliminal self was a brilliant attempt to follow a middle way in the explanation of these strange cases, to reconcile the two kinds of explanation with one another, and at the same time to bring into line with these other alleged facts of perplexing character, especially veridical hallucinations (*q.v.*), various types of communication at a distance (*see* TELEPATHY), and all the more striking instances of the operation of suggestion and of hypnosis, including the exaltation of the powers of the senses, of the memory and of control over the organic processes.

Myers conceived the soul of man as capable of existing independently of the body in some super-terrestrial or extra-terrene realm. He regarded our normal mental life as only a very partial expression of the capacities of the soul, so much only as can manifest itself through the human brain. He regarded the brain as still at a comparatively early stage of its evolution as an instrument through which the soul operates in the material world. So much of the life of the soul as fails to find expression in our conscious and organic life through its interactions with this very inadequate material mechanism remains beneath the threshold of consciousness and is said to constitute the subliminal self. It is held to be in touch with a realm of psychical forces from which it is able to draw supplies of energy which it infuses into the organism, normally in limited quantities, but, in exceptionally favourable circumstances, in great floods, which for the time being raise the mental operations and the powers of the mind over the body to an abnormally high level.

Abnormal mental manifestations that have commonly been regarded as symptoms of mental or nervous disease or degeneration are by its aid brought into line with mental processes that are by common consent of an unusually high type, the intuitions of genius, the outbursts of inspired poesy, the emotional fervour or the ecstasy that carries the martyr triumphantly through the severest trials, the enthusiasm that enables the human organism to carry through incredible labours. Myers's hypothesis thus boldly inverts the dominant view, which sees in all departures from the normal symptoms of weakness and degeneracy and which seeks to bring genius and ecstasy down to the level of madness and hysteria; the hypothesis of the subliminal self seeks to level up, rather than to level down and to display many departures from normal mental life as being of the same order as the operations of genius.

This bold and far-reaching hypothesis has not up to the present time been accepted by any considerable number of professional psychologists, though its author's great literary power has secured for him a respectful hearing.

BIBLIOGRAPHY.—*See* F. W. H. Myers, *Human Personality and its Survival of Bodily Death* (1st ed., London, 1903; 2nd ed., abridged and edited by L. H. Myers, London, 1907); Morton Prince, *The Dissociation of a Personality* (London, 1906); J. Jastrow, *The Subconscious* (London, 1906); H. A. B. Bruce, *The Riddle of Personality* (1908); Earl Murchison (ed.), *The Case for and Against Psychical Belief* (Worcester, Mass., 1927); Helen C. Lambert, *A General Survey of Psychic Phenomena* (1928). *See* also many papers by various hands in *Proceedings of the Society for Psychical Research*, especially in part xlvi., vol. xviii., and the literature referred to under TRANCE.

SUBMARINE. A submarine is a vessel capable of being submerged and propelled under water and essentially armed with torpedoes which can be fired while submerged, aim being taken by means of a periscope, which alone is visible to the surface craft being attacked. Submarines are also fitted with a gun armament to be used when on the surface, and in some instances for minelaying. Three British submarines M1, M2, M3, were equipped with a 12 in. gun apiece. One of these has had her big gun replaced by a hangar to carry a small seaplane.

In view of aerial warfare, it would be a mistake to regard a repetition of submarine warfare on German lines as beyond the range of possibility.

It may be claimed for the new class of big cruiser submarines that they are better able to "visit" and "search" merchant ships than German submarines were in the World War. However used, there can be little doubt that the development of this type of warship does constitute a new danger to merchant shipping in war, and one which it will certainly be more difficult to track down than the surface cruiser. On the other hand, the production of under-water craft of this size gives less excuse for the adoption of a "sink at sight" policy. In spite of their lack of success as fleet units in the World War, endeavours are still being made by some of the principal sea Powers to develop the submarine in this capacity. But apart from difficulties of speed and limited range of vision, it would seem that the retention of submarines in company with the surface fleet must complicate tactics and add considerably to an admiral's difficulties and anxieties in a fleet action. The exact measures for combating submarines are necessarily confidential, but it may be taken for granted that the lessons of the World War have been taken to heart and that scientific improvements in anti-submarine devices have continued.

A new form of defence against the submarine, and possibly a new ally for her, has arisen in the form of the aeroplane. The surface warship in her turn is now better equipped to withstand underwater attack than ever before. Only the merchant vessel remains as defenceless as ever.

Great Britain and the United States have expressed their readiness to outlaw the submarine as a weapon of war, but lesser naval powers, like France and Italy, have declined. They explain that while they in no way subscribe to the employment of submarines on the lines adopted by Germany in the World War, they do regard these craft as legitimate and economical units in their sea defences which they cannot afford to do without. (E. A.)

TECHNICAL

The history of the submarine dates from 1620 when Cornelius van Drebel, a Dutchman in the service of King James I. of England, built such a vessel, which is stated to have been navigated by twelve rowers at a depth of 12 to 15 feet for several hours in the Thames. Van Drebel was followed by others during the 17th and 18th centuries either with designs or actual vessels, but it was not until 1776 that a submarine was used for war purposes. In that year the "Turtle," an American submarine designed by David Bushnell, attempted to sink the English warship "Eagle" anchored off New York, by fixing a gun powder charge with time fuse to the "Eagle's" bottom by a screw. All attempts to force the screw through the copper sheathing failed, and the submarine rowed away, releasing the charge, which exploded without damage. On the night of February 17th 1864 during the American Civil War, the "Housatonic," blockading Charleston, was sunk by a spar torpedo fitted over the bow of a submarine. The submarine swamped through an open hatch, sank and was lost with her crew of nine men. The loss of the "Housatonic" is the first recorded instance of a warship being sunk by a submarine.

In France and the United States experiments were numerous, progress was slow but sure, and finally the naval authorities of the two nations decided the submarine had attained a stage of development which warranted its inclusion in their navies. In France, the "Gymnote," the first naval submarine, was ordered in 1886 and launched in 1888. Originally prepared by Dupuy de Lome, the design was modified by Gustave Zedé, who was placed in charge of its construction. She was of 30 tons displacement, fitted with a screw propeller driven by an electric motor supplied with current from secondary cells. The trials being satisfactory, the "Gustave Zedé" of 270 tons, similarly propelled, was ordered in 1890 and launched in 1893. Success was again attained, and in 1896 the Ministry of Marine opened a competition for the design of submarines, the first prize being awarded to M. Max Laubeuf, the "Narval" built to his design being completed in 1900.

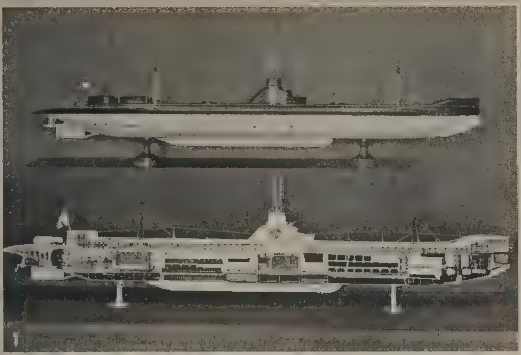
In the United States, John P. Holland, engaged in the study of the problem for many years, built the first of several submarines in 1875. Other early research was undertaken by Simon Lake who developed the "Lake" type submarine. In 1888 the Navy Department invited submarine designs, that of Holland being selected, but the contract for the "Plunger" to that design was not signed until 1895. She was to be propelled by steam on the surface, and an electric motor submerged, but before completion, Holland, dissatisfied with the design, returned the sums advanced by the Government, and started on the "Holland." She was purchased for the U.S. Navy on April 11, 1900, five similar vessels being ordered to be built. On Dec. 13, 1900, the British Admiralty ordered five of the same type from Messrs. Vickers, who had obtained the rights to build to the Holland designs. In Italy the "Pullino" of 25 tons designed by a naval engineer of that name was launched in 1892, and was followed by the "Delfino" of 95 tons, launched in 1894. In Germany two submarines of 200 tons of Nordenfelt design were completed in 1890, but until 1906 the construction of this type of vessel was not seriously taken in hand for that navy.

Types of Hull Construction.—In order to submerge a submarine several tanks designated "main ballast tanks" are completely flooded and a less number of smaller tanks are partly flooded. As these tanks when filled bring the vessel from the surface to the submerged condition, their total volume is the reserve of buoyancy of the submarine when on the surface, and is a measure of her seaworthiness. Submarines are either "single hull" or "double hull."

The "Gymnote," "Gustave Zedé" and "Holland" were of the first type having a strong hull of circular section throughout, the centres of the circles lying on a straight line, the axis of the submarine. In later examples the circular changes into elliptical sections at the extremities, the centres of the sections rising towards the ends. The main ballast tanks are at the bottom of the circles, and may or may not have vertical extensions at the sides enclosing the battery spaces (fig. 1).

The "Narval" of Laubeuf, the first of the double hull type, had a strong hull of almost circular section,—the pressure hull—enclosed by another—the outer hull—of light construction, the space between the two being the ballast tanks (fig. 2). The capacity of the latter was far greater than in the single hull type, being in "Narval" 41 per cent of the displacement as compared with 13 in the "Holland." The removal of these tanks from inside the pressure hull gives more space in the latter for other purposes. In addition to improved seaworthiness, a better shape for surface propulsion can be given the outer hull and increased speed obtained. When air pressure is used to clear the ballast tanks of water, this pressure is brought on the curved surface of the pressure hull, instead of on the flat plating of the tanks in the single hull type. The pressure on the outer hull, when blowing, is the small difference between air and sea pressure, permitting the outer hull to be of light construction. The metacentric height of the single hull type on the surface is small, that of the other type can be made any desired amount by a suitable choice of breadth of the outer hull. The single hull type has the advantage of more rapid submergence, the tanks being smaller and well below the surface water plane, whilst parts of the tanks in the double hull type are above that plane. The double hull type is heavier and costs considerably more to build.

Generally the single hull type of construction is now limited to the smallest submarines, the double hull to the largest. In the medium size a partial double hull is adopted, the outer hull



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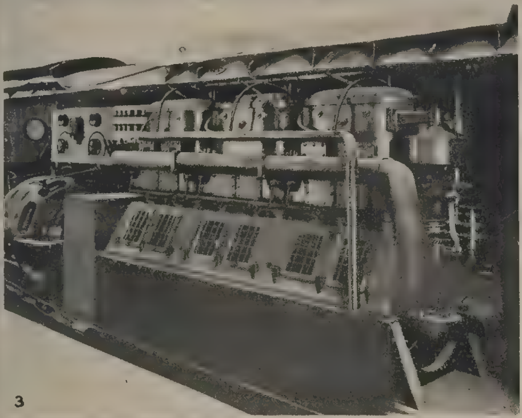

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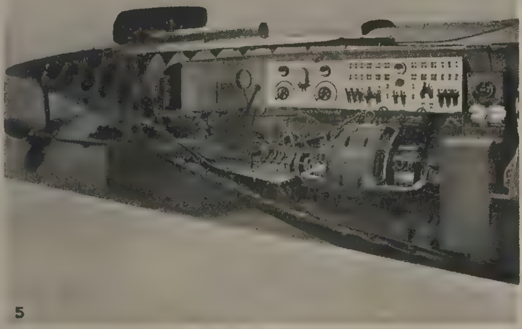

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BY COURTESY OF (1, 3, 5) DEUTSCHES MUSEUM, (7) "JANE'S FIGHTING SHIPS"; PHOTOGRAPHS, (2, 4) STEPHEN CRIBB, (6) ABRAHAMS AND SONS

INTERIOR AND EXTERIOR VIEWS OF VARIOUS TYPES OF SUBMARINES AND SUBMARINE MODELS

1. Exterior view and longitudinal section of the U–1, the first German U–Boat. Displacement on surface, 240 tons. Armament: one bow torpedo tube; carrying capacity, three torpedoes. Speed on surface, 11 knots; submerged, 9 knots. Built at the Germania Works, Kiel, in 1906
2. H.M.S. "X.I." Displacement on surface, 2,525 tons; submerged, 3,600 tons. Armament: four 5·2-in. guns, six 21-in. torpedo tubes. Speed on surface, 19·5 knots; submerged, 9 knots
3. Munich Museum model of the U–1, showing that portion of the engine room containing the 450 h.p. petroleum motors used to drive the twin screws which propel the submarine on the surface
4. H.M.S. Oxley. Displacement on surface, 1,430 tons; submerged 1,835 tons. Speed on surface, 15·5 knots; submerged, 9 knots. Built in England in 1927 as the first in the Australian Navy
5. Munich Museum model of the U–1, showing the aft section of the submarine and the electric drive, including one of the 200 h.p. motors used for propulsion
6. H.M.S. "L. 69." Displacement on surface, 870 tons; submerged, 1,150 tons. Armament: one 4-in. gun, and six 21-in. torpedo tubes. Speed on surface, 17·5 knots; submerged, 10·5 knots
7. Japanese first class submarine "I.55." Displacement on surface, 1,650 tons; submerged 2,100 tons. Armament: one 4·7-in. gun, and eight torpedo tubes. Speed on surface, 21 knots; submerged, 7–9 knots. Built in 1927

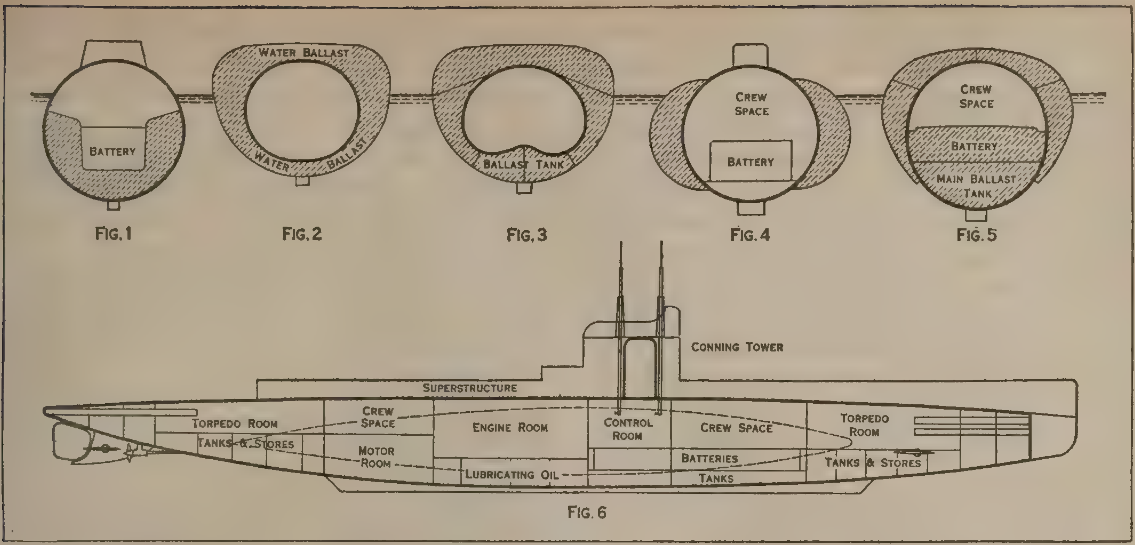

FIG. 1.—SINGLE HULL, FIRST TYPE OF SUBMARINE MADE; FIG. 2.—DOUBLE HULL, DESIGN USED IN LARGE SUBMARINES; FIG. 3.—PRESSURE HULL, DESIGNED FOR STOWAGE SPACE; FIGS. 4 & 5.—PARTIAL DOUBLE HULL TYPE, USED IN SUBMARINES OF MEDIUM SIZE; FIG. 6.—SUBDIVISIONS OF SUBMARINE OF MEDIUM DISPLACEMENT, SHOWING TANKS FORE AND AFT FOR TRIMMING

enclosing the pressure hull over a portion of its extent only, both transversely and longitudinally (figs. 4 and 5). Fig. 3 shows the section of pressure hull adopted by Colonel Laurenti of the Fiat Company, the shape being designed to suit the requirements of stowage. Fig. 4 is the section of the British D, E and L classes, the bulk of the ballast water being outside the pressure hull. Fig. 5 is a section of the British K class. In the latest types of "double" and "partial double hull" submarine oil fuel is also stowed between the two hulls. The double hull types are sometimes termed "submersibles" to indicate they are especially suitable for surface propulsion.

Superstructure.—The "superstructure" is the light structure fitted above the pressure or the external hull, in which are stowed the cable holders, boats, bollards, hatches, mufflers, fairleads and other fittings, and which unless enclosed would cause undue resistance when submerged. The superstructure is fitted with a deck, and is raised in height amidships to form a navigating bridge, which is reached from the control room through the conning tower built up from the pressure hull. The conning tower is fitted with hatches at the bottom and at the bridge level, and being the last portion of the pressure hull to submerge, is frequently constructed of thick plating to resist projectiles. The conning tower forms a base for the vertical brackets which support the periscopes. The sides of the raised superstructure enclosing the conning tower and other high openings and forming a support for the bridge is called a conning tower cutwater. The superstructure with the exception of the low buoyancy tanks is "free flooding," *i.e.*, it is flooded and vented when submerging through open holes along its sides, the air escaping through numerous holes in the superstructure deck. The low buoyancy tanks are free flooding, central vented.

Subdivision.—Except for the tanks essential for their operation, earlier submarines had little or no watertight subdivision. In later types the hull is subdivided to the maximum extent, experience having proved the value of this feature in case of accident. Transverse bulkheads are the main feature of subdivision, a submarine of medium displacement having at least six main compartments, whilst at the extremities trimming and other tanks are added (fig. 6). Starting from forward the main compartments in order are: the fore torpedo room, into which the bow torpedo tubes project and from which they are loaded and operated; the battery space, the lower portion of which contains the battery cells whilst accommodation for the crew is provided in the upper portion; the control room, in which all controlling mechanisms for the submerged operations of the submarine are fitted, whilst below is a battery space and over the conning tower giving access to the bridge; the engine room with the two Diesel engines, the spaces below them being utilised for the lubricating oil tanks; the motor room with the main motors and switchboards and some accommodation for the crew; and finally, the stern torpedo room containing the breech ends of the torpedo tubes, spare torpedoes, and the motors and gear for rudder and hydroplanes. A deck further subdivides the two torpedo rooms, the spaces below it being divided by watertight bulkheads, boundaries to the compensating and fresh water or fuel oil tanks and provision and other stores. In a single hull submarine the main ballast tanks are below and at the sides of the battery, and at the bow and stern, whilst in a double or partial double hull submarine the space between the two hulls is divided by transverse bulkheads and flats to form main ballast and oil fuel tanks.

The main bulkheads at the after end of the fore torpedo room and at the fore end of the stern room are generally tested to 35 or 50 lb. per sq.in., the two rooms being sometimes termed refuge compartments, where in case of accident the survivors may take refuge. The other main bulkheads are tested to 15 to 20 lb. per sq.in., being primarily intended to limit the entry of water in surface collisions. The bulkheads at the extremities are tested to 50 to 75 lb. whilst those below the decks are subject to 50 lb. test and those between the hulls to 15 or 20 pounds. In many submarines the transverse bulkheads are of curved form to better withstand the pressure. Watertight doors of a special quick closing type are provided, with manholes, and other means of access.

Tanks in Submarines.—The most important tanks are the "main ballast tanks" by the filling of which almost all the positive buoyancy is destroyed. Each tank has a valve at the bottom for the entry or exit of water; a vent valve at the top for the escape of air; and a pipe through which compressed air enters the tank and forces out the water. Some tanks are also fitted with drain pipes for emptying them by pumping. When cruising on the surface the bottom valve may be open and the vent valve closed. Water then enters the tank compressing the air until the pressure prevents further entry, or a slight air pressure is put into the tank to limit the water to the least amount. When submerging all main ballast vent valves are opened, water floods the tanks, the air escaping through the vent valves, which, when the tanks are full, are closed. The submarine "Narval" on her first trials submerged in 25 minutes, reduced to 12 when the crew were trained. War experience has shown that the time for submersion is a vital factor in escaping gun attack or ramming, and the valves have been increased until 1 to 2 minutes is now required. The flooding valves are open and vent valves closed when submerged, and the submarine is brought to the surface by forcing air into the tanks, thus clearing out the water. The vent and blowing valves are all operated from the control room. When enemy ships may be met, a submarine navigating on the surface has her main ballast tanks partially filled to secure more rapid submergence. If the tanks are half full she is at "half buoyancy," and if three-quarter, at "quarter buoyancy," if empty she is at "full buoyancy." Some of the main ballast tanks are arranged for the stowage of fuel, in case extra cruising endurance is required.

A submarine is at "main ballast trim," or in "diving trim," when the flooding of the main ballast tanks alone will bring her to the desired submerged condition, with practically no reserve of buoyancy. During war or practice operations, a submarine is always in "main ballast trim," or in "diving trim," and can at once submerge. To maintain this trim the officers have to exercise a ceaseless vigilance, any loss or gain of weight being met by letting in or blowing or pumping out water. For this purpose "compensating tanks," or "auxiliary ballast tanks," are provided, generally one on either side amidships, and one at either end. These have flooding, venting, pumping and blowing arrangements, and gauges to indicate the amount of water in them under all conditions.

The oil fuel is the main item for which compensation is needed. The fuel is stored in the "oil fuel tanks," sometimes placed in the spaces exterior to the pressure hull in the "double hull" or partial "double hull" type, and necessarily inside in the "single hull" type. The fuel tanks are completely filled with oil, and are positioned symmetrically transversely and longitudinally. When fuel from a tank is required, it is forced to the engine room by pumping sea water into the bottom of the tank, the oil passing out through a pipe at the top. The difference in densities between sea water and oil fuel prevents mixing, but involves an increase in weight as fuel is used. If, for example, the oil fuel is ·9 specific gravity, and a tank of 500 cubic feet has been emptied of fuel and filled with sea water, the added weight is 3,900 lb., and this weight of water must be discharged from the compensating tanks. Other items, *i.e.*, lubricating oil, ammunition, shell, food, fresh water, etc., when consumed, must be compensated for by adding an equal weight of water, the compensating tank used for the purpose being as close as possible, longitudinally, to the item consumed. In minelaying submarines special tanks are fitted for compensating for the release of mines.

For correcting any alteration in the longitudinal distribution of weight, a "trimming tank" is fitted at either end of the vessel. They are partially filled in the normal diving condition and connected by a pipe through which water is forced from one to the other as required.

"Water around torpedo" tanks are fitted below the centre of length of the torpedo tubes, and contain sufficient water to fill the spaces around the torpedoes when in the tubes. By their use the torpedoes can be left dry in the tubes and withdrawn for examination. If it is desired to fire a torpedo the tube is closed, the water from the "water around torpedo" tanks is blown into the tube, and when the cap of the tube is opened, no water enters and the weight of the submarine is unaltered. An experienced submarine officer keeps a log of the variations of weight of the stores and of the amount of water in all his tanks, and checks the records on every convenient occasion by submerging his vessel.

Air System.—The compressed air for blowing tanks and for the torpedo service is stored in reservoirs or air bottles at 2,500 lb. per square inch. The capacity of a reservoir varies in different navies, but in British submarines is about 3 cubic feet and the number sufficient to blow the ballast tanks three times. They are recharged by compressors when the vessel is on the surface with hatches open. A shore connection is fitted for use when charging from the shore or parent ship. It was formerly the practice to clear the tanks entirely by air from the reservoirs, but the vessel is now brought to the surface by partially clearing one or more ballast tanks with stored air, and fully clearing the tanks by motor driven air or blowers which, with the conning tower hatch open, supply air at 15 or 20 lb. per square inch. Divers' connections are fitted in the superstructure for supplying air to the compartments in case of accident.

Pumping System.—At least two motor driven pumps are provided for pumping out a submarine. These are capable of pumping against any pressure up to that at the greatest depth the vessel is designed to navigate. Both deliver overboard, and their suctions are connected with at least two of the main ballast tanks for use in the event of the compressed air failing.

Rudder and Hydroplanes.—The rudder is like that of a surface ship. Hydroplanes, or horizontal rudders, are used for the depth and horizontal control of submarines when navigating submerged. In earlier submarines, a pair of hydroplanes were fitted at the stern, but now a pair is fitted forward and a pair aft, the latter generally in the propeller races. The hydroplanes are rectangular or elliptical in shape, and are of the balanced type. They can be turned through 30 or 35 degrees either way by a motor and mechanism. The after pair are of greater area than the forward, and when in the neutral position act as fins, giving a certain amount of stability to the motion of the vessel. The forward hydroplanes are generally fitted below the surface waterplane, but in fast submarines they are often placed above water, and are of the housing type, stowing in or against the superstructure. The resistance to surface propulsion is thereby decreased, and the hydroplanes are not subjected to the forces of the sea. When a vessel is diving the hydroplanes are used to overcome the small reserve of buoyancy usual when submerged.

The operating motor and mechanism of each pair of hydroplanes are controlled by a handwheel mounted on a pedestal in the control room, close to the commander. The two pedestals are placed side by side, with a diving coxswain at each wheel. In front of each is a depth gauge showing the depth below water, and a clinometer giving the longitudinal inclination of the vessel. The coxswain at the forward pedestal moves his wheel, and by it the forward hydroplanes, to maintain the depth ordered by the commander, whilst his colleague moves the after wheel and the after hydroplanes to maintain the submarine horizontal. In the earlier types with after hydroplanes only, change of depth was attended with large longitudinal inclinations of the submarine. In the event of a breakdown of the motors operating the hydroplanes, hand gear can be used. Hydroplane guards are fitted to prevent wires catching in the hydroplanes when passing through nets fitted as a defence to entrances to harbours, etc.

Periscopes.—The earliest submarines had a circular tower amidships which projected above the hull, glass lights around its circumference serving for the navigation of the vessel. The submarines "porpoised" to allow for frequent observations. Later an optical tube, fitted with inclined mirrors top and bottom, was added giving deeper immersion of the hull, if not better observation. The periscope was introduced about 1902. It consists of a tube with a window and a glass prism at the top, and an eye piece and prism at the bottom, various lenses being fitted in the tube to obtain the best image at the eyepiece. The periscope tube is about 6 inches diameter, with 5 or 6 feet of the upper portion reduced to 2 or 3 inches diameter, about 3 feet being above water when the periscope is fully raised, the submarine then being at "periscope depth." The field of view is restricted to about 15 degrees, but two handles allow the observer to rotate it and sweep the horizon, the angle in azimuth being projected on the image. The length of the periscope has gradually increased, and 30 to 35 feet is now not unusual, the pressure hull of the vessel being 25 to 30 feet below the sea level. Two periscopes, one before and one abaft the conning tower, are fitted in the majority of submarines, but the largest types have three. The normal view is a horizontal one, but aircraft have necessitated an addition by which the top prism can be rotated, and an almost vertical view obtained.

Propulsion of Submarines.—Towards the middle of the 19th century designers turned to steam engines and screw propellers for both surface and submerged propulsion, but a funnel and an air duct extending above water when submerged had to be fitted. In 1860, Brun and Bourgeous in the "Plongeur" fitted an air engine, the compressed air for its operation being stored in large cylinders, the vessel being completely closed in when submerged. In 1863 the American, Alstitt, used steam for surface propulsion, and an electric motor and battery when submerged, the first instance of the dual methods of propulsion. The "Gymnote" and the "Gustave Zedé" were fitted with electric motors for both surface and submerged propulsion, and had to return to their base for recharging when the batteries were exhausted. The "Narval" had a petrol engine for surface, and an electric motor and battery for submerged navigation, and the "Holland" was similarly equipped. The internal combustion engine possesses marked advantages for the surface propulsion of submarines, and the evolution of the latter has closely followed that of the former. Petrol engines were replaced by Diesel engines when the latter had sufficiently developed (1905), the first British submarine so fitted being "A.13" completed June, 1908. In the modern submarine twin screws are fitted, the propeller shafts being driven either by the Diesel engines, or by the electric motors placed abaft the engines. For submerged propulsion the motors drive the propellers. The motors are generally used for surface propulsion when navigating in narrow waters or coming alongside ships or quays, being more easily operated than the engines.

The Diesel engines fitted in submarines are of a special type running at from 380 to 450 revolutions per minute when developing full power. In 1914 the b.h.p. of the largest available submarine Diesel unit was from 800 to 900 in 6 to 8 cylinders. At present the most powerful unit develops 3,000 b.h.p., but the diameter of hull for two such engines is such, that the size of the submarine is too large for ordinary naval purposes, and consequently less powerful engines are being fitted, ranging from 1,200 to 2,400 b.h.p. per unit. The displacement of submarines has gradually increased with the power of the available engines. In 1914 the largest submarines had surface displacements of from 600 to 800 tons, it is now 2,800 tons in a few special cases, but in the majority of new vessels ranges from 1,000 to 1,800 tons. The surface speed in 1914 varied from 15 to 18 knots, it is now from 17 to 20. With the 3,000 b.h.p. engine it is estimated that no more than 22 to 23 knots surface speed can be attained, the displacement reaching about 3,000 tons.

Steam was employed in some of the earlier classes of French submarines, and in the British "K" Class. In the former the Diesel engines were unreliable and had to be replaced by steam, whilst in the "K" Class the speed required (24 knots) was beyond the possibility of the Diesel engine. Turbines of 10,000 b.h.p. were therefore installed, and an auxiliary Diesel engine driving a generator which supplied current to the main motors on the propelling shafts was also fitted for low speeds. The number of large openings for funnels and boiler air supply, the greater consumption of fuel per unit power with the consequent limited endurance, and the heat in the engines and boilers after submergence, are objections to steam and strong reasons for the preference for Diesel engines. At present the British "K.26" is the only steam propelled submarine in commission.

Batteries.—The underwater propulsion and navigation of a submarine depend upon the batteries which supply current to the propelling, rudder and hydroplane motors. These batteries are of the lead pasted plate type, the details varying with the makers. In small submarines, two batteries of 55 to 60 cells are installed, and in the larger, two or three of 110 to 120 cells each. For convenience in replacement and transfer, the cell containers have standardised dimensions, those in British submarines being such that the cell weighs about 900 lb. The power for submerged propulsion varies with the cube of the speed, and the higher the latter the sooner the battery is exhausted, necessitating recharging by the engines on the surface. The cruising underwater speed is from 2 to 3 knots, the battery capacity being sufficient to maintain this for 30 hours, and also meeting the auxiliary requirements. At full speed the battery is exhausted after 1 to 1½ hours. The capacity of a typical cell is such that a current of 2,300 amperes can be maintained for one hour or 225 for 20 hours when fully charged. These currents, with the appropriate voltages, correspond to about 5·5 h.p. and ·5 h.p. per cell. In the smaller types the cells stand on the crown of the ballast tanks, portable wooden beams and airtight covers closing the space, and in the larger a steel deck is fitted over the battery room, the cells at the sides standing at different levels to suit the section. When the battery is being charged hydrogen gas is evolved, and to obviate explosions, exhaust fans and trunks discharge this into the open. A battery switchboard is fitted in or close to the control room.

Armament.—The submarine is essentially a torpedo vessel, launching its torpedoes when submerged and unseen. The size of the torpedo and number of discharge tubes have gradually increased, the usual armament at present being the 21 inch torpedo, the largest conveniently manhandled, with four tubes at the bow and two at the stern. The tubes are horizontal and fore and aft, the breech ends being inside the pressure hull, loading and other operations being readily effected when submerged. Two torpedoes for each tube is the usual complement, one being stowed in the tube and the other in the torpedo room. Each tube has a watertight cover at either end, the inboard cover being opened and closed in the torpedo room, whilst that outboard—the cap—is operated by gearing from the room. The apertures for discharge in the bow are fitted with shutters which open and close with the caps, and when closed give a fair form to the bow to reduce resistance. The torpedoes are discharged by air pressure, either from the control room by the commander or at the tubes at his orders. The French are partial to revolving tubes fitted in the superstructure and trained by mechanism from the interior of the vessel. Such tubes are lighter than the ordinary tube, but have the disadvantage that they can only be loaded on the surface.

Previous to 1914 a few submarines carried a small gun of the disappearing type stowed in the superstructure. By the end of 1918 guns were fitted in all classes, the calibre having gradually increased, the limit being reached in the British "M" Class with one 12 inch. B.L. gun, the largest German submarine having two 150 mm. Against merchantmen the gun with a large number of rounds was more effectual than the relatively small number of torpedoes which could be carried. A 4 or 5 inch gun is now mounted in all classes, and although it is recognized that in a gun duel with an ordinary warship the submarine is at a great disadvantage, the gun may prove useful against weaker vessels or aircraft. The guns are mounted on the superstructure in the open, reducing the submerged speed and endurance.

During the War the submarine was utilised for a purpose not previously suggested, but for which it proved particularly useful, viz.:—minelaying. Two types were developed by the Germans, the short range and the distant minelayer. The former were relatively small—170 to 500 tons—with six almost vertical tubes, open at top and bottom to the sea, passing through the pressure hull at the middle line forward of the conning tower. Three mines, one above the other, were stowed per tube, each held in position by stops which could be withdrawn, thus releasing the mines. The distant type were of 1,070 tons with a large compartment at the stern for stowing 42 mines. Two horizontal tubes with water-tight doors at both ends were used for discharging each tube taking three mines in line at a time, these being forced out of the tubes by two motors, one to each tube, which drove a number of spur wheels gearing with racks on the mine sinkers. Two apertures in the stern below the outer doors allowed the mines to fall into the sea abaft the propellers. In the short-range type of minelayer the mines were inaccessible after insertion in the tubes and were always in sea water, whilst in the other type they were dry and accessible for examination and adjustment until loaded into the tubes. The two are also termed "wet" and "dry" types.

Bow torpedo tubes and guns were fitted in both types, but to provide for the space and weight of mines and tubes, the power of the engines and motors, and with it the surface and submerged speeds, were reduced as compared with the ordinary submarine. A few mine-laying submarines are attached to all navies, the largest being V-4 of the U.S. Navy, of 2,890 tons, carrying 60 mines and arranged with a mine room and tubes at the stern.

Classification.—Up to 1914 submarines were divided into two main classes or types, the general service or patrol, and the coastal. The former was of 600 to 800 tons surface displacement with good speed and endurance, and capable of detached duties at some distance from its base, whilst the coastal submarine was of 250 to 400 tons, intended primarily for the defence of naval ports and bases. During the war other types were introduced, amongst which were the following:—Fleet submarine, with a surface speed of 24 knots, to accompany the fleets, and of which the British "K" class was the only example; the cruiser submarine with good torpedo and a relatively powerful gun armament (2–150 mm.) of great endurance (18,000 miles at 8 knots), capable of detached service in distant seas, but too large and unhandy for ordinary duties, of which the German "U.140" class of 1,930 tons was the first; the minelayer submarine already referred to; the monitor submarine, of which the British "M" Class was the only example, mounting a large calibre gun arranged for rapid fire when surfacing, and which at short range was sufficient to cripple unarmoured warships; and the submarine-destroyer submarine with high submerged speed (14 to 15 knots), which, sighting an enemy submarine on the surface, would close with her at top speed submerged, and sink her before she could submerge, the only example being the British "R" Class. In addition to these, the Germans built the commercial submarine—the "Bremen" class—which was not a success. Several of these new types have disappeared or are not being repeated. A study of the submarines under construction by the naval powers indicates three distinct types. The most numerous is the general service type with good surface and submerged speeds, high endurance and excellent seagoing qualities, with strong torpedo armament, but mounting one gun of 4 or 5 inches calibre, and of displacement from 900 to 1,800 tons. Few cruiser submarines are being built, almost the only example being the British "X·1" with an average torpedo armament, but with a powerful gun armament of four 5·2 inch guns. The third type is the minelaying submarine, of which the number is small compared with the general service type. (W. J. B.)

SUBMARINE CAMPAIGN. When the World War broke out the submarine was a weapon of unknown capabilities. In its legitimate rôle as one of the essential arms of a modern navy, it was not a serious menace to Great Britain, but the "unrestricted" war on commerce was, in the words of Lord Jellicoe, "the greatest peril which ever threatened the population of this country."

In Aug. 1914 the British navy had some 36 submarines of varying ages, of which the old "A" and "B" class boats were fit only for harbour defence. The "C" class could keep the sea for a few days and were used for defence of the Firth of Forth, mouth of the Thames, and Strait of Dover, while the "D" and "E" classes were based on Harwich and employed in keeping a close watch on the Heligoland Bight. Germany had 28 "U" boats, of which 18 were fit only for harbour defence. "U 19" to "U 28" were seagoing boats but their capabilities were then unknown either to Germany or England. It was the German custom, on the rare occasions on which their fleet ventured into the North sea, to station "U" boats off the British harbours beforehand to lie in wait for her ships as they came out, but these measures met with little success. Previous to the sortie of the High Sea Fleet which ended in Jutland (*q.v.*), "U" boats were lying in wait off Scapa, Moray Firth, the Firth of Forth and the Humber from May 23 to June 1, but Admiral Scheer says "Their reports gave no enlightenment," and in fact they were actually misleading. After the sortie of Aug. 18, however, "U" boats did sink the "Nottingham" and "Falmouth" on their way home. By the end of the war the Grand Fleet possessed a submarine flotilla designed to act with it as a tactical unit, but no opportunity occurred of testing its capabilities in battle.

ALLIED OPERATIONS

In addition to their patrol work in the Bight and Strait of Dover, Allied submarines were employed in the Baltic, the Marmora, the Adriatic, the Otranto barrage and the Dardanelles patrol. Owing to the mining of Danish territorial waters the Baltic was closed to the British fleet from the beginning of the war, and Germany was able to carry on her trade with Scandinavia unmolested. It was therefore decided to send British submarines into it, and on Oct. 17, 1914, "E 1" passed through the Sound, followed two days later by "E 9." Though little time remained before ice compelled the boats to cease operations for the winter, the knowledge of their presence in those waters put an end to Germany's feeling of security. With the disappearance of the ice the submarines began to make their presence felt. More boats were sent during 1915. One of them, "E 13," ran ashore in Danish territory on entering, owing to a breakdown of her compass. The Danes correctly allowed her 24 hours to endeavour to refloat, but before this interval elapsed two German destroyers arrived and, in spite of her being in Danish territorial waters, opened fire on her, killing 15 men as they swam ashore. In the autumn the boats were chiefly employed against the traffic in iron ore from Sweden to Germany, and produced a serious hold-up of that vitally important trade. They also succeeded in sinking the armoured cruiser "Prinz Adalbert," a light cruiser and a destroyer. After the Russian Revolution, when the Germans advanced on the submarine base at Helsingfors, the whole flotilla of eight boats was taken out to sea through the ice and blown up by their own crews.

The experiences of the Allied submarines during the Gallipoli campaign are among the most thrilling episodes of the war. The straits are 27 miles long and for 3·5 miles are only one mile wide. The current is swift and variable, and minefields were known to exist, but Lieut. Holbrook in "B 11" successfully passed under the mines and torpedoed the Turkish cruiser "Messudieh." On the return journey his compass became unserviceable, but in spite of all perils he returned safely and was awarded the Victoria Cross. No further attempt was made until April 1915, by which time anti-submarine nets and obstructions had been added to the defences. The passage was then tried by "E 15," but unluckily she grounded some ten miles up. Being unable to get off again, she was destroyed after considerable difficulty with a torpedo dropped from a picket boat, one of two boats which crept up to the stranded submarine under cover of darkness. The next attempt, by "E 14," was successful. She sank three Turkish ships in the Marmora including a transport with 6,000 troops, but "A.E. 2" of the Australian navy was sunk by gunfire on the way up on April 30, and the French "Joule" struck a mine and was lost in May. "E 11," returning from a successful trip, found a mine sitting on her bows, but got rid of it by clever manoeuvring. She had penetrated as far as Constantinople itself where she torpedoed a Turkish gunboat, sank transports and storeships off Rodosto and torpedoed the "Stamboul" in the Golden Horn. This was the first time an enemy warship had appeared in those waters since the Turkish conquest. Her exploits held up all sea communication between Constantinople and Gallipoli for a time. Many boats followed, most of them meeting with considerable success, all with thrilling adventures. They attacked troops and railway lines, fought with "Q" ships and "U" boats. "E 12," returning from a 40-days' cruise, carried off part of the Nagara obstruction in passing through the nets and was dragged down to a depth of 40 fathoms before the entanglement, whatever it was, was scraped off her by a chain stretched across the straits a little lower down. Though she broke surface in her struggles and came under fire from guns and torpedoes, she managed to reach Helles in safety. After the evacuation in 1915 there was no further object in sending submarines into the Marmora, and these hazardous enterprises ceased.

GERMAN OPERATIONS

The Opening Phase.—The German naval authorities expected the Grand Fleet to appear in force in the Heligoland Bight immediately on the declaration of war, and had their submarines ready waiting for them. As the Grand Fleet did not oblige them, ten "U" boats started on Aug. 6, 1914, to make a sweep in the North sea to try to locate it. One boat, "U 15," did so, being rammed and sunk by the "Birmingham." Eight of the others returned, and as no useful result had been obtained this plan was discontinued. Their first submarine success of the war was scored by "U 21," who torpedoed the light cruiser "Pathfinder" off St. Abb's

Head on Sept. 5; but the most important achievement of the opening phase was the torpedoing of the "Aboukir," "Cressy" and "Hogue," by "U 9," with the loss of over 1,200 men. Though the feat was an easy one, as the last two ships closed their consorts and lowered boats in the attempt to save life, its effect was to raise the submarine in the estimation of both belligerents. After a credible report that periscopes had been seen in Scapa Flow the Grand Fleet withdrew from there until the harbour had been made secure with booms and nets. In actual fact no "U" boat had so far visited Scapa, German effort having been mainly directed against the troop transports going to France. "U 20" was sighted on her way to attack a convoy of Canadian troops and was hunted so hotly that she returned to Germany by the northern route in preference to the Strait of Dover again, thus demonstrating the practicability of this route for submarines.

The "Glitra," sunk by "U 17" off Stavanger, was the first merchant ship to suffer at their hands; but losses in the channel, especially off Havre, soon led to troops being sent across only at night, in fast ships escorted by destroyers. The first shock to public sentiment was the sinking of a Belgian relief ship full of refugees in mistake for a troop transport. Though the "Hawke," "Formidable" and several smaller British men-of-war had been sunk by the end of the year, submarines had so far done little to affect the naval situation.

The Attack on Commerce.—The submarine possessed certain decided advantages over the surface vessel for commerce destruction. She could attack shipping in the congested waters around the British Isles and France without undue risk to herself and within reach of her own refuelling bases. She was comparatively cheap, and could be produced quickly in large numbers. On the other hand her use as a commerce destroyer involved total disregard for the accepted canons of naval warfare. She could neither spare men for prize crews nor send prizes into port, for to effect a capture in the legitimate way she must come to the surface and remain there long enough to incur enormous risk.

The sinking of half-a-dozen British merchant ships on Jan. 30, 1915, gave an indication, but the first official intimation was a notice published on Feb. 2 warning all peaceful shipping against approaching the coasts of Great Britain. It was followed by the celebrated memorandum of Feb. 4 proclaiming that after Feb. 18 the waters around Great Britain would be considered a military area; that every hostile merchant ship found there would be sunk without regard to the safety of passengers or crew; and that even neutral ships in that area would be in danger. Germany sought to obtain the advantages of a commercial blockade without rendering such a blockade effective according to international law.

The United States pointed out the illegality of this, but Germany suggested that the American Government might provide a naval escort for their ships. Before Feb. 18, several merchant ships were attacked in the channel and North sea. The first neutral to suffer was the Norwegian steamer "Belridge," bound from New Orleans to Amsterdam with a cargo of oil for the Dutch Government, torpedoed without warning off the Varne on Feb. 19.

Anti-submarine Measures.—Great Britain's reply to the German memorandum was the Order in Council of March 11, known as the Retaliatory Order (*see* BLOCKADE). The State insurance scheme was just as effectual in preventing panic then as it had been at the outbreak of the war, and the flow of trade was maintained. Merchant ships were advised as to what precautions to take, the best procedure when attacked and the use of wireless telegraphy. The auxiliary patrol was strengthened, till by April 30 there were, on their stations or fitting out, some 60 yachts and over 500 trawlers and drifters in addition to 400 trawlers and drifters of the mine-sweeping service. Behind the Dover minefield a line of drifters with indicator nets was maintained across the straits, supported by destroyers and armed trawlers; and the Gull Stream, the northern entrance to the Downs, was closed with a boom.

For the protection of the North Channel into the Irish sea, all shipping was restricted to the passage between Rathlin island and the mainland of Ireland. the area between Rathlin island and the Mull of Cantire being closed by nets. Lines of nets and patrol flotillas protected the southern end of the Irish sea, while important harbours and anchorages were also provided with net defences. In spite of all precautions the tale of losses continued and the range of attack increased. During March casualties were reported from all parts and every week saw two or three vessels sunk in the channel. On March 27 and 28 alone "U 28" sank four vessels in the neighbourhood of Lundy island and the Smalls, and submarines were passing down the west coast of Ireland to attack vessels in the approaches to the Channel. Nevertheless, there was little diminution in the flow of trade and the officers and men of the merchant service who ran the personal risk regarded it with superb indifference. When opportunity offered they were not slow to retaliate, as witness the ramming of "U 6" by the "Thordis" off Beachy Head.

The first 18 "U.B." boats had a surface speed of only 6·5 knots and only two torpedoes for armament. Although nets were moored off the Belgian coast (*see* BELGIAN COAST OPERATIONS) and the patrols were numerous and active, these feeble little craft fought the tide rips and navigated amongst the sandbanks of the east coast, sinking ships and raiding fishing fleets. On June 21 "U.B. 6" passed through the Dover barrage and reconnoitred Boulogne. Thence forward the Dover patrol could not keep them out. The "U.C." boats, no faster than the "U.Bs" and totally unarmed, were intended only as minelayers. Their function was to creep at night to some light-vessel or buoy and lay their mines close to it. These mines claimed many victims of all nationalities on the thickly frequented east and south coast routes. After April 10 "U" boats operated only in the North sea and western approaches. In the North sea the attack was chiefly on shipping of the Scandinavian Powers. In the western approaches three "U" boats were kept at work between Ireland and Ushant; this service absorbed nine boats, three working, three on passage and three resting.

The liner "Falaba" was torpedoed after 5 minutes' warning with a loss of 104 lives, 57 of them passengers, while the sinking of the "Lusitania" without any warning on May 7 with a loss of 1,198 men, women and children sent a thrill of horror throughout the civilized world. Two U.S. steamers, the "Gullflight" and "Nebraska," were torpedoed without warning in May, and so powerful was the feeling eventually raised in the U.S.A. that the German Government gave way and on June 5 issued orders that large passenger ships were to be spared unless they made deliberate attempts to injure submarines. American indignation flamed up anew when on Aug. 19 the White Star liner "Arabic" was torpedoed without warning with a loss of 44 lives, and to appease America fresh orders were given on Aug. 30 that no liners were to be sunk without due regard to the safety of the passengers. September saw the end of the first campaign in home waters; 166 British steamers and 168 fishing vessels had been sunk, the latter a class which by The Hague Convention should have been spared. France, Russia and Belgium had lost 34 ships between them. Of the neutrals Norway lost 51, Sweden and Denmark 15 each, Holland and Spain two each. These losses are exclusive of those due to mines, by which Holland suffered especially.

Spring Campaign of 1916.—During the winter the naval authorities in Germany managed to wring from the political heads permission to torpedo defensively armed merchant ships without warning, though passenger ships were still to be spared. In Feb. 1916 the attack began again, many more boats both of the "U" and "U.B." classes being now ready. The western approaches to the British Isles were the main theatre. On March 24 the French packet "Sussex," crowded with passengers for Dieppe, was torpedoed in spite of Germany's promise to President Wilson. The President sent what was practically an ultimatum demanding the immediate abandonment of Germany's "present methods of submarine warfare against passenger and freight carrying vessels." The German Government surrendered and at the end of April stopped this second campaign. In this three months the British lost 58 ships and fishing craft from submarines and the Norwegians eighteen. France also lost three steamers. Throughout the summer of 1916 the "U" boats took part in the operations of the High Sea Fleet, and an attack was made on the ships carrying munitions from Great Britain to North Russia.

Owing to Germany's surrender to the President's ultimatum, tension between her and America diminished, whereas the Allied blockade was bearing so heavily on American commercial classes that feeling grew very bitter against England and a strong protest was sent from the United States. Encouraged doubtless by this reversal of the situation, Germany decided to renew her war on commerce. A specially severe attack was made on Scandinavian shipping carrying iron ore, and also on ships carrying coal to France and Italy. Between Sept. 1916 and Jan. 1917 inclusive, 170 Norwegian, 29 Swedish and 50 Danish ships were destroyed by "U" boats as against 86 British sunk in home waters. In September and October Norway lost 5% of her mercantile marine.

The rate of sinking rose so much that Admiral Jellicoe took the unusual step of writing to the prime minister direct to call his attention to the fact that loss of shipping alone might soon force the Allies to conclude peace. As a result of the conference which followed he was appointed first sea lord to carry into effect the various proposals for dealing with submarines. By that time the tension between the U.S. and Germany had increased again owing to the appearance of "U 53" off Nantucket where, within sight of land, she sank one Dutch, one Norwegian and three British ships.

The Dardanelles campaign provided an excellent object for attack. "U" boats came out from Germany and by the end of May "U 21" had sunk the "Triumph" and "Majestic" off the Peninsula and passed on up to Constantinople. "U.B." and "U.C." boats were sent in pieces by train from Germany to Pola where they were assembled, and by the autumn the Central Powers had five large "U" boats, four "U.B." and four "U.C." boats operating in those waters. Mediterranean conditions are most favourable for submarines, and the protests of President Wilson had no effect there, where the sinking of merchant vessels went on without those interruptions which cut the home waters campaign into such well defined sections. In the 18 months from their arrival to the end of Jan. 1917 a total of 200 British, 189 Italian and 52 French ships were destroyed by them. Contrary to Admiral Scheer's wishes the autumn campaign of 1916 was conducted under certain restrictions with regard to passenger ships and sinking without warning in home waters. Only reluctantly had he allowed his High Sea Fleet submarines to participate, but the results exceeded anticipation. In October 148,000 tons of British and 164,000 tons of foreign shipping were destroyed, a total of over 300,000 tons for all the nations of the world.

Shipping Destroyed by Submarines

	Dec. 1916.		Jan. 1917.	
	Ships.	Gross tons.	Ships.	Gross tons.
British	39	110,160	51	111,974
Allies	58	66,690	63	58,253
Norwegian	32	43,537	34	55,487
Danish	17	16,113	13	17,151
Other Neutrals	21	39,900	19	42,142
Totals	167	276,400	180	285,007

The favourable results of this campaign, limited though it was, strengthened the case for the advocates of unrestricted warfare. They argued that if all restrictions were removed the rate of destruction would be doubled, and Britain would be brought to her knees before America would have time to intervene effectively. Their arguments carried the day.

THE FINAL STRUGGLE

The Second "Unrestricted" Campaign.—On Feb. 1, 1917, unrestricted warfare was recommenced, Germany declaring the areas enclosing the British Isles and France to be war zones, also the Mediterranean. The Portuguese Atlantic islands and the area around Archangel were added later. Vessels of any nationality or character found in the war zones were to be destroyed, and consideration for the safety of the lives of the seamen on board these vessels was not to be allowed to hinder the submarines at their work. To carry on this campaign Germany had 111 sea-going submarines of the "U," "U.B." and "U.C." classes. Though the "U.C." class were still primarily minelayers, they now carried guns and a few torpedoes, and were capable of any form of attack. Even with the reduction of traffic resulting from the natural reluctance of neutrals to enter the war zones the losses increased rapidly.

1917 Losses

	February.		March.		April.	
	Ships.	Gross tons.	Ships.	Gross tons.	Ships.	Gross tons.
British	114	260,000	146	287,000	196	522,000
Allies	77	77,000	114	115,000	108	145,000
Neutral	69	132,000	78	122,000	126	185,000
Totals	260	469,000	338	524,000	430	852,000

From this great increase in the rate of destruction it appeared that the submarines would win the war for Germany. They were being built faster than they were being destroyed; from 111 on Feb. 10 they increased to 127 on April 10, and it was clear the existing methods of dealing with them were insufficient. On April 19, the worst day for Britain of that worst month, 11 British merchant vessels and eight fishing vessels were sunk by them. One out of every four vessels that left the British Isles in that month never returned.

Convoy System (*see* Convoy).—It was obvious that unless some new and effective form of defence could be devised the defeat of the Allies was in sight. The convoy system which had been used in the old wars seemed to present such great difficulties that it was at first considered impracticable except for the export of coal to France. This latter traffic was maintained very successfully in small slow ships escorted by trawlers. Owing to their enormous losses Scandinavian vessels at length had to be collected into convoys and guarded by such armed vessels as could be spared. These convoys also proved successful, and the system was introduced on other routes as escorting craft became available. Experience proving that the difficulties, though great, had been overestimated, the convoy system became universal. In May 1917 submarines sank 303 vessels of all nationalities, totalling 550,000 tons; by November the losses had fallen to 116 ships, totalling 259,000 tons. As the losses in shipping decreased the destruction of submarines increased; in April, May and June of 1917 12 boats were destroyed; in the next three months 20, and in the last quarter twenty-four. One of those destroyed was "U 88," sunk by the "Q" ship "Stonecrop," and commanded by the notorious Schwieger who had sunk the "Lusitania." The resumption of the unrestricted war on commerce brought the United States into the war in April 1917, and by the end of the year they had sent 37 destroyers to assist in convoy work.

The Attack Defeated.—As 1917 progressed it became increasingly clear that the submarine attack on commerce had been countered. The number of "U" boats in commission reached its maximum of 140 in October and then slowly diminished. They failed to impede either the transport of British troops to France or of American troops to Europe. Four of the best "U" boats were sent across the Atlantic especially to attack troop transports. Between them they destroyed 60 ships, but not one which carried troops. One of them, "U 156," was lost in the great minefield laid across the North sea. During April 1917 submarines sunk 840,000 tons of British and Allied merchant ships and fishing vessels. Merchant ship-building in Great Britain had been practically suspended in order to provide for the requirements of the navy and army. Her skilled engineers and shipwrights were mostly at the front and could neither be recalled nor replaced. Her total output for the month was only 67,536 tons gross, and continuance of these conditions would soon have brought about Allied defeat; but from that date, due to the introduction of the convoy system, the sinkings decreased, and the efforts of the Ministry of Shipping increased output to such an extent that by Oct. 1918 it had overtaken the rate of Allied losses. The Flanders bases had to be evacuated and the submarines in them blown up

—all except "U.B. 116," whose commander, Lieut. Emsmann, made one last effort. He reached the entrance to Scapa Flow on October 28, but the boat was picked up by a searchlight and sunk. At the armistice 138 boats were surrendered and brought to Harwich. (*See* also BLOCKADE and CONVOY.)

TABLE I.

Ships and tonnage sunk by Submarines, 1917–18

A Number of British and Allied merchant ships and fishing vessels sunk by submarines.
B Number of neutral merchant ships sunk by submarines.
C Total gross tonnage in thousands of tons.
D Number of German submarines sunk.

	1917.				1918.			
	A	B	C	D	A	B	C	D
Jan. .	96	65	293	2	112	19	299	9
Feb. .	171	66	468	4	104	19	316	4
March .	204	85	511	4	147	25	332	5
April .	277	118	840	2	96	12	262	6
May .	192	89	551	6	108	18	291	17
June .	211	81	633	4	77	22	241	3
July .	171	56	495	6	83	24	260	6
Aug. .	149	33	490	4	84	30	272	6
Sept. .	137	18	316	10	65	8	181	9
Oct. .	134	19	429	8	41	9	107	19
Nov. .	95	21	260	9	. .	. .	. .	4
Dec. .	123	28	353	7	. .	. .	. .	. .
Totals	1,960	679	5,639	66	917	186	2,561	88

TABLE II.

British, Allied and Neutral Vessels sunk by Submarines

	1914–15.	1916.	1917.	1918. (10 months)
British merchant vessels	231	288	1,052	527
British fishing vessels	168	134	200	76
Allied merchant vessels	76	344	708	314
Neutral merchant vessels	93	332	679	186
Totals	568	1,098	2,639	1,103

Grand total, 5,408 ships; 11,189,000 gross tons.

	1914–15.	1916.	1917.	1918. (10 months)
German submarines destroyed	24	25	66	88

Grand total, 203 ships.

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(R. N. BA.)

SUBMARINE MINES: *see* MINES AND MINELAYING.

SUBMARINE SIGNALS: *see* FATHOMETER.

SUB-MEDIANT, in music, the 6th degree of the diatonic scale, as A in the scale of C. (*See* HARMONY; INTERVAL.)

SUBNORMAL AND FEEBLE-MINDED, EDUCATION OF. The mentally handicapped are most frequently thought of as those who, because of failure of development of the brain, cannot carry out the activities which are considered normal. Especially because of the finding of developmental defects of the brain, there is a tendency on the part of pathologists to consider some of the mentally handicapped to be essentially different from the normal. On the other hand there are equally cogent reasons for the belief that from the lowest to the highest degree of intelligence there may be an unbroken line. For purposes of convenience we may be justified in isolating mentalities into groups, but we must not forget that the groups are contiguous, and even overlapping.

Method of Classification.—The most convenient method of classification of the mentally handicapped is by comparison with average mentalities of children. If a 20-year old boy knows and can do only those things which are known and done by children of 16 years or over he is considered normal; if he can suitably adjust himself only to those things known ordinarily to and appropriately reacted upon by a two-year old child he is known as an idiot; if he knows and acts as an average child from three to seven years of age, he is considered an imbecile; and if his knowledge and reactions resemble those of an eight to nine-year old child he is spoken of as a moron. These divisions, it will be noted, are artificial limitations in that (1) they take a positive view of the "average" intelligence, (2) they are based on "abstract" knowledge or social behaviour, or on both; and (3) they do not take into account special aptitudes or capabilities.

The acquisition of modes of behaviour other than those of a fixed reflex character is a characteristic of normal development. As development proceeds and the child has new experiences the adjustments become more complex. In the lowest form of feeble mindedness, idiocy, there is a retention of the infantile reflex activities without the acquisition of more than the simplest modifications of the reflexes. The idiot is helpless, he does not control his physiological functions, he cries and he makes inarticulate sounds. A few idiots learn to feed themselves and occasionally to select their food, but many will eat whatever comes to hand,—earth, lime, wood, cloth, etc. The imbecile adds to the advanced learning of the idiot the activities of play, the performance of simple home duties and sometimes the ability to read and to write short sentences, as well as consecutive, though limited, vocal speech. The moron can be taught to carry on without immediate supervision operations such as digging, cultivating land, simple carpentering, driving a horse or automobile; he does housework well and he has some social characteristics of co-operation in group activities. He can learn to read simple books and he can talk on ordinary every-day topics. Notwithstanding the limitations expressed above, it is not unusual to find some feeble-minded who far surpass the performances of normal or even mentally superior persons because of special aptitudes. Thus, an "imbecile" who had not learned to read or write was able to give accurately the day of the week for any date in the past century. Another was able to multiply "mentally" four- or six-place numbers in less time than most normal persons could do with pencil and paper.

These deviations in capability, especially the limitations, of the feeble-minded make their educational training both simpler and more tedious than the educational handling of the normal child. The simple character of their accomplishments makes for ease of instruction; their slowness of learning makes their instruction tedious, irksome and monotonous. An unwearying drill master is usually required, and because of this many of the higher grade feeble-minded become excellent teachers for the routine training of those who are of lower intellectual grade. A feeble-minded child may attain a three-year mental level by the age of four, but although he may continue to develop mentally he does so only slowly. At the age of 12 he may attain the normal six-year level. In cases of this kind, which with different age figures are very common among the school population, the slow learning leaves the feeble-minded almost unaffected intellectually by the mass instruction in our public school systems. Each day's work is planned for the average child, and is too great for the retarded child to assimilate. The more rapid learning of the normal children may, on the one hand, tend to discourage the feeble-minded if the latter have sufficient mentality to be affected by a recognition of their own deficiency. It may even bring about resentment and bad-temper.

Advantages of Special Classes.—There are well-recognized advantages in special classes for the feeble-minded both for them and for normal children. The normal is not held back by the retarded, and the instruction of the feeble-minded can be adapted to their degree of development. Because of this, many school systems have organized departments for their special care. It is also recognized that the public schools can care for those who have social characteristics, but not for those who are idiots or low grade imbeciles. The latter groups must be cared for in special institutions, or in their own homes when institutional care is wanting or when parental prejudice prevents separation from the family group. Special classes and institutions are best adapted to the education of practically all feeble-minded, both because of the provision of interested and trained teachers, and because of special curricula—the direction of school energies towards the adaptation of their charges in social directions which are commensurate with the pupils' potential mental development. Special training makes for individual happiness and for social welfare. When the feeble-minded are not pushed into intellectual and manual work beyond their capabilities, there is less tendency to personal conflict, and at the same time the pupils can be trained in those relatively simple activities for which greater mentality is a handicap.

Much, nearly all, of the education of the feeble-minded should be motor. It should be a training in behaviour directed to those occupations which require little judgment and little analysis, viz., those which are routine. Most factories and shops have work which can be done best by the routine worker, who may become self-supporting. In and around homes and hotels many household duties can be carried out successfully and with little supervision by those of little intelligence if they are given suitable training. These jobs should be selected in accordance with the physical make-up and interests of the individual, and in conformity with his home situation. Except with respect to the lower grades of the feeble-minded the schools should not neglect the matter of instruction in reading, writing and simple arithmetic, because simple attainments in these lines are fundamental to practically every occupation. The latter warning may appear superfluous, because in some quarters there is a tendency to try to develop to the highest degree the intellectual side of every individual, regardless of the difficulty or the ultimate value. A further effort to make the feeble-minded a part of society is being made in some communities by having after-care or supervision after school training. This excellent procedure insures a close co-operation between the school and the community in the solution of one aspect of the problem of feeble-mindedness, and it achieves a better result for the individual as well as for society. Because all grades of the educable feeble-minded are chronologically and physically older than the normal children with whom they may be instructed, they are apt to be detrimental to the latter. Their greater physical development, coupled with their lack of judgment, result in oppression or physical danger to the normal, younger and weaker children. Because of their greater physiological development they may prove a moral menace. Because of their less controlled emotional reactions they sometimes become brutal or bestial after the onset of puberty. It is because of an individualistic development that the feeble-minded may readily be led into careers of crime. The lack of inhibition coupled with sex impulses leads also to sexual abnormalities. Both of these results are unsocial or antisocial. *See* also MENTAL DEFICIENCY.

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SUBOTICA, a town of the Voivodina, Yugoslavia. Pop. (1921) 101,857. It is the centre of an immense agricultural district, and in the adjoining territory of Puszta Telecska (369 sq.m.) large herds of cattle are reared. The chief industries are the making of iron articles of furniture, railway trucks and boots. Lake Palics near by is a favourite watering place and summer resort.

SUBSTANCE. The concept of substance is that of a permanent substratum preserved through all changes. The term substance is Latin for the Greek ὑποκείμενον, "that which underlies," as the permanent "basis" of its "accidents" (συμβεβηκότα, *e.g.*, Aristotle, *Metaphysics* IV., 30, 1025a).

Greek Philosophy.—To set forth this permanent Being which in all transformations remains identical, was conceived by Greek philosophy from first to last as one of its principal tasks. Greek Philosophy is essentially "ontology"; it aims at the determination of "Being as such" (ὂν ᾗ ὄν; Aristotle, *Metaphysics*, 1, 2). In the characterization of this Being lies the difference between the various schools of Greek thought. In the natural philosophy of the Ionians it is first conceived as *material* Being; substance is the basic matter from which all other materials have issued. It designates, accordingly, the "beginning" of all becoming at large and, at the same time, an immutable unit, a uniform and constant "nature" (μία τις φύσις), which is neither subject to nor affected by becoming.

But already in the next phase of Greek Philosophy, Heraclitus and the Pythagoreans replaced this material determination of substance by another type of determination. For them, the permanent consists not in an unchangeable material substratum, but in certain constant *proportions* which persist in all Becoming. The true substance, the "essence" (οὐσία) of things is not sought in an individual thing, but, according to the Pythagoreans, in *Number*, this being the principle underlying all measured proportions; according to Heraclitus in the immanent law, in the "Logos" that governs all events and retains them within definite limits. Here substance does not lie outside Becoming, but designates a law which pervades all Becoming and gives it its "form." This view forms the transition from the "physical" explanation of things to their "ideal," *i.e.*, mathematical and logical, explanation. The logical view of substance was developed by Parmenides and the Eleatic school. True "Being" can be grasped only in pure *thought*. Thinking and Being are one; so, true Being is determinable only by predicates of thought. It is eternal; it is subject to no change of place; it is one and admits of no partition.

This idea of logical identity becomes the determining motive in the further development of the concept of substance in Greek philosophy.

The systems of the "younger philosophy of nature" (Empedocles, Anaxagoras, Democritus) attempt to connect and reconcile this motive with the physical explanation of the universe. They seek to exhibit within nature itself certain elements which, although themselves incapable of change, produce, by their mutual relationships, the manifold of reality and their changes.

Atomism, especially, became of fundamental importance for the further development of the concept of Substance. The idea of the absolute oneness of Substance is here abandoned; true substantiality is attributed to atoms which are infinite in number, but simple and indestructible. From the differences of position, shape, arrangement and spatial motion of the atoms results the manifold of sensible phenomena, which accordingly possess only secondary Being; genuine Being is attributable only to the atoms and to empty space, which is required for their motion.

The classical systems of Greek philosophy, however, effect a decisive change. Instead of matter, pure *form* is made the basis of all substantiality. The form (εἶδος, ἰδέα) is the one persistent element; unlike sensible phenomena which always "become" and never "are," it remains the same. Equal *things* can become unequal; the small, by growing, can become large; but the *idea* of the equal, etc., remains what it is and suffers no change (Plato, *Phaidon* 99 *sqq.*). Thus, the idea forms that which alone has genuine, constant, true Being (ὄντως ὄν), while empirical objects, in so far as they have Being owe this to their "participation" in ideas. In the system of Aristotle, too, this interpretation of the problem of substance is retained, although he rejects the substantiality of pure ideas as taught by Plato. For him, substance is the individual Being composed of "matter" and "form." But the specific function of determination belongs to the form: Logically substance is the ultimate "subject" of all predication, but which cannot be predicated of anything else. All our judgments refer to a Something of which they claim to be true; and this Something is that to which the judgment refers (Aristotle, *Categ.* V., *Metaphysics*, 1069a 18). From this "first substance" (πρώτη οὐσία), Aristotle distinguishes the species and genera as "substances of the second degree" (δεύτεραι οὐσίαι). They do not subsist in themselves, but only in the individual beings, the first substances; but they express the most general determinations without which individual beings could not be thought.

Descartes, etc.—The Aristotelian conception of substance determined for many centuries the form of western thought and metaphysics. Mediaeval Scholasticism was in its essence a philosophy of "substantial forms." This fundamental outlook was shaken only by the new scientific view of the world, which originated in the 17th century. The establishment of the helio-centric system by Copernicus and Kepler, and of modern dynamics by Galilei, deprived the Aristotelian physics, cosmology, and metaphysics, of their foundation. The new concept of substance goes back historically to pre-Aristotelian philosophy, especially to the doctrines of the Pythagoreans and of Democritus. Substance is now conceived *mathematically;* it is that which, in all transformations of phenomena, remains unchangeable in *magnitude*.

Thus, the problem of substance, or matter, is supplemented by the problem of *motion*. For also motion, now conceived as pure translocation, reveals a *quantitative constancy* which makes it something substantial. In this sense, the Galilean doctrine of motion is headed by the principal of inertia, *i.e.*, the theorem that the motion of a material point upon which no external forces are working, remains invariant in velocity and direction. Similarly, the mechanics of Descartes rests on the principle of the "preservation of motion," *i.e.*, the assumption that the so-called magnitude of motion, which is measured by the product of mass and velocity (mv), can suffer neither increase nor diminution. This product remains constant in the whole world; through the exchange of velocity, which takes place at the impact of bodies, no new quantity of motion can be created nor any existing one be destroyed; there occurs only a change in the *distribution*.

From this assumption, however, it follows that the world of bodies is a system completely closed in itself and incapable of suffering any interference from the outside. All action of body upon body, all "causality" within the realm of extension, rests upon mechanical laws; mental, "immaterial" powers cannot act upon bodies, nor increase or diminish the sum total of their momentum. Between the worlds of "external" and "internal" experience, between "matter" and "consciousness," no kind of transition takes place.

Through this viewpoint, the metaphysical doctrine of substance receives a decisive turn. Descartes defines substance (*Principia philosophae*, I. 50) as that type of thing which exists in such a way that it needs no other thing for its existence. Accordingly, the concept of substance is applicable only to the Being of God. Next to it, there subsist, as *relatively* independent and mutually irreducible entities, consciousness and the world of bodies. The fundamental problem consists now in determining how these two essentially different substances can enter that kind of *connection* which is exhibited in the concrete existence of man. For man is a whole consisting of "thought" and "extension," of "soul" and "body." The search for an explanation of the *empirical* union of soul and body, notwithstanding their metaphysical difference, gives rise to the systems of Spinozism, of Occasionalism, and of the doctrine of monads.

Locke and Hume.—A new and decisive turn is given to the problem by the *critical analysis of cognition* which starts with Locke and Hume and reaches its completion in Kant. The characteristic of this turn lies in the fact that the weight of the problem is transferred from the realm of metaphysics to that of epistemology. Substance appears as a "category," as a fundamental concept of pure understanding. That this concept is not *derivable* directly from experience, that it cannot be thought as the mere "copy" of a sense-impression: this is emphasised also by Locke and Hume.

The empiricist and sensualist conception of knowledge, which they represent, is thus confronted with the question whether the concept of substance, not being reducible to empirical sources, retains any "objective" *significance* or is merely *"subjective"* as a kind of natural illusion of the human understanding. Locke starts with the assumption that true reality belongs only to the simple, sensible "ideas," to the sensations of colour, sound, etc., whereas the understanding cannot create any new reality, but can merely connect these ideas in certain modes with one another. Such a mode of connection is represented by the concept of substance. What the senses deliver individually, is thereby connected; the changing states and properties being united in one "substratum," or "bearer." But the idea of a persistent thing as "bearer" of the changeable qualities is, in itself, utterly empty; it represents a mere form of knowledge to which no content corresponds. Not adding anything new to the sensible elements in which all our knowledge of reality is rooted, it originates in the mere habit of correlating with one another many such elements on the basis of their regular conjunction, their spatial coexistence.

This correlation, however, is not a real, objectively founded *connection*. We know, for instance, that in the thing commonly called by the name of "gold," a certain density, a certain colour, a certain specific weight, etc., appear regularly in conjunction; but the *necessity* of this conjunction, the "ground" for the combination of the various qualities in *this*, and no other, mode, is not understood. Even if there be such a ground in reality, it must be undiscoverable and unintelligible. (Locke, *Essay on the Human Understanding*.) The subjective nature of substance is emphasized even more by Hume.

The concept of substance, according to Hume (*Treatise on Human Nature*), is not reducible to any sense impression; it has, therefore, no positive significance for knowledge, but is merely a product of the imaginative power which combines what is frequently together, into *one* idea and gives it *one* name. This criticism of the concept of substance refers to the realm of external as well as of internal experience. The supposition that a material *thing* as such persists even when not perceived is denied objective significance; and the concept of "soul-substance" is rejected and the "I" declared a mere "bundle of perceptions."

Kant.—Kant's *Critique of Pure Reason* takes up the results of Locke and Hume; but it draws from them an entirely different *epistemological* conclusion. For Kant, too, substance is a pure concept of understanding; a form of connection established by pure thought. But this form of connection cannot be reduced to the *empirical* rules of habit and association; it has universal and necessary validity; it is a *synthesis a priori*. The validity of this synthesis consists in the fact that it is the basis of experience itself. Without the idea of a Something persisting in the stream of appearances, it would be impossible to establish and to make intelligible that *order* of phenomena which we conceive under the name of "experience."

The proof, the "transcendental deduction" of the concept of substance is, accordingly, presented by exhibiting it as a constitutive condition of any possible experience. This implies, on the one hand, that it is indispensable for all experience, for all scientific cognition of nature; on the other hand, that it is designed for use in experience only, that its validity does not refer to "things-in-themselves" but to phenomena. The principle of substance, according to Kant, belongs to the "analogies of experience," *i.e.*, to those principles on the basis of which alone it is possible to set a fixed, objective *time-relation* between phenomena and to conceive them as "nature" coherent in itself and ordered according to universal laws. Such an objectivation of time would be impossible without the category of substance. "The persistent is the *substratum* of the empirical notion of time itself, and it is on its basis alone that all temporal determination is possible." For change does not affect time itself, but only its contents, only the concrete events which we conceive as following each other in time. Time itself does not change, but all change occurs in it as the "constant corollary of all Being of phenomena." However, the strictly "empty" time does not constitute any possible object of perception; in order to think of time as constant, as "duration," we must, therefore, presuppose a persistent element within appearance itself and oppose it to all that is merely changeable.

The concept of something persistent is, accordingly, "the condition of the possibility of all synthetic unity of perceptions, *i.e.*, of experience; and in proportion to this persistent element, all being and all change in time can be viewed only as a modus of the existence of that which remains and persists." (*Kritik der reinen Vernunft*, 2nd. ed.; p. 225 *seq.*)

Recent Epistemology.—The contrast between Hume's and Kant's conceptions of substance, reappears in the recent epistemology. The further pursuit of the road of Hume leads to empiricism and positivism; the further pursuit of the road of Kant, to logical idealism. For positivist epistemology as developed in Avenarius' *Kritik der reinen Erfahrung* (1888–90) and in the writings of Ernst Mach (*Beiträge zur Analyse der Empfindungen*, 1886; *Die Mechanik in ihrer Entwicklung*, 1883; *Prinzipien der Wärmelehre*, 1896), the concept of substance has an essentially *biological* significance. It serves the "economy of thought" inasmuch as it is a means of correlating a multiplicity of experiences, and giving them *one* name.

But the unity of substance is a merely nominal unity. What we call material substance, is only "a relatively constant sum of sensations of touch and light associated with sensations of space and time." This constancy can never be considered absolute, only relative, so that the identity of the "thing" is a mere function. In the place of the substantial identity of things we must set the constancy of certain relations, especially of mathematical relations. "A body consists in the fulfillment of certain equations which obtain between sensible elements. These equations are the truly constant element." (*See* CATEGORY.)

Critical idealism essentially agrees with this result, but differs from empiricism and positivism in the *explanation* which it gives. It, too, emphasises the fact that, the further the scientific cognition of nature progresses, the more the concepts of *things* are replaced by concepts of *relations*. The concept of substance resolves into the concept of function. But the concept of function is not considered as the expression of a mere "togetherness" of experienced facts, but as a genuine achievement of thought. It is the original form of connection as such, and of experience itself. The concept of substance, is, therefore, to be replaced ultimately by that of *invariance*. The whole of experience is never a mere aggregate of perceptual data linked up by purely external, habitual associations, but is organized and unified according to definite theoretical viewpoints. Without such viewpoints, no single predication of fact, especially no kind of exact measurement, would be possible. (Ernst Cassirer, *Substance and Function*, 1923.) (E. CR.)

SUBSTITUTIONS: *see* GROUPS.

SUBWAY, a subsurface passage. The term is generally used in America in connection with urban underground electric transportation to represent a railway operating either in a tube, a steel framework built in an open cut and then covered, or in any other type of tunnel. *See* ELECTRIC RAILWAYS; RAILWAYS, TUBE; NEW YORK (CITY), *Transportation and Communication;* and TUNNEL.

SUCCESSION: *see* LAWS OF SUCCESSION.

SUCCESSION DUTY. In the English fiscal system, a tax placed on the gratuitous acquisition of property which passes on the death of any person, by means of a transfer from one person to another person. (*See* LEGACY DUTY and SUCCESSION DUTIES.)

SUCCESSOR STATE, a term applied to a State formed wholly or partly out of another State which has ceased to exist, thus forming a wholly distinct political entity, but inheriting certain obligations, *e.g.*, the repayment of a public debt, inherent in its origin. As neither Turkey nor Russia have ceased to exist, although their forms of State have changed, the only modern States to which this term can strictly be applied are those which the Treaties of St. Germain and Trianon describe as "States to which territory of the former Austro-Hungarian Monarchy is transferred and States arising from the dismemberment of that Monarchy." These States were taken by the authors of the above treaties to be Czechoslovakia, Poland, Rumania and Yugoslavia. East Galicia, which, like these four States, had been recognized as its successor by the Austrian "Liquidierungskabinett" of Oct. 1918, failed to maintain its existence, and the plea of the Austrian republic to be considered a Successor State was rejected by the Powers at St. Germain, who affirmed its identity with the old Austria. The Successor States were acquitted of moral identity with the old monarchy, and were thus not called on to pay reparations, but were required instead to pay "contributions towards the Allied cost of liberation" on a scale based on pre-war taxation. Among other obligations was the signing of the Minorities Treaties. Italy signed no Minorities Treaty, but consented to regulate the financial position of the territories which she had inherited from Austria and Hungary on a basis similar to that taken for the Successor States. Among Italy, Austria and Hungary, the equitable partition of both the assets and the liabilities of the old Austro-Hungarian Monarchy led to various clauses in the peace treaties, followed by international commissions and conferences.

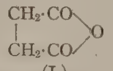
See *History of the Peace Conference* (ed. H. V. Temperley, 1924), vols. iv. and v. *passim*. (C. A. M.)

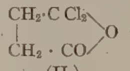
SUCCINIC ACID is an organic compound occurring in amber (3 to 4%), from which fossilised gum it is obtained by distillation. It is also found in other resins, in lignites, in fossilised woods and in many plants belonging to the Compositae and Papaveraceae. It occurs in the animal kingdom, as in the thymus gland of calves and in the spleen of cattle.

Chemically, succinic acid or ethylenesuccinic acid,

$$CO_2H{\cdot}CH_2{\cdot}CH_2{\cdot}CO_2H,$$

is a saturated dibasic acid which crystallises in colourless prisms or plates melting at 186° C, and boiling at 235° C. Its vapour readily loses water to form succinic anhydride (I.) which crystallises in plates melting at 120° C.


(I.)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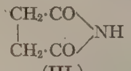
(III.)

The acid itself is soluble in water and its salts with the alkali and alkaline-earth metals are also soluble in water. Barium succinate is precipitated from aqueous solution by alcohol; ferric succinate is insoluble in water and is sometimes employed in the analytical separation of iron from other metals. When heated with phosphorus trisulphide, sodium succinate yields thiophen.

Succinic acid is produced during the bacterial fermentation of ammonium tartrate or calcium malate. It arises from the oxidation of fats and fatty acids by nitric acid. It may be prepared synthetically from ethylene, C_2H_4, through ethylene dichloride, $C_2H_4Cl_2$, ethylene dicyanide or succinonitrile, $C_2H_4(CN)_2$. The last compound yields the acid on hydrolysis. Maleic acid, now produced industrially by the catalytic oxidation of benzene, yields succinic acid on reduction with sodium amalgam.

Succinyl chloride (formula II.) is obtained by the interaction of phosphorus pentachloride and succinic acid. *Succinic anhydride* (formula I.), also produced by heating the acid or its salts with acetic anhydride or by heating succinyl chloride with anhydrous oxalic acid, is employed as an intermediate in colour making, when it yields two brands of Rhodamine S (*see* DYES, SYNTHETIC) by condensation with dimethyl- or diethyl-*meta*-aminophenol, $NR_2{\cdot}C_6H_4{\cdot}OH$.

Succinimide (formula III.), produced by heating succinic anhydride in ammonia, crystallises in colourless octahedra melting at 125–126° C, and readily soluble in water. This imide when distilled with zinc dust furnishes pyrrole (*q.v.*).

Succinonitrile, $CN{\cdot}CH_2{\cdot}CH_2{\cdot}CN$, obtained as above and also by electrolysis of potassium cyanoacetate, is a colourless solid melting at 54°–55° C. On reduction with sodium and alcohol it is converted into the ptomaine alkaloid, putrescine (tetramethylenediamine), $NH_2{\cdot}[CH_2]_4{\cdot}NH_2$, and into pyrollidine (tetrahydropyrrole, *see* PYRROLE).

Methylsuccinic acid or pyrotartaric acid,

$$CO_2H{\cdot}CH_2{\cdot}CH(CH_3){\cdot}CO_2H,$$

formed during dry distillation of tartaric acid, by heating pyruvic acid with concentrated hydrochloric acid, or by the reduction with sodium amalgam of citraconic and mesaconic acids, is obtained in colourless prismatic crystals soluble in water and melting at 112° C. It forms an anhydride and its sodium salt heated with phosphorus trisulphide yields β-methylthiophen. *Isosuccinic acid* (ethylidenesuccinic acid), $CH_3{\cdot}CH(CO_2H)_2$, an isomeride of ordinary succinic acid, is obtained on hydrolysing α-cyanopropionic acid, $CH_3{\cdot}CH(CN){\cdot}CO_2H$, or by the action of methyl iodide on ethyl sodio-malonate, $CHNa(CO_2{\cdot}C_2H_5)_2$. It crystallises in prisms melting at 120° C, and soluble in water. Unlike ordinary succinic acid, it does not yield an anhydride on heating, but loses carbon dioxide and passes into propionic acid. Reference: T. E. Thorpe, *Dictionary of Applied Chemistry*, Vol. VI., 1926. (G. T. M.)

SUCEAVA, a town of the Bukovina, Rumania, on the river Suceava. Pop. (1928), 11,300. It was from 1401 the seat of the metropolitan of Moldavia and until 1565 the capital; its 14th century church contains the grave of the patron saint of the Bukovina. It was many times besieged by Poles, Hungarians, Tatars and Turks, and also suffered in the World War. Near by is the early 17th century monastery of Dragomirna in the Byzantine style.

SUCHET, LOUIS GABRIEL, Duc d'Albufera da Valencia (1770–1826), marshal of France, one of the most brilliant of Napoleon's generals, was the son of a silk manufacturer at Lyons, where he was born on March 2, 1770. As *chef de bataillon* he was present at the siege of Toulon in 1793, where he took General O'Hara prisoner. During the Italian campaign of 1796 he was severely wounded at Cerea on Oct. 11. After serving under Joubert in Tirol in 1797, and also in Switzerland under Brune in 1797–98, he was made chief of the staff to Brune, and restored the efficiency and discipline of the army in Italy. In July 1799 he was made general of division and chief of staff to Joubert in Italy, and was in 1800 named by Masséna his second in command. His action contributed to the success of Napoleon's crossing the Alps, which culminated in the battle of Marengo on the 14th of June. In the campaigns of 1805 and 1806 he greatly increased his reputation at Austerlitz, Saalfeld, Jena, Pultusk and Ostrolenka. He obtained the title of count on March 19, 1808, married Mlle. de Saint Joseph, a niece of Joseph Bonaparte's wife, and soon afterwards was ordered to Spain. Here he was commander of the army of Aragon and governor of the province, which in two years he brought into complete submission. He annihilated the army of Blake at Maria on June 14, 1809, and on April 22, 1810, defeated O'Donnell at Lerida. Suchet, now a marshal of France, in 1812 conquered Valencia, and received the title of duc d'Albufera da Valencia (1812). When the tide set against the French Suchet defended his conquests step by step till compelled to retire into France, after which he took part in Soult's defensive campaign. By Louis XVIII. he was made a peer of France, but, having rallied to Napoleon during the Hundred Days, he was deprived of his peerage in 1815. He died near Marseilles on Jan. 3, 1826. Suchet left unfinished *Mémoires* dealing with the Peninsular War; these were printed by St. Cyr-Nogués in 1829–34.

See C. H. Barault-Roullon, *Le Maréchal Suchet* (Paris, 1854); Choumara, *Considerations militaires sur les mémoires du Maréchal Suchet* (1840). *See* also bibliography in article Peninsular War.

SU-CHOW, formerly Tsin-tsuan-tsiun, a free city in the province of Kansu, just within the extreme north-west angle of the Great Wall, near the gate of jade. It was completely destroyed by the Mohammedan or Dungan rising (1865–72), but it was recovered by the Chinese in 1873 and has been rebuilt. The neighbourhood is very fertile; rice, wheat, maize, melons, rhubarb, etc., are grown in large quantities. (*See* Soo-Chow; Sui-Fu.)

SUCKLING, SIR JOHN (1609–1642), English poet, was born at Whitton, in the parish of Twickenham, Middlesex, and baptized there on Feb. 10, 1609. His father, Sir John Suckling (1569–1627), had been knighted by James I. and was successively master of requests, comptroller of the household and secretary of state. He amassed a considerable fortune, of which the poet became master at the age of eighteen. He was sent to Trinity College, Cambridge, in 1623, and was entered at Gray's Inn in 1627. He was intimate with Thomas Carew, Richard Lovelace, Thomas Nabbes and especially with John Hales and Sir William Davenant, who furnished John Aubrey with information about his friend. In 1628 he left London to travel in France and Italy, returning, however, before the autumn of 1630, when he was knighted. In 1631 he volunteered under Gustavus Adolphus and was present at the battle of Breitenfeld and in many sieges. He returned in May, 1632. He was handsome, rich and generous; the best cardplayer and best bowler at court; with a gift for verse. In 1634 he was beaten by Sir John Digby, a rival suitor of the daughter of Sir John Willoughby. Under the proclamation of 1632 against absentee landlordism, enforced by the Star Chamber, he retired to his estates in 1635. This leisure resulted in *A Sessions of the Poets* (ms. 1637) and a tract on Socinianism entitled *An Account of Religion by Reason* (pr. 1646). Suckling applied to his dramas the accessories of the masque. His *Aglaura* (pr. 1638) was produced at his own expense with elaborate scenery. Other plays are *The Goblins* (1638), *Brennoralt, or the Discontented Colonel* (1639) and *The Sad One*, left unfinished at the outbreak of the Civil War.

Suckling forthwith raised a troop of a hundred horse, at a cost of £12,000, and accompanied Charles on the Scottish expedition of 1639. He shared in the earl of Holland's retreat before Duns, and was ridiculed in an amusing ballad (pr. 1656), in *Musarum deliciae*. He was elected for Bramber (1640) to the Long Parliament; and wrote to Henry Jermyn, afterwards earl of St. Albans, advising the king to disconcert the opposition leaders by making more concessions than they asked for. In May 1641 he conspired to rescue Strafford from the Tower and to bring in French troops. The plot was exposed, and Suckling fled beyond the seas. Aubrey's statement that he took poison in May or June 1642 in fear of poverty is generally accepted. Suckling's minor pieces have at times exquisite felicity of expression. "Easy, natural Suckling," is Millamant's comment in Congreve's *Way of the World* (Act IV., sc. i.). Among the best known are the "Ballade upon a Wedding," on the marriage of Roger Boyle, afterwards earl of Orrery, and Lady Margaret Howard, "I prithee, send me back my heart," "Out upon it, I have loved three whole days together" and "Why so pale and wan, fond lover?" from *Aglaura*. "A Sessions of the Poets," describing a meeting of the contemporary versifiers under the presidency of Apollo to decide who should wear the laurel wreath, is the prototype of many later satires.

A collection of Suckling's poems was first published in 1646 as *Fragmenta aurea*. The so-called *Selections* (1836), published by the Rev. Alfred Inigo Suckling, author of the *History and Antiquities of Suffolk* (1846–48), with *Memoirs* based on original authorities and a portrait after Van Dyck, is really a complete edition of his works, of which W. C. Hazlitt's edition (1874; revised ed., 1892) is little more than a reprint with some additions. *The Poems and Songs of Sir John Suckling*, edited by John Gray and decorated with woodcut border and initials by Charles Ricketts, was artistically printed at the Ballantyne Press in 1896. In 1910 Suckling's works in prose and verse were edited by A. Hamilton Thompson. For anecdotes of Suckling's life *see* John Aubrey's *Brief Lives* (Clarendon Press ed., ii. 242).

SUCRE, ANTONIO JOSÉ DE (1795–1830), was born on Feb. 3, 1795, at Cumuná, Venezuela, where his family had for generations held a position of importance. He had only a meagre education and turned early to the profession of arms. In 1811 he was placed in charge of the republican engineers at Margarita, with the rank of lieutenant. In 1821 he acted as Bolívar's agent in the campaign against Spain in the presidency of Quito. There in 1822 he defeated the Spanish forces at the battle of Pichincha which definitely ended the power of Spain in that province. In March 1823, Perú accepted Bolívar's offer of services in her struggle for independence, and a month later Sucre went to Lima as Colombia's commissioner. Bolívar arrived at Callao on Sept. 1, and was appointed by congress to the command of the patriot forces. During the preliminary stages of organization Sucre served as Bolívar's lieutenant. In Feb. 1824. Spanish troops re-occupied Lima. Congress immediately declared Bolívar "supreme political chief"; and he in turn placed Sucre in command of his troops.

At the end of July 1824, the army which Bolívar had been organizing gathered near Lake Reyes in the Peruvian uplands, and on Aug. 6, Sucre defeated the Spanish army under Canterac in the battle of Junín. Withdrawing to Cuzco, Canterac waited for additional troops, and then marched upon Sucre. After two months of manoeuvring, Sucre, on Dec. 9, faced the combined forces of Spain under Viceroy La Serna on the plain of Ayacucho and utterly routed them. After the battle Sucre and Canterac signed a treaty of capitulation arranging for the total evacuation of Lower Perú by the Spaniards. Carrying his work of reconquest into the district of Charcas or Upper Perú—now Bolivia—Sucre convened a deliberative assembly, which on Aug. 6, 1825, declared Upper Perú independent of Spain and proclaimed it a new State under the name of República Bolívar.

The liberator was named first president, Sucre to be chief executive in his absence. In Dec. 1825, Bolívar transferred his authority to Sucre, who resigned May 25, but was immediately elected provisional president. In Feb. 1826, the Bolivian congress adopted the famous Constitution which Bolívar had drawn up for them, and in October Sucre was elected constitutional president. It was an awkward position. The native leaders objected to the presence of a foreigner; Sucre fretted at the limitations to his power, and doubted the practicability of Bolívar's Constitution. A mutiny of soldiers at Chuquisaca in April 1828, followed by an invasion from Perú, crystallized his determination to resign. On Aug. 2, 1828, he made his last address to Congress and soon afterward moved to Quito resolved to retire to private life. But in Jan. 1830, he was chosen president of a constituent congress called by Bolívar as a last expedient to preserve the unity of Great Colombia, and was one of the special commissioners appointed to consider ways and means. The plan failed, and on his way back to Quito, he was killed by assassins in the forest of Berueros, near the town of Pasto, Colombia, on June 4, 1830. Sucre stands to-day with Bolívar and San Martín as a great liberator.

See also W. S. Robertson, *The Rise of Spanish-American Nations* (New York, 1921). (W. B. P.)

SUCRE, capital of Bolivia. Pop. (1924, estimate), 16,194, of whom many are Indians and mestizos. The city is in an elevated valley opening southward on the narrow ravine through which flows the Cachimayo, the principal northern tributary of the Pilcomayo. Its elevation, 9,338 ft., gives it an exceptionally agreeable climate. Fertile valleys provide fruit and vegetables, while the vineyards of Cinti supply wine and spirits. The city has broad streets, a central plaza and a *prado.*

The cathedral, dating from 1553, was noted for its wealth; the president's palace and halls of congress are no longer used as such; the cabildo, or townhall; a mint dating from 1572; the courts of justice, and the university of San Xavier, founded in 1624, are historic. Sucre is the seat of the archbishop of La Plata and Charcas, the primate of Bolivia. It is isolated by the difficulty of the roads leading to it. An automobile road, however, now runs to Potosí and the railway lacks only some 50 kilometres of completion (1928).

The Spanish town was founded in 1538 on the site of an Indian village called Chuquisaca, or Chuquichaca (golden bridge), and was called Charcas and Ciudad de la Plata by the Spaniards, though the natives clung to the original Indian name. It was the first city of Spanish South America to revolt against Spanish rule—on May 25, 1809. In 1840 the name Sucre was adopted in honour of the first president of Bolivia (*q.v.*).

SUCROSE: *see* SUGAR: *Manufacturing and Refining.*

SUDAN (Arabic *Bilad-es-Sudan,* country of the blacks), that region of Africa which stretches, south of the Sahara and Egypt, from Cape Verde on the Atlantic to Massawa on the Red sea. It is bounded south (1) by the maritime countries of the west coast of Africa, (2) by the basin of the Congo, and (3) by the equatorial lakes, and east by the Abyssinian and Galla highlands. The name is often used in Great Britain, in a restricted sense, to designate only the eastern part of this vast territory, but it is properly applied to the whole area indicated, which corresponds, roughly, to that portion of negro Africa north of the Equator under Mohammedan influence. The Sudan has an ethnological rather than a physical unity, and, politically, it is divided into a large number of States, all now under the control of European Powers.

Within the limits assigned it has a length of about 4,000 m., extending southwards at some points 1,000 m., with a total area of over two million square miles, and a population, approximately, of 40 millions. Between the arid and sandy northern wastes and the well-watered and arable Sudanese lands there is a narrow transitional zone of level grassy steppes, partly covered with mimosas and acacias. Otherwise, the Sudan may be described as a moderately elevated region, with extensive open or rolling plains, level plateaux, and abutting, at its eastern and western ends, on mountainous country. Crystalline rocks, granites, gneisses and schists, of the Central African type, occupy the greater part of the country. Toward the south-east, slates, quartzites and iron-bearing schists occur, but their age is not known.

The Sudan contains the basin of the Senegal and parts of three other hydrographic systems, viz., the Niger, draining southwards to the Atlantic; the central depression of Lake Chad; and the Nile, flowing northwards to the Mediterranean. Lying within the Tropics, and with an average elevation of not more than 1,500 to 2,000 ft. above the sea, the climate of the Sudan is hot, and, in the river valleys, very unhealthy. Cut off from North Africa by the Saharan desert, the inhabitants, who belong, in the main, to the negro family proper, are thought to have received their earliest civilization from the East. Arab influence and the Muslim religion began to be felt in the western Sudan as early as the 9th century, and had taken deep root by the end of the 11th. The existence of native Christian States in Nubia hindered for some centuries the spread of Islam in the eastern Sudan, and throughout the country some tribes have remained pagan. It was not until the last quarter of the 19th century that the European nations became the ruling force.

The terms western, central and eastern Sudan are indicative of geographical position merely. The various States are politically divisible into four groups: (1) Those west of the Niger; (2) those between the Niger and Lake Chad; (3) those between Lake Chad and the basin of the Nile; (4) those in the upper Nile valley.

The first group fell under the control of France at the end of last century, and are now known as the Upper Senegal and Niger Colony. (*See* SENEGAL, FRENCH WEST AFRICA, etc.)

The second group of Sudanese States is almost entirely within the British protectorate of Northern Nigeria. The third, or central group of Sudanese States, is included in French Congo (*q.v.*). The fourth group consists of the States conquered during the 19th century by the Egyptians, and now under the joint control of Great Britain and Egypt. These countries are known collectively as the Anglo-Egyptian Sudan (*see* below).

THE ANGLO-EGYPTIAN SUDAN

Boundaries and Area.—The region which, before the revolt of the Arabized tribes under the Madhi Mohammed Ahmed in 1881–84, was known as the Egyptian Sudan, has, since its reconquest by the Anglo-Egyptian expeditions of 1896–98, been under the joint sovereignty of Great Britain and Egypt. It is bounded north by Egypt (the 22nd parallel of N. lat. being the dividing line), east by the Red sea, Eritrea and Abyssinia, south by the Uganda Protectorate and Belgian Congo, west by French Congo. North of Darfur is the Libyan desert, in which the western and northern frontiers meet. Here the border is defined.[1]

As thus constituted, the Anglo-Egyptian Sudan extends north to south about 1,200 m. in a direct line, and west to east about 1,000 m., also in a direct line. It covers 950,000 sq.m., being about one-fourth the area of Europe. In what follows the term Sudan is used to indicate the Anglo-Egyptian condominium only.

Physical Features.—The Sudan may be divided, broadly, into two zones. The northern portion, from about 16° N., is practically the south-eastern continuation of the Sahara desert; the southern region is fertile, abundantly watered, and, in places, densely forested. West of the Nile there is a distinctly marked intermediate zone of steppes. In the southern district, between 5° and 10° N., huge swamps extend on either side of the Nile and along the Bahr-el-Ghazal.

From south to north the Sudan is traversed by the Nile, at a general level of from 1,600 to 600 ft., and all the great tributaries of that river are either partly or entirely within its borders. The most elevated district is a range of mountains running parallel to the Red sea. They present their steepest face eastward, attaining heights within the Sudan of 4,000 to over 7,000 feet. Jebel Erba, 7,480 ft., and Jebel Soturba, 6,889 ft. (both between 21° and 22° N.), the highest peaks, face the Red sea about 20 m. inland. From the Nile, westward, extend vast plains, which, in

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[1] It was supposed to be indicated by the line which, according to the Turkish firman of 1841, describes a semi-circle from the Siva Oasis to Wadai, approaching the Nile between the Second and Third Cataracts. This line is disregarded by the Sudan government.

Kordofan and Dar Nuba (between 10° and 15° N.), are broken by hills reaching 2,000 feet. Farther west, in Darfur, the country is more elevated, the Jebel Marra range being from 5,000 to 6,000 ft. high. In the south-west, beyond the valley of the Bahr-el-Ghazal, the country gradually rises to a ridge of low hills which form the water-parting between the Nile and the Congo.

Apart from the Nile system, the Sudan has two other rivers, the Gash and the Baraka, intermittent streams rising in the eastern chain of mountains in Eritrea, and flowing in a general northerly direction. The Gash enters the Sudan near Kassala, and north of that town turns west towards the Atbara, but its waters are dissipated before that river is reached. The Gash, nevertheless, fertilizes a considerable tract of country. The Khor Baraka lies east of the Gash. It flows towards the Red sea in the neighbourhood of Trinkitat (some 50 m. S. of Suakin), but about 30 m. from the coast forms an inland delta. Except in seasons of great rain, its waters do not reach the sea.

The Coast Region.—The coast extends along the Red sea, north to south, from 22° N. to 18° N., a distance following the indentations of the shore of over 400 miles. The most prominent headland is Ras Rawaya (21° N.), which forms the northern shore of Dokhana bay. There are few good harbours, Port Sudan and Suakin being the chief ports. South of Suakin is the shallow bay of Trinkitat. A large number of small islands lie off the coast. A belt of sandy land covered with low scrub stretches inland 10 to 20 miles. Beyond this plain rise the mountain ranges already mentioned. Their seaward slopes often bear a considerable amount of vegetation.

The Desert Zone.—Between the coast and the Nile lies the Nubian desert, a rugged, rocky, barren waste, scored with khors or wadis, along whose beds there is scanty vegetation. Along either bank of the Nile is a narrow strip of cultivable land. West of the Nile, except for a few oases, the country is even more desolate than the Nubian desert.

The Intermediate Zone and the Fertile Districts.—The country enclosed by the Nile, the Atbara and the Blue Nile, the so-called Island of Meroë, consists of very fertile soil. The fork between the White and Blue Niles, the Gezira, is also fertile land. South of the Gezira is Sennar, a well-watered country of arable and grazing lands. West of the Nile, Kordofan, which comes between the desert and the plains of the Bahr-el-Ghazal, is largely barren and steppe land. South of 10° N. there is everywhere abundance of water. Darfur is mainly open, steppe-like country, with extensive tracts of cultivable land and a central mountain massif, the Jebel Marra.

Climate.—The country lies wholly within the Tropics, and as the greater part of it is far removed from the ocean and less than 1,500 ft. above the sea, it is extremely hot. The heat is greatest in the central regions, least in the desert zone, where the difference between summer and winter is marked. Nevertheless, the dryness of the air renders the climate healthy. The steppe countries, Kordofan and Darfur, are also healthy, except after the autumn rains. At Khartoum (Khartum), centrally situated, the minimum temperature is about 40° F, the maximum 113°, the mean annual temperature 80°. January is the coldest and June the hottest month. Violent sandstorms are frequent from June to August. Four rain zones may be distinguished. The northern (desert) region is one of little or no rain. There are, perhaps, a few rainy days in winter and an occasional storm in the summer. In the central belt, where "the rainy season" is from mid-June to September, there are some 10 in. of rain during the year. The number of days on which rain falls rarely exceeds, however, 15. The rainfall increases to about 20 in. per annum in the eastern and south-eastern regions. In the swamp district and throughout the Bahr-el-Ghazal, heavy rains (40 in. or more a year) are experienced. The season of heaviest rain is from April to September. In the sudd region the temperature averages about 85° F, the air is always damp, and fever is endemic.

Flora.—In the deserts north of Khartoum, vegetation is almost confined to stunted mimosa and, in the less arid districts, scanty herbage. Between the desert and the cultivated Nile lands is an open growth of samr, hashab (*Acacia verek*) and other acacia trees. Between Khartoum and 12° N. forest belts line the banks of the rivers and khors, in which the most noteworthy tree is the sunt (*Acacia arabica*). Farther from the rivers are open woods of heglig (*Balanites aegyptiaca*), hashab, etc., and dense thickets of laot (*Acacia nubica*) and kittr (*Acacia mellifera*). These open woods cover a considerable part of Kordofan, the hashab and talh trees being the chief producers of gum arabic. On the Blue Nile the forest trees alter, the most abundant being the babanus (Sudan ebony), and the silag (*Amogeissus leiocarpus*), while gigantic baobabs, called tebeldi in the Sudan, and tarfa (*Sterculia cinerea*) are numerous. In southern Kordofan and in the higher parts of the Bahr-el-Ghazal the silag and ebony are also common, as well as African mahogany (homraya, *Khaya senegalensis*) and other timber trees. In the Ghazal province also are many rubber-producing lianas, among them the *Landolphia owariensis*. There are also forest regions in the Bahr-el-Jebel, in the Mongalla Mudiria and along the Abyssinian-Eritrean frontier. East of the Bahr-el-Jebel and north of the Bahr-el-Ghazal are vast prairies covered with tall coarse grass. Cotton is indigenous in the valley of the Blue Nile, and in some districts bamboos are plentiful. The castor-oil plant grows in almost every province.

Fauna.—Wild animals and birds are numerous. Elephants are abundant in the Bahr-el-Ghazal and Bahr-el-Jebel forests, and are found in fewer numbers in the upper valley of the Blue Nile. The hippopotamus and crocodile abound in the swamp regions, which also shelter many kinds of water-fowl. The lion, leopard, giraffe and various kinds of antelope are found in the prairies and in the open woods. In the forests are numerous bright-plumaged birds and many species of monkeys, mostly ground monkeys—the trees being too prickly for climbing. Snakes are also plentiful, many poisonous kinds being found. In the steppe regions of Kordofan, Darfur, etc., and in the Nubian desert, ostriches are fairly plentiful. Insect life is very abundant, especially south of 12° N., the northern limit of the tsetse fly. The chief pests are mosquitoes, termites and the serut, a brown fly about the size of a wasp, with a sharp stab, which chiefly attacks cattle.

Inhabitants.—The population, always sparse in the desert and steppe regions, was never dense, even in the more fertile southern districts. Excluding Darfur, the population before the Mahdist rule was estimated at 8,500,000. After the desolation of the Mahdia, an estimate made in 1905 put the population at 1,853,000. This included 11,000 foreigners, of whom 2,800 were Europeans. Since that year there has been a rapid increase, and in 1926 the population was officially estimated at close on six million.

The northern portion of the Sudan is occupied by Hamitic and Semitic tribes, chiefly nomads, and classed as Arabs. In the Nile valley north of Khartoum the inhabitants, especially the so-called Nubians, are of very mixed origin. Elsewhere, the inhabitants north of 12° N. are of mixed Arab descent. In the Nubian desert the chief tribes are the Ababda and Bisharin. In the region south of Berber and Suakin are the Hadendoa. The Jaalin, Hassania and Shukria inhabit the country between the Atbara and Blue Nile; the Hassania and Hassanat are found chiefly in the Gezira. The Kabbabish occupy the desert country north of Kordofan, which is the home of the Baggara tribes. In Darfur the inhabitants are of mixed Arab and negro blood.

Of negro Nilotic tribes there are three or four main divisions. The Shilluks occupy the country along the west side of the Nile northward from about Lake No. The Dinkas are widely spread over the Bahr-el-Ghazal province. South of Kordofan and west of the Shilluk territory are the Nubas, apparently the original stock of the Nubians. In the south-west of the Bahr-el-Ghazal are the Bongos and other tribes, and along the Nile-Congo water-parting are the A-Zande or Niam-Niam, a comparatively light-coloured race.

Social Conditions.—In contrast with the Egyptians, a most industrious race, the Sudanese tribes, both Arab and negro, are, as a general rule, indolent. Where wants are few and simple, where houses need not be built nor clothes worn to keep out the cold, there is little stimulus to exertion. Many Arabs "clothed in rags, with only a mat for a house, prefer to lead the life of the free-born sons of the desert, no matter how large their herds or how numerous their followings." Following the establishment of British control, slave-raiding and the slave trade were stopped, but domestic slavery continues. A genuine desire for education is manifest among the Arabic-speaking peoples, and slow but distinct moral improvement is visible among them. The Dongolese people are the keenest traders in the country. The Arab tribes are all Mohammedans, credulous and singularly liable to fits of religious excitement. Most of the negro tribes are pagan, but some of them who live in the north have embraced Islam.

Divisions and Chief Towns.—The Sudan is divided into mudirias (provinces) and these are subdivided into mamuria. The mudirias are Halfa, Red sea, Dongola and Berber in the north (these include practically all the region known as Nubia); Khartoum, Blue Nile and White Nile in the centre; Kassala and Fung in the east; Darfur (until recently under native rule), Kordofan and Nuba mountains in the west; and Bahr-el-Ghazal, Upper Nile (formerly Fashoda) and Mongalla in the south. The mudirias vary considerably in size.

The capital, Khartoum, is built in the fork formed by the junction of the White and Blue Niles. Opposite Khartoum, on the west bank of the White Nile, is Omdurman, the capital of the Sudan during the Mahdia. On the Nile, north of Khartoum, are the towns of Berber, Abu Hamed, Merawi (Merowe), Dongola and Wadi Halfa. On the Red sea are Port Sudan and Suakin. Kassala is on the river Gash, east of the Atbara and near the Eritrean frontier. On the Blue Nile are Kamlin, Sennar, Wad Medani, a thriving business centre and capital of the Blue Nile mudiria, and Roseires, which marks the limit of navigability by steamers of the river. Gallabat is a town in the Kassala mudiria, close to the Abyssinian frontier, and Gedaref lies between the Blue Nile and Atbara. El Obeid, the chief town of Kordofan, is 230 m. S.W. by S. of Khartoum. Duiem, capital of the White Nile mudiria, is the river port for Kordofan. El Fasher, the capital of Darfur, is 500 m. W.S.W. of Khartoum. All the towns named, except Roseires, are situated north of 13° N. In the south of the Sudan there are no towns properly so called. Fashoda, renamed Kodok, is the headquarters of the Upper Nile mudiria.

Communications.—North of Khartoum the chief means of communication is by railway; south of that city by steamer. There are two trunk railways, one connecting the Sudan with Egypt, the other affording access to the Red sea. The first line runs from the Nile at Wadi Halfa across the desert in a direct line to Abu Hamed, and thence along the right (east) bank of the Nile to Khartoum. At Khartoum the Blue Nile is bridged, and the railway is continued south through the Gezira to Sennar, where it branches west to cross the White Nile at Kosti and run on to El Obeid. The length of the line from Halfa to Khartoum is 575 m.; from Khartoum to Obeid 350 miles. The railway from the Nile to the Red sea starts from the Halfa-Khartoum line at Atbara junction, and runs to Port Sudan and Suakin; a branch leaving at Haiya for Kassala and (shortly) Gedaref. The total distance to Port Sudan from Khartoum is 493 miles. Besides these main lines a railway, 138 m. long, runs from Abu Hamed, on the right bank of the Nile, to Kareima (opposite Merawi), in the Dongola mudiria below the Fourth Cataract. The railways are owned and worked by the State.

In connection with the Khartoum-Halfa railway, steamers ply on the Nile between Halfa and Shellal, where the railway from Alexandria ends. The distance by rail and steamer between Khartoum and Alexandria is about 1,490 miles. Steamers run on the Nile between Kerma and Kareima, and above Khartoum the Government maintains a regular service of steamers as far south as Gondokoro, in the Uganda Protectorate, and Rejaf, for the Belgian Congo. During the flood season there is also a steamship service on the Blue Nile as far as Roseires. Powerful dredgers and sudd-cutting machines are used to keep open communications in the Upper Nile and Bahr-el-Ghazal. The ancient caravan routes, Korosko–Abu Hamed and Berber–Suakin, have been superseded by the railways, but elsewhere wells and rest-houses are maintained along the principal routes between the towns and the Nile. On some of these roads a motor car service is in operation.

There is an extensive telegraphic system. Khartoum is connected by land lines with Egypt and Uganda, thus affording direct telegraphic connection between Alexandria and Mombassa (2,500 miles). From Khartoum other lines go to Kassala and the Red sea ports. In some places the telegraph wires are placed 16 ft. 6 in. above the ground, to protect them from damage by giraffes.

Agriculture and Other Industries.—North of Khartoum agricultural land is confined to a narrow strip on either side of the Nile and to the few oases in the Libyan desert. In the Gezira, and in the plains of Gedaref between the Blue Nile and the Atbara, there are wide areas of arable lands, as also in the neighbourhood of Kassala, along the banks of the Gash; and these have recently been converted, by great irrigation works, into fertile cotton lands, with remarkable effects on the prosperity of the country. In Kordofan and Darfur cultivation is confined to the khors or valleys. The chief grain crop is durra, the staple food of the Sudanese. Two crops are obtained yearly in several districts. On lands near the rivers the durra is sown after the flood has gone down, and also at the beginning of the rainy season. Considerable quantities of wheat and barley are also grown. Other food-stuffs raised are lentils, beans, onions and melons. The date-palm is cultivated along the Nile valley below Khartoum, especially on the west bank in the Dongola mudiria and in the neighbouring oases. Dates are also a staple product in Darfur and Kordofan. Ground-nuts and sesame are grown in large quantities for the oil they yield. The Sudan was the original home of Egyptian cotton, and the cotton now grown is equal to the produce of the Delta.

For watering the land by the river banks sakias (water-wheels) are used, oxen being employed to turn them. In 1910 a system of basin irrigation was begun in Dongola mudiria. In 1925 was completed a canal scheme for irrigating the Gezira, drawing its waters from the new Makwar reservoir on the Blue Nile, near Sennar. It commands an area of 300,000 acres. The Gash irrigation in the Kassala district is steadily expanding.

Gum and rubber are the chief forest products. The gum is obtained from eastern Kordofan and in the forests in the upper valley of the Blue Nile. The wood of the sunt tree is used largely for boat-building, and for fuel, and the mahogany tree yields excellent timber. Elephants are hunted for the sake of their ivory. The Dongola breed of horses is noted for its strength and hardiness. The camels are bred in the desert north of Berber, between the Nile and the Red sea, in southern Dongola, in the Hadendoa country and in northern Kordofan. The camel, horse and ostrich are not found south of Kordofan and Sennar. The negro tribes living south of those countries possess large herds of cattle, sheep and goats. Fowls are plentiful, but of poor quality. Donkeys are much used in the central regions; they make excellent transport animals.

Mineral Wealth.—In ancient times Nubia, *i.e.*, the region between the Red sea and the Nile south of Egypt and north of the Suakin-Berber line, was worked for gold. In 1905 gold-mining recommenced in Nubia, in the district of Um Nabardi, which is in the desert, about midway between Wadi Halfa and Abu Hamed; and the producing stage was reached in 1908. Small quantities of gold-dust are also obtained from Kordofan. Gold is found in the Beni-Shangul country south-west of Sennar. There is lignite in the Dongola mudiria and iron ore is found in Darfur, southern Kordofan and in the Bahr-el-Ghazal. The district of the Hofrat-el-Nahas (the copper mine) is rich in copper, the mines having been worked intermittently from remote times.

Trade.—As an export, cotton is ahead of all the others taken together. It is followed by gum, cotton-seed, sesame, and hides and skins. Live stock, dates, ivory and gold are also exported. The Red sea ports trade largely with Arabia and engage in pearl fishery. The principal imports are cotton goods, food-stuffs (flour, sugar, tea and coffee), timber, tobacco, coal, railway materials, iron and machinery. The value of the trade, which during the

Mahdist rule (1884–98) was a few thousands only, had increased in 1905 to over £1,500,000. In 1927 the exports of Sudan produce were valued at £5,000,000, of which more than half was cotton; the total imports at £6,155,000. Great Britain takes the major part of the exports, and provides over one-third of the imports.

Economic Development.—Since the pacification of the Sudan, the two chief advances in its prosperity have been the provision of an efficient sea-base for its trade, and the extension of its cotton cultivation. Until 1906, when the railway to the Red sea was opened, trade was gravely hampered by the heavy cost of transit through Egypt. At Port Sudan, in 1927, the trade handled was over £9,500,000 in value, by shipping with a tonnage in the vicinity of four million tons; and railway developments are keeping pace with the popularity of the port. The production of long staple cotton of the best Egyptian type has been stimulated by the settlement and irrigation of the Gezira. Its canal scheme cost about 12 millions, obtained on loan guaranteed by the British Government, and the land is worked on the basis of a partnership between the Government, the Sudan Plantations syndicate and the Sudanese cultivators. The syndicate breaks up new land, provides villages and cultivating plant, and collects the produce. The cultivator gets the whole of the rotation food crops, 40% of the value of the cotton, and free land and water.

The Kassala cotton area on the inland delta of the Gash was developed by a railway financed under the guarantee of the British Government, and it is worked by the Kassala Cotton company, under an arrangement similar to that which operated in the Gezira. In the Tokar area cotton is grown between the Red sea mountains and the coast, and with the help of a small railway to the harbour of Trinkitat. The total export of ginned cotton in 1927 was 642,024 cantars, and of cotton seed 57,847 tons; their gross value being taken at £3,693,000.

ADMINISTRATION

Government.—Pending the settlement between Great Britain and the new Egyptian Government of the status of the Sudan, the convention of Jan. 10, 1899, still holds good, by which the governor-general of the Sudan is appointed by the king of Egypt, on the recommendation of the British Government. He is assisted by a council of six to eight members (largely official), who advise him in executive and legislative matters, subject to his power of veto. The country is divided into provinces (*mudirias*) each under a governor (mudir) who is responsible to the governor-general. The administrative service, formerly staffed mainly by British officers, is now recruited by restricted competition from England. The minor officials are mostly Egyptian or Sudanese, with a small admixture of Syrians; the Egyptians have been much reduced in number since the troubles of 1924. Revenue is derived from the customs and earning departments (railways, steamers, posts and telegraphs), supplemented by substantial receipts from taxes on land, date-trees, trade-licences, royalties on gum, ostrich feathers, ivory, rubber, senna and other forest produce, excise and arms licences and shooting fees. The tariff comprises a 10% *ad valorem* duty on most articles, with from 16s. to £1 per kilo. on tobacco, and an all-round export duty of 1% *ad valorem.* The Government has always been largely dependent on the Egyptian Treasury, both for loans and for the liquidation of its annual deficits; but recently it has looked for its loans to the British market, while it endeavoured to develop its own financial resources to meet the expenditure on its defence, education, public works and administration. The State revenue was £126,596 in 1899; by 1926 it had risen to £5,858,000, with an expenditure of £5,482,000.

Justice.—The Sudan judicial codes, based, in part, on those of India, and, in part, on the principles of English law and of Egyptian commercial law, provide for the recognition of "customary law" so far as applicable and "not repugnant to good conscience." In each mudiria criminal justice is administered by a court, consisting of the mudir (or a judge) and two magistrates, which has general competence. The magistrates are members of the administrative staff, who try minor cases without the help of the mudir (or judge). The governor-general possesses revising powers in all cases. Civil cases of importance are heard by a judge (or where no judge is available by the mudir or his representative); minor civil cases are tried by magistrates. From the decision of the judges an appeal lies to the High Court at Khartoum, composed of a chief justice and four puisne judges. Jurisdiction in all legal matters as regards personal status of Mohammedans is administered by a grand cadi and a staff of subordinate cadis. The police force of each mudiria is independently organized under the control of the mudirs.

Education.—Education is in charge of the department of public instruction. Elementary education, the medium of instruction being Arabic, is given in *kuttabs* or village schools. There are primary schools in the chief towns where English, Arabic, mathematics, and, in some cases, land-measuring are taught. There are also Government industrial workshops, and a few schools for girls. The Gordon college at Khartoum undertakes a suitable variety of vocational teaching, along with the training of teachers and judges in the Mohammedan courts, and has annexed to it a secondary school. The college also contains the Wellcome laboratories for scientific research. Among the pagan negro tribes Protestant and Roman Catholic missions are established. These missions carry on educational work, special attention being given to industrial training.

Defence.—The defence of the country used to be entrusted to the Egyptian army; but in 1924 the Egyptian units were removed, and the defence force is now composed of local material under British officers. A small force of British troops is also stationed in the Sudan—chiefly at Khartoum. They are under the command of the governor-general in virtue of an arrangement made in 1905, having previously been part of the Egyptian command.

ARCHAEOLOGY

Archaeological study in the Sudan, retarded for many years by political conditions, gave rich returns. The work, which had been begun by Cailliaud, Champollion, Lepsius and others, was interrupted by the rise of the Mahdist power; and with the frontiers of Egypt itself menaced by dervishes, the country south of Aswan was necessarily closed to the student of antiquity. Even after the dervishes had been overthrown at the battle of Omdurman (1898) it was some time before archaeologists awoke to the sense of the historical importance of the regions thus made accessible to them. What aroused them was the danger of submergence with which many ancient sites were threatened by the raising of the Aswan dam. A large sum of money was assigned by the Government, partly for the preservation of the visible temples in the area to be submerged, partly for an official expedition under the charge of Dr. G. A. Reisner, which was to search for all remains of antiquity hidden beneath the ground. At the same time the University of Pennsylvania dispatched the Eckley B. Coxe, jun., expedition, which devoted its attention to the southern half of Lower Nubia, from Halfa to Korosko, while the Government excavators explored from Korosko to Aswan. Thus material was acquired which throws a flood of light on the archaeology at once of Egypt and the Sudan. For though all except the southern twenty miles of Lower Nubia has been attached for purposes of administration of Egypt proper, yet this political boundary is purely artificial. The natural geographical and ethnical southern frontier of Egypt is the First Cataract; Egyptian scribes of the Old Empire recognized this truth no less clearly than Diocletian, and Juvenal anticipates the verdict of every modern observer when he describes the "porta Syenes" as the gate of Africa. The reconnaissances of Dr. Wallis Budge, Prof. A. H. Sayce, Mr. Somers Clarke, Prof. J. Garstang and more recent investigators, cover the well known monuments left by Egyptian kings whose history is tolerably familiar from other sources. The inscriptions of these kings and their officials have been collected by Prof. J. H. Breasted. But, while the central and southern Sudan is almost a virgin field for the archaeologist, the exploration of Lower Nubia has made important progress.

The Sudan is primarily and above all the country of the *black* races, of those Nilotic negroes whose birthplace may be supposed to have been near the Great Lakes. But upon this aboriginal stock were grafted, in very early times, fresh shoots of more vigorous and intellectual races coming, probably, from the East. Lower Nubia was one of the crucibles in which several times was formed a mixed nation which defied or actually dominated Egypt. There is some scientific ground for dating the earliest example of such a fusion to the exact period of the Egyptian Old Empire. The Ethiopians who usurped the crown of the Pharaohs from 740–660 B.C. were of a mixed stock akin to the modern Barabra; the northern Nubians who successfully defied the Roman emperors were under the lordship of the Blemyes (Blemmyes), an East African tribe, and the empire of the Candace dynasty, no less than the Christian kingdoms which succeeded it, included many heterogeneous racial elements. The real history of the Sudan will, therefore, be concerned with the evolution of what may be called East African or East Central African civilizations.

From the purely Egyptological standpoint there is much of value to be learned from the Sudan. The Egyptian penetration of the country began, according to the evidence of inscriptions, as early as the Old Empire. Under the 12th dynasty colonies were planted and fortresses established down to the Bahr-el-Hagar. During the 18th dynasty the political subjugation was completed, and the newly-won territories were studded with cities and temples as far south as the Fourth Cataract. Some 200 years later the priests of Amen, flying from Thebes, founded a quasi-Egyptian capital at Napata. But after this date Egypt played no part in the evolution of the country. Its history, therefore, as an independent civilization may be said to date from the 8th century B.C., though future researches may be able to carry its infant origins to a remoter past.

Of the 1,000 years or more of effective Egyptian occupation many monuments exist, but on a broad, general view it must be pronounced that they owe their fame more to the accident of survival than to any special intrinsic value. For, excepting Philae, which belongs as much to Egypt as to Ethiopia, Abu Simbel is the only temple which can be ranked among first-rate products of Egyptian genius; although Dr. Reisner's discoveries leave little doubt that the archaic culture first detected at Nagada and Abydos, and then at many points as far north as Giza, extended southwards into Nubia at least as far as Gerf Husein. This was wholly unexpected, and if, as seems probable, the evidence stands the test of criticism, it is a new historical fact of great importance. The government expedition found traces between Aswan and Korosko of all the principal periods from this early date down to the Christian era. The specimens obtained are kept in a separate room of the Cairo Museum, where they form a collection of great value.

The work of the Pennsylvanian expedition opened a new chapter in the history of the African races. No records, indeed, were discovered of the founders of the first great Ethiopian kingdom from Piankhi to Tirhakah, nor has any fresh light been thrown upon the relations which that remarkable king, Ergamenes, maintained with the Egyptian Ptolemies. But the exploration of sites in the southern half of Lower Nubia has revealed the existence of a wholly unsuspected independent civilization which grew up during the first six centuries after Christ. The history of the succeeding periods, moreover, has been partially recovered and the study of architecture enriched by the excavation of numerous churches dating from the time of Justinian, when Nubia was first Christianized, down to the late mediaeval period when Christianity was extirpated by Mohammedanism.

The civilization of the first six centuries A.D. may be called "Romano-Nubian," a term which indicates its date and suggests something of its character. It is the product of a people living on the borders of the Roman empire who inherited much of the Hellenistic tradition in minor arts, but combined it with a remarkable power of independent origination. The sites on which it has been observed range from Dakka to Halfa, that is to say, within the precise limits which late Latin and Greek writers assign to the Blemyes, and there is a good reason to identify the people that evolved it with this hitherto almost unknown barbarian nation. Apart from this, however, the greatest value of the new discoveries consists in the fact that they are laying the foundations for a new documentary record of past ages. For the graves yielded not only new types of statues, bronzes, ivory carvings and painted pottery —all of the highest artistic value—but also a large number of stone stelae inscribed with funerary formulae in the Meroitic script.

In the course of sixty years the small collection of Meroitic inscriptions made by Lepsius had not been enlarged and no progress had been made towards decipherment. But the cemeteries of Shablul and Karanog alone yielded 170 inscriptions on stone, besides some inscribed ostraka. This mass of material brought the task of decipherment within the range of possibility, and even without any bilingual record to assist him, Mr. F. Ll. Griffith rapidly succeeded in the first stages of translation. As further explorations bring more inscriptions to light the records of Ethiopia will gradually be placed on a firm documentary basis and the names and achievements of its greatest monarchs will take their place on the roll of history.

Ancient Monuments South of Halfa.—Ruins of pyramids, temples, churches and other monuments are found along both banks of the Nile, almost as far south as the Fourth Cataract, and again in the "Island of Meroë." In the following list the ruins are named as met with on the journey south from Wadi Halfa. Opposite that town, on the east bank, are the remains of Bohon, a town founded under the 12th dynasty, and with a fine temple of 18th dynasty work. Forty-three miles farther south are the ruins of the twin fortresses of Kumma and Semna. At Amara, some 80 m. above Semna, are the ruins of a temple with Meroitic hieroglyphics. At Soleb, 143 m. above Halfa, are the ruins of a fine temple commemorating Amenophis (Amenhotep) III. (*c.* 1414 B.C.), to whose queen, Taia, was dedicated a temple at Sedeinga, a few miles to the north. At Sesebi, 40 m. higher up the Nile, is a temple of the heretic king, Ikhnaton, re-worked by Seti I. (*c.* 1327 B.C.). Opposite Hannek, at the Third Cataract on Tombos island, are extensive ancient granite quarries, in one of which lies an unfinished colossus. On the east side of the river, near Kerma, are the remains of an Egyptian city. Argo island, a short distance higher up, abounds in ruins, and from Old Dongola to Merawi (a distance of 100 m. by the river) are numerous ruins of monasteries, churches and fortresses of the Christian era in Nubia—notably at Jebel Deka and Magal. In the immediate neighbourhood of Jebel Barkal (the "holy mountain" of the ancient Egyptians), a mile or two above the existing village of Merawi (Merowe), are many pyramids and six temples, the pyramids having a height of from 35 to 60 feet. They mark the site of Napata, the religious capital of ancient Ethiopia, from which spread the worship of Amen. On the left bank of the Nile, opposite Merawi, are the pyramids of Nuri, and a few miles distant, in the Wadi Ghazal, are the ruins of a great Christian monastery, where were found gravestones with inscriptions in Greek and Coptic. Thirty miles north of the town of Shendi are the pyramids of Meroë, in three distinct groups. From one of these pyramids was taken "the treasure of Queen Candace," now in the Berlin museum. Excavation is busy with this ancient site, and, among a vast number of tombs, shrines and dwellings there stand out the Temple of the Sun (600 B.C.) and the pylon of a great temple to Amen (300 B.C.), the most perfect ruins in the Sudan, associated with the Ethiopian kingdom of Queen Candace. They comprise three temple groups, in good preservation, at Nagaa, and a mass of buildings at Mussawarat, belonging to the 2nd or 3rd century A.D. Farther south, Christian remains are to be seen on the east bank of the Blue Nile, about 13 m. above Khartoum, at Soba, at Ceteina, on the White Nile, and at Wad-el-Hadad, some miles north of Sennar, on the Blue Nile.

Between the Nile at Wadi Halfa and the Red sea are the remains of towns inhabited by the ancient miners who worked the district. The most striking of these towns is Deraheib (Castle Beautiful), so named from the picturesque situation of the castle, a large square building with pointed arches. The walls of some 500 houses still stand.

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HISTORY

From the Earliest Time to the Egyptian Conquest.—The southern regions of the Anglo-Egyptian Sudan are without recorded history until the era of the Egyptian conquest in the 19th century. In the northern regions, known as Ethiopia or Nubia, Egyptian influence made itself felt as early as the Old Empire. In process of time powerful States grew up with capitals at Napata and Meroë (see *ante* sec. *Archaeology* and Ethiopia and Egypt). The Nubians—that is the dwellers in the Nile valley between Egypt and Abyssinia—did not embrace Christianity until the 6th century, considerably later than their Abyssinian neighbours. The Arab invasion of north Africa in the 7th century, which turned Egypt into a Mohammedan country, had not the same effect in Nubia, the Muslims, though they frequently raided the country, being unable to hold it. On the ruins of the ancient Ethiopian States arose the Christian kingdoms of Dongola and Aloa, with capitals at Dongola and Soba (corresponding roughly to Napata and Meroë). These kingdoms continued to exist until the middle of the 14th century or later (*see* Dongola). Meanwhile Arabs of the Beni Omayya tribe, under pressure from the Beni Abbas, had begun to cross the Red sea as early as the 8th century and to settle in the district around Sennar on the Blue Nile, a region which probably marked the southern limits of the kingdom of Aloa. The Omayya, who during the following centuries were reinforced by further immigrants from Arabia, intermarried with the negroid races, and gradually Arab influence became predominant and Islam the nominal faith of all the inhabitants of Sennar. In this way a barrier was erected between the Christians of Nubia and those of Abyssinia. By the 15th century the Arabized negro races of the Blue Nile had grown into a powerful nation known as the Funj, and during that century they extended their conquests north to the borders of Egypt. The kingdom of Dongola had already been reduced to a condition of anarchy by Muslim invasions from the north. Christianity was still professed by some of the Nubians as late as the 16th century, but the whole Sudan north of the lands of the pagan negroes (roughly 12° N.) was then under Muslim sway. At that time the sultans of Darfur (*q.v.*) in the west, and the sultans or kings of Sennar (the Funj rulers) in the east, were the most powerful of the Mohammedan potentates.

The first of the Funj monarchs acknowledged king of the whole of the allied tribes, of which the Hameg were next in importance to the Funj, was Amara Dunkas, who reigned *c.* 1484–1526. During the reign of Adlan, *c.* 1596–1603, the fame of Sennar attracted learned men to his court from such distant places as Cairo and Baghdad. Adlan's great-grandson Badi Abu Daku attacked the Shilluk negroes and raided Kordofan. This monarch built the great mosque at Sennar, almost the only building in the town to survive the ravages of the dervishes in the 19th century. In the early part of the 18th century there was war between the Sennari and the Abyssinians, in which the last named were defeated with great slaughter, a victory over the "infidels" which became celebrated throughout the Mohammedan world. Towards the end of the 18th century the Hameg wrested power from the Funj and the kingdom fell into decay, many of the tributary princes refusing to acknowledge the king of Sennar. The disorders resulting from this decline continued up to the time of the conquest of the country by the Egyptians.

From the Egyptian Conquest to the Rise of the Mahdi.—The conquest of Nubia was undertaken in 1820 by order of Mehemet Ali, the pasha of Egypt, and was accomplished in the two years following. His leading motive was, probably, the desire to obtain possession of the mines of gold and precious stones which he believed the Sudan contained. Mehemet Ali also wished to crush the remnant of the Mamelukes, who in 1812 had established themselves at Dongola, and to keep busy the Albanians and Turks in his army, whose fidelity was doubtful.

Mehemet Ali gave the command of the army sent to Nubia to his son Ismail, who at the head of some 4,000 men left Wadi Halfa in October 1820. Following the Nile route he occupied Dongola without opposition, the Mamelukes fleeing before him. (Some of them went to Darfur and Wadai, others made their way to the Red Sea. This was the final dispersal of the Mamelukes.) With the nomad Shagia, who dominated the district Ismail had two sharp encounters, one near Korti, the other higher up the river, and in both fights Ismail was successful. Thereafter the Shagia furnished useful auxiliary cavalry to the Egyptians. Ismail remained in the Dongola province till February 1821, when he crossed the Bayuda Desert and received the submission of the meks (kings) of Berber, Shendi and Halfaya, nominal vassals of the king of Sennar. Continuing his march south Ismail reached the confluence of the White and Blue Niles and established a camp at Ras Khartum. (This camp developed into the city of Khartum.) At this time Badi, the king of Sennar, from whom all real power had been wrested by his leading councillors, determined to submit to the Egyptians, and as Ismail advanced up the Blue Nile he was met at Wâd Medani by Badi who declared that he recognized Mehemet Ali as master of his kingdom. Ismail and Badi entered the town of Sennar together on June 12, 1821, and in this peaceable manner the Egyptians became rulers of the ancient empire of the Funj. In search of the gold-mines reported to exist farther south Ismail penetrated into the mountainous region of Fazokl, where the negroes offered a stout resistance. In Feb. 1822 Ismail set out on his return to Dongola, having received reports of risings against Egyptian authority. The Egyptian soldiery had behaved with barbarity. Ismail, Nair Mimr, the *mek* of Shendi, had been a sort of hostage, and entertained hatred of the pasha. On Ismail's return to Shendi, Oct. 1822, he demanded of the *mek* 1,000 slaves to be supplied in two days. The *mek*, promising compliance, invited Ismail and his chief officers to a feast in his house, around which he had piled heaps of straw. Whilst the Egyptians were feasting the *mek* set fire to the straw and Ismail and all his companions were burnt to death.

Ismail's death was speedily avenged. A second Egyptian army, also about 4,000 strong, had followed that of Ismail's up the Nile, and striking south-west from Debba, had wrested, after a sharp campaign, the province of Kordofan (1821) from the sultan of Darfur. This army was commanded by Mohammed Bey, the Defterdar, son-in-law of Mohammed Ali. Hearing of Ismail's murder the Defterdar marched to Shendi, defeated the forces of the *mek*, and took terrible revenge upon the inhabitants of Metemma and Shendi, most of the inhabitants, including women and children, being burnt alive. Nair Mimr escaped to the Abyssinian frontier, where he maintained his independence.

Character of Egyptian Rule.—Having conquered Nubia, Sennar and Kordofan the Egyptians set up a civil Government, placing at the head of the administration a governor-general with practically unlimited power. Khurshid pasha (governor-general 1826–39) gained a great reputation both for rectitude and vigour, but, with rare exceptions, his successors did not conceive that the welfare of the people was any part of the task of government. About this period Mohammed Ali leased from the sultan of Turkey the Red sea ports of Suakin and Massawa, and thus got into his hands the trade routes of the eastern Sudan. The pasha of Egypt practically monopolized the trade of the country except that in slaves, for which border lands were raided annually. From the negro population the army was so largely recruited that in a few years the only non-Sudanese in it were officers. The Egyptian rule proved harmful to the country. The governors-general and the leading officials were nearly all Turks, Albanians or Circassians, and, with rare exceptions, the welfare of the various peoples of the Sudan formed no part of their conception of government.

Numerous efforts were made to extend the authority of Egypt. In 1840 the fertile district of Taka, watered by the Atbara and Gash and near the Abyssinian frontier, was conquered and the town of Kassala founded. In 1837 the pasha himself had visited the Sudan, going as far as Fazokl, where he inspected the goldfields.

The successors of Mohammed Ali, in an endeavour to make the country more profitable, extended their conquests to the south, and in 1853 and subsequent years trading posts were established on the Upper Nile. The Government monopoly in trade had ceased in 1849 on the death of Mohammed Ali. The pioneer European merchant was John Petherick, British consular agent at Khartoum. Petherick sought for ivory only, but those who followed him soon found that slave-raiding was more profitable than elephant hunting. The viceroy Said, who made a rapid tour through the Sudan in 1857, found it in a deplorable condition. The viceroy ordered many reforms to be executed and proclaimed the abolition of slavery. The reforms were mainly inoperative and slavery continued. The European merchants above Khartoum had sold their posts to Arab agents, who oppressed the natives in every conceivable fashion. Ismail Pasha, who became viceroy of Egypt in 1863, again gave orders for the suppression of the slave trade, and to check the operations of the Arab traders a military force was stationed at Fashoda (1865), this being the most southerly point then held by the Egyptians. Ismail, however, was ambitious to extend his dominions and to develop the Sudan on the lines he had conceived for the development of Egypt. He obtained (1865) from the sultan of Turkey a firman assigning to him the administration of Suakin and Massawa, the lease which Mohammed Ali had of these ports having lapsed after the death of that pasha. Ismail subsequently (1870–75) extended his sway over the whole coast from Suez to Cape Guardafui but on the rise of the Mahdi (see *infra*) Egyptian authority was withdrawn (1884) from the coast regions south of Suakin.

Baker and Gordon.—At the same time that Ismail annexed the seaboard he was extending his sway along the Nile valley to the equatorial lakes, and conceived the idea of annexing all the country between the Nile and the Indian ocean. An expedition was sent (1875) to the Juba river with that object, but it was withdrawn at the request of the British Government, as it infringed the rights of the sultan of Zanzibar. Meanwhile, on the main Nile, control of all territories south of Gondokoro had been given to Sir Samuel Baker, who, reaching Gondokoro on May 26, 1870, formally annexed that station, which he named Ismailia, to the khedival domains. Baker remained as governor of the Equatorial Provinces until Aug. 1873, and in March 1874 Col. C. G. Gordon took up the same post. Both Baker and Gordon made strenuous efforts towards crushing the slave trade, but their endeavours were largely thwarted by the inaction of the authorities at Khartoum. Under Gordon the Upper Nile region as far as the borders of Uganda came more or less effectively under Egyptian control. On the west the Bahr-el-Ghazal had been overrun by Arab or semi-Arab slave-dealers who reduced that region to a state of abject misery. The most powerful of the slave traders was Zobeir Pasha, who, having defeated a force sent from Khartoum to reduce him to obedience, invaded Darfur (1874). The khedive, fearing the power of Zobeir, also sent an expedition to Darfur, and that country, after a stout resistance, was conquered. Zobeir claimed to be made governor-general of the new province; his request being refused, he went to Cairo to urge his claim. At Cairo he was detained by the Egyptian authorities.

Though spasmodic efforts were made to promote agriculture and open up communications the Sudan continued to be a constant drain on the Egyptian exchequer. A project to link Wadi Halfa to Khartoum by railway was abandoned (1877) after 50m. of rails had been laid in five or six years at a cost of £450,000. In Oct. 1876 Gordon left the Equatorial Provinces and gave up his appointment. In Feb. 1877, under pressure from the British and Egyptian Governments, he went to Cairo, where he was given the governorship of the whole of the Egyptian territories outside Egypt; namely, the Sudan provinces proper, the Equatorial Provinces, Darfur and the Red sea and Somali coasts. Gordon remained in the Sudan until Aug. 1879. During his tenure of office he did much to give the Sudanese the benefit of a just and considerate Government. He pacified Darfur and then received the submission of Suliman Zobeir (son of Zobeir Pasha), who was at the head of a gang of slave-traders in the Bahr-el-Ghazal. In 1878 there was further trouble in Darfur and also in Kordofan, and Gordon visited both these provinces, breaking up many companies of slave-hunters. Meantime Suliman (acting on the instructions of his father, who was still at Cairo) had broken out into open revolt against the Egyptians in the Bahr-el-Ghazal. The crushing of Suliman was entrusted by Gordon to Romolo Gessi (1831–81), an Italian who had previously served under Gordon on the Upper Nile. Gessi, after a most arduous campaign (1878–79), defeated and captured Suliman, whom, with other ringleaders, he executed. The slave-raiders were completely broken up and over 10,000 captives released. A remnant of Zobeir's troops under a chief named Rabah succeeded in escaping westward (*see* RABAH). Having conquered the province, Gessi was made governor of the Bahr-el-Ghazal, becoming pasha.

When Gordon left the Sudan he was succeeded at Khartoum by Raouf Pasha, under whom the old abuses of the Egyptian administration were revived. At this time the high European officials in the Sudan, besides Gessi, included Emin Pasha (*q.v.*), governor of the Equatorial Province since 1878, and Slatin Pasha (*q.v.*), governor of Darfur. Gessi found his position under Raouf intolerable, resigned his post in Sept. 1880 and was succeeded by Frank Lupton, an Englishman and formerly captain of a Red sea merchant steamer. At this period (1880–82) schemes for the reorganization and better administration of the Sudan were elaborated on paper, but the revolt in Egypt under Arabi (*see* EGYPT: *History*) and the appearance of a Mahdi intervened.

The Rise and Power of Mahdism.—Venality and the extortion of the tax-gatherer flourished anew after the departure of Gordon, while the feebleness of his successors inspired in the Baggara a contempt for the authority which prohibited them pursuing their most lucrative traffic. When Mohammed Ahmed (*q.v.*), a Dongolese, proclaimed himself the long-looked-for Mahdi (guide) of Islam, he found most of his original followers among the grossly superstitious villagers of Kordofan, to whom he preached universal equality and a community of goods, while denouncing the "Turks"—at that time the Sudanese called all foreigners Turks—as unworthy Muslims on whom God would execute judgment. The Baggara perceived in this Mahdi one who could be used to shake off Egyptian rule. The new Mahdi married the daughters of their sheikhs and found in Abdullah, a member of the Taaisha section of the tribe, whom he appointed Khalifa (lieutenant), his chief supporter.

The Mahdi's capture of El Obeid on Jan. 17, 1883, and the annihilation in the November following of an army of over 10,000 men commanded by Hicks Pasha (Col. William Hicks [*q.v.*] formerly of the Bombay army) made the Mahdi undisputed master of Kordofan and Sennar. The next month, Dec. 1883, saw the surrender of Slatin in Darfur, whilst in Feb. 1884 Osman Digna, his amir in the Red sea regions, inflicted a crushing defeat on some 4,000 Egyptians at El Teb near Suakin. In April following Lupton Bey, governor of Bahr-el-Ghazal, was sent captive to Omdurman, where he died on May 8, 1888.

Gordon at Khartoum.—On learning of the disaster to Hicks Pasha's army, the British Government (Great Britain having been since 1882 in military occupation of Egypt) insisted that the Egyptian Government should evacuate such parts of the Sudan as they still held, and Gen. Gordon was despatched, with Lt.-col. Donald H. Stewart, to Khartoum to arrange the withdrawal of the Egyptian civil and military population. Gordon's instructions, based largely on his own suggestions, were not wholly consistent; they contemplated vaguely the establishment of some form of stable government on the surrender of Egyptian authority, and among the documents with which he was furnished was a firman creating him governor-general of the Sudan. Gordon reached Khartoum on Feb. 18, 1884, and at first his mission, which had aroused great enthusiasm in England, promised success. To smooth the way for the retreat of the Egyptian garrisons and civilians he issued proclamations announcing that the suppression of the slave trade was abandoned, that the Mahdi was sultan of Kordofan, and that the Sudan was independent of Egypt. He enabled some thousands of refugees to make their escape to

Aswan and collected at Khartoum troops from some of the outlying stations. By this time the situation had altered for the worse and Mahdism was gaining strength among tribes in the Nile valley at first hostile to its propaganda. Gordon telegraphed to Cairo asking that Zobeir Pasha might be sent to him, his intention being to hand to Zobeir the government. Zobeir (*q.v.*), a Sudanese Arab, was probably the one man who could have withstood successfully the Mahdi. Owing to Zobeir's notoriety as a slave-raider Gordon's request was refused. All hope of a peaceful retreat of the Egyptians was thus rendered impossible.

The Mahdist movement now swept northward and on May 20, Berber was captured by the dervishes and Khartoum isolated. From this time the energies of Gordon were devoted to the defence of that town. After delay, an expedition was sent up the Nile under the command of Lord Wolseley. It started too late to achieve its object, and on Jan. 25, 1885, Khartoum was captured by the Mahdi and Gordon killed. Col. Stewart, Frank Power (British consul at Khartoum) and M. Herbin (French consul), who (accompanied by 19 Greeks) had been sent down the Nile by Gordon in the previous September to give news to the relief force, had been decoyed ashore and murdered (Sept. 18, 1884). The fall of Khartoum was followed by the withdrawal of the British expedition, Dongola being evacuated in June 1885. In the same month Kassala capitulated, but just as the Mahdi had practically completed the destruction of the Egyptian power he died.

The Khalifa's Rule.—The Mahdi was at once succeeded by the khalifa Abdullah, whose rule continued until Sept. 2, 1898, this period in the history of the Sudan being known as the Mahdia. On the date named the khalifa's army was completely overthrown by an Anglo-Egyptian force under Sir H. (afterwards Lord) Kitchener. (*See* EGYPT: *Egypt and Sudan, Campaigns in.*)

The Mahdi had been regarded by his fanatical adherents as the only true commander of the faithful, endued with Divine power to conquer the whole world. He had at first styled his followers dervishes (*i.e.,* religious mendicants) and given them the *jibba* as their characteristic garment or uniform. Later on he commanded the faithful to call themselves *ansar* (helpers), and at the time of his death he was planning an invasion of Egypt. He had liberated the Sudanese from the extortions of the Egyptians, but the people soon found that the Mahdi's rule was even more oppressive. Gradually all chiefs and amirs not of the Baggara tribe were got rid of except Osman Digna, whose sphere of operations was on the Red sea coast. Abdullah's rule produced complete agricultural and commercial ruin. He was also almost constantly in conflict either with the Shilluks, Nuers and other negro tribes of the south; with the peoples of Darfur, where at one time an anti-Mahdi gained a great following; with the Abyssinians; with the Kabbabish and other Arabic speaking tribes who had never embraced Mahdism, or with the Italians, Egyptians and British. Notwithstanding all this opposition the khalifa found in his own tribesmen and in his black troops devoted adherents and he successfully defended his position. The attempt to conquer Egypt ended in the total defeat of the dervish army at Toski (Aug. 3, 1889). The attempts to subdue the Equatorial Provinces were but partly successful. Emin Pasha, to whose relief H. M. Stanley had gone, evacuated Wadelai in April 1889. The greater part of the region and also most of the Bahr-el-Ghazal relapsed into a state of chaos.

Pilgrimages to the Mahdi's tomb at Omdurman were substituted for pilgrimages to Mecca. The arsenal and dockyard and the printing-press at Khartoum were kept busy (the workmen being Egyptians who had escaped massacre). Otherwise Khartoum was deserted, the khalifa making Omdurman his capital. The population of the country dwindled from warfare and disease, small-pox being endemic.

The European captives were kept prisoners at Omdurman. Besides ex-officials like Slatin and Lupton, they included several Roman Catholic priests and sisters, and numbers of Greek merchants established at Khartoum. Although several were closely imprisoned, loaded with chains and repeatedly flogged, it is a noteworthy fact that none was put to death. From time to time a prisoner, among them Slatin, made his escape.

The khalifa, when defeated, fled to Kordofan where he was killed in battle in Nov. 1899. In Jan. 1900 Osman Digna, a fugitive, was captured. As in 1903 and 1908, other Mahdis arose, but they were captured and hanged.

The Anglo-Egyptian Condominium.—Of the cause which led to the reconquest of the Sudan the most weighty was the necessity of securing control of the Upper Nile, Egypt being wholly dependent on the waters of the river for its prosperity. France was endeavouring to establish her authority on the river between Khartoum and Gondokoro, as the Marchand expedition from the Congo to Fashoda demonstrated.

The Sudan having been reconquered by "the joint military and financial efforts" of Great Britain and Egypt, the British Government claimed "by right of conquest" to share in the settlement of the administration and legislation of the country. To meet these claims an agreement between Great Britain and Egypt was signed on Jan. 19, 1899, establishing the joint sovereignty of the two States throughout the Sudan. The reorganization of the country had already begun, supreme power being centred in an official termed the "governor-general of the Sudan," who by the terms of the agreement is appointed on the recommendation of the British Government. Thus in effect Great Britain controlled the Sudan. Lord Kitchener, the sirdar (commander-in-chief) of the Egyptian army, under whom the Sudan had been reconquered, was the first governor-general. On Kitchener's departure to South Africa, at the close of 1899, he was succeeded as sirdar and governor-general by Maj.-gen. Sir F. R. Wingate, who had served with the Egyptian army since 1883. Wingate remained as governor-general and sirdar until Dec. 1916, when he was appointed high commissioner for Egypt. With Wingate served Slatin Pasha as inspector-general and his knowledge of native affairs was most valuable. But Slatin was an Austrian, and on the outbreak of the World War his services were lost to the Sudan. Under a just and firm administration, which from the first was essentially civil, though the principal officials were officers of the British army, the Sudan recovered in a surprising manner from the woes it suffered during the Mahdia. At the head of every *mudiria* (province) was placed a British official, though many of the subordinate posts were filled by Egyptians. An exception was made in the case of Darfur, which, before the battle of Omdurman, had thrown off the khalifa's rule and was again under a native sovereign. This potentate, the sultan Ali Dinar, was recognized by the Sudan Government, on condition of the payment of an annual tribute. During the World War Ali Dinar revolted; an expedition under Lt.-col. P. V. Kelly inflicted a crushing defeat on the Darfurians outside the capital, El Fasher, on May 22, 1916. The Sultan fled and was killed in action in the following November. Darfur had meanwhile been incorporated as a province in the Sudan.

The first duty of the new administration, the restoration of public order, met with comparatively feeble opposition, though tribes such as the Nuba mountaineers, accustomed from time immemorial to raid their weaker neighbours, gave some trouble. The delimitation (1903–04) of the frontier between the Sudan and Abyssinia helped in the restoration of order in a particularly lawless region but occasional raids by Abyssinians across the border for slaves were reported as late as 1926.

With good administration and public security the population increased steadily. The Sudan Government devoted much attention to the revival of agriculture and commerce, to the creation of an educated class of natives, and to the establishment of an adequate judicial system. It was made easier by the decision to govern, as far as possible, in accordance with native law and custom, no attempt being made to Egyptianize or Anglicize the Sudanese. The Arab-speaking and Mohammedan population found their religion and language respected, and showed a marked desire to profit by the new order. To the negroes of the southern Sudan, who were exceedingly suspicious of all strangers—whom hitherto they had known almost exclusively as slave-raiders—the very elements of civilization had, in most cases, to be taught. In these pagan regions the Sudan Government encouraged the work of missionary societies, both Protestant and Roman Catholic, while discouraging propaganda work among the Muslims.

Basis of Prosperity.—In their general policy the Sudan Government adopted a system of light taxation. Prosperity was largely the result. A short route to the sea being essential, a railway from the Nile near Berber to the Red sea was built (1904–06). It shortened the distance from Khartoum to the coast by nearly 1,000 miles. Sir Eldon Gorst (high commissioner in Egypt) after a tour of inspection declared in his report for 1909, "I do not suppose that there is any part of the world in which the mass of the population have fewer unsatisfied wants."

The next development came out of the search for new cotton-fields by the British Cotton Growing Association. Experiments had been made in 1911 as to whether long staple cotton could profitably be grown in the Gezira (the "island" between the White and Blue Niles immediately above Khartoum). At that time a railway was being built from Khartoum along the edge of the Gezira to Sennar and thence to Kordofan. This railway was opened in 1912; it brought the Gezira within easy reach of Khartoum besides rendering more easily accessible the rich gum and cattle areas of Kordofan. In the same year the Cotton Growing Association experts who had visited the Sudan reported enthusiastically upon its cotton growing possibilities, with the result that in 1913 the British parliament guaranteed a loan of £3,000,000 for irrigation and railway schemes. Just at this time (1913–14) the value of any project which would give to large areas adequate water supplies by means of artificial irrigation received a striking demonstration. The 1913 rains were very bad and the river flood was the lowest recorded for more than a century, so that all over the northern Sudan, and particularly in the Gezira area, famine conditions obtained during the following winter. The situation was saved by the Government importing corn from India, and it is probable that this contributed more than any other factor to the quiet in the Sudan during the World War.

The World War and After.—Fortunately rains and Nile flood alike were excellent in 1914. But Sudanese came into touch with European thought as well as European markets. The agitation among the Egyptian Nationalists for the ejection of the British from the Sudan was not without effect, and the national self-consciousness which is dormant in every race showed signs of awakening among that section of the people, mainly town dwellers, most receptive of new ideas. Happily 1920 was a year of prosperity, rich harvests and increasing trade, and the interests of the classes in question was largely centred on money making and the possibilities of the Gezira irrigation scheme, on which preliminary work was being actively prosecuted. The Sudan, too, had the advantage of very able and sympathetic government under Sir Lee Stack who had succeeded Sir Francis Wingate as governor-general and sirdar. He was fully in sympathy with a recommendation made by the Milner Commission in 1920 that a policy should be pursued of "decentralization and the employment, wherever possible, of native agencies for the simple administrative needs of the country." This was indeed no new policy in the Sudan, but its authoritative restatement had value.

The only hindrance to an ordered and healthy political evolution in the Sudan, came as a reaction from political disturbances in Egypt. The Milner Commission recommended that whatever change was made in the relation between Great Britain and Egypt, British predominance in the Sudan should not be affected. Accordingly, when in Feb. 1922 the independence of Egypt was declared, provision was made for the maintenance of the *status quo* in the Sudan. But the Nationalist party in Egypt demanded the handing over of the Sudan to Egypt and again conducted an active anti-British campaign of propaganda in the Sudan. There the position was complicated by the fact that the military garrison was furnished by the Egyptian army, consisting partly of purely Egyptian units but mainly of locally recruited units officered by Egyptians and Sudanese with a small addition of British officers. A "White Flag League" with funds from Egypt had been started in the Sudan, and a few disturbances occurred, including mutinies of the Egyptian Railway Battalion at Atbara, and of Sudanese cadets in Khartoum, in Aug. 1924, but the country was quiescent.

In Sept. and Oct. 1924 conversations took place in London between the prime minister (Ramsay MacDonald) and Zaghlul Pasha (prime minister of Egypt) in which the position of the Sudan as well as Egypt was discussed. No agreement was reached, whereupon MacDonald sent a despatch (Cmd. 2269 of 1924) to the British High Commissioner in Cairo in which, referring to the Sudan, he said:

> . . . In the meantime, the duty of preserving order in the Sudan rests, in fact, upon His Majesty's Government, and they will take every step necessary for this purpose. Since going there they have contracted heavy moral obligations by the creation of a good system of administration; they cannot allow that to be destroyed; they regard their responsibilities as a trust for the Sudan people; there can be no question of their abandoning the Sudan until their work is done. His Majesty's Government have no desire to disturb existing arrangements, but they must point out how intolerable is a *status quo* which enables both military and civil officers and officials to conspire against civil order, and unless the *status quo* is accepted and loyally worked out until such time as a new arrangement may be reached, the Sudan Government would fail in its duty were it to allow such conditions to continue. . . .

The failure of Zaghlul in London left him without any constructive policy for dealing with the Sudan, and the forces of disorder asserted themselves. On Nov. 20, 1924, Sir Lee Stack succumbed to a murderous attack made on him in the streets of Cairo. An ultimatum was thereupon presented by the British Government and among its terms was the immediate withdrawal of all Egyptian troops from the Sudan, *i.e.*, all purely Egyptian units and the Egyptian officers of the Arab and Sudanese units. The demand was refused, and on Nov. 23 orders were issued for their compulsory removal. Some of them departed without demur; others adopted an attitude of passive resistance. At this stage some black Sudanese detachments stationed in Khartoum, probably misunderstanding the exact position of affairs, and certainly instigated by the Egyptian officers and by sympathisers among their own officers, mutinied on Nov. 27, and it was not until the 29th that order was restored. The evacuation of the Egyptian units and personnel was followed by the creation of a Sudan defence force, consisting of Sudanese and Arab units which had hitherto been incorporated in the Egyptian army. The new force undertook allegiance solely to the governor-general of the Sudan who was no longer also sirdar of the Egyptian army. By the end of 1924 conditions had been restored to normal.

Sir Geoffrey Archer, a man of much experience of African races, became governor-general in Jan. 1925. He put into fuller practice the principle of decentralized control—that is, leaving the administration as far as possible in the hands of the native authorities. On account of ill-health Sir Geoffrey resigned his post in 1926; Sir John Maffey, who succeeded him, adopted fully Archer's devolutionary policy and in 1927 a measure was passed ("Powers of Sheikhs ordinance") which strengthened the authority of the chiefs over their tribes as judges in criminal and civil cases. A notable event was the opening in Jan. 1926 of the Sennar dam, which brought a great part of the Gezira under irrigation. A particularly satisfactory feature of this work was its popularity among the native owners and cultivators. While 1925 and 1926 were both years of drought in the northern Sudan, the material progress of the people continued; the Government established a central reserve of grain and controlled prices.

Among the pagan negroid tribes of the southern Sudan probably the greatest agent in development was the building of roads as adjuncts to river transport; by 1928 thousands of miles of road were in use by motor traffic in the dry season. This opened up markets and led to the introduction of money, and the cultivation of food crops and of cotton. Whether they desired it or not these backward races felt the impact of new methods and agencies. The first steps in their transformation, the stopping of inter-tribal warfare and the establishment of public order, were slowly accomplished, mainly by the personal influence of British officials. One difficulty was that the Government had not forces sufficient effectively to control the border region. To help in this matter there were in 1914 and again in 1926, territorial rearrangements in the south (*see* UGANDA). In administered areas peaceful progress was not uninterrupted. There was a somewhat serious rising among a section of the Dinkas in Mongalla province in 1919, during which the governor, Maj. C. H. Stigand, and Maj. R. F. White lost their lives, their small force being attacked by spearmen in the long grass. Punitive measures followed in 1920 and the Dinkas gave little trouble thereafter; some of them took to cotton growing and coffee planting. There was unrest among the Nuer of the Bahr-el-Ghazal province in 1927 and Capt. V. H. Fergusson, district commissioner, with several other persons, was murdered in December of that year. Aeroplanes were used in the retributory action taken.

In March 1928 a new draft treaty between Great Britain and Egypt was rejected by the Egyptian cabinet; whereupon the British Government reminded the Egyptian Government that under the agreement of 1899, Great Britain continued to control the Sudan.

By an exchange of notes on May 7, 1929, an agreement, satisfactory to both parties, was reached by the British and Egyptian Governments in regard to Nile irrigation schemes. It was agreed that no measures, such as supplying the needs of the northern Sudan, should be taken which would prejudice the interests of Egypt, and that there should be co-operation between the Egyptian and Sudanese irrigation services. The immediate effect of the agreement was to allow the Egyptian authorities at once to proceed with the construction of a dam across the White Nile at Gebel Aulia, 30 m. above Khartoum—a project of special importance to Egypt, and in no way affecting the Gezira scheme of the Sudan Government.

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(F. R. C.)

SUDAN, CAMPAIGNS IN: *see* EGYPT AND SUDAN, CAMPAIGNS IN, 1882–1899.

SUDAN, FRENCH, one of the colonies of French West Africa, of which the area is now 1,672,000 sq.km. (a third of French West Africa); population, 2,635,000, of which 1,500 only are Europeans. The colony of Upper Volta was separated from it in 1919; French Sudan, for several years called Upper Senegal and Niger, took its present name in 1920. Those tribes living north and east of the Niger are mainly of Berber (Tuareg) stock; the inhabitants of the Niger bend are chiefly Negroids, such as the Mandingo, with Fula in certain districts.

The colony, as a whole, consists of a great plateau of granite and sandstone, rarely more than 1,600 ft. high. Hydrographically the western portion belongs to the basin of the Senegal, the central to that of the Niger. At Mopti, 200 m. S.W. of Timbuktu, the Niger receives the Bani, which rises in about 9½° N. and with its tributaries drains a very large area. In its lower courses its divergent channels, uniting with offshoots from the Niger, form in the flood season an immense lake. The lakes or widenings of the Niger itself occupy vast areas; Lake Debo, the Lake of Horo, the Lake of Dauna and Lake Faguibini are all to the south or west of Timbuktu, and are permanent. Towards the south the country is somewhat mountainous. The country west of the Niger contains patches of forest, but it consists mainly of open land well adapted to agriculture and stock-raising. The fauna includes the lion, elephant, hippopotamus, wild boar, panther and various kinds of antelope. The climate is tropical.

Of the old native States included in the colony, Bambuk lies between the Senegal and the Faleme and Bafing. It is traversed from north-west to south-east by the steep and wall-like range of the Tamba-Ura mountains. The soil in a large part of the country is of remarkable fertility; rice, maize, millet, melons, manioc, grapes, bananas and other fruits grow abundantly; the forests are rich in a variety of valuable trees; and extensive stretches are covered with abundant pasturage of the long guinea-grass. The inhabitants, a branch of the Mandingo race, own large herds of cattle and sheep. The reports which reached Europe during the 17th and 18th centuries of a country in Upper Senegal rich in gold, referred to this district, where both alluvial and quartz deposits have been found.

Towns.—Kayes (pop. 10,000, of which 200 are Europeans) is situated on the Senegal at the point at which that river ceases to be navigable from the sea—a distance of 460 m. from St. Louis. Bamako (pop. 16,000, of which 600 are Europeans), chosen in 1904 as the capital of the colony, is on the upper Niger at the head of its navigable waters, and is in railway communication with Kayes; the military and administrative buildings stand on the healthy plateau of Koulouba, which overlooks the commercial town and the river. Segu, where Mungo Park first reached the Niger, is a series of townships stretching for 15 km. along the river (pop. 6,000). Before the French occupation the possessor of Segu was the ruler of the surrounding country; and the town was the headquarters of the emirs Omar and Ahmadu. Sansandig stands on the north bank of the Niger below Segu. It was visited by Mungo Park in 1796, and Lieut. E. Mage and Dr. Quintin, French officers, witnessed its stand in 1865 against a siege by Ahmadu, sultan of Segu, from whom it had revolted. Before its conquest by the Tuareg, in the first half of the 19th century, Sansandig was an important mart.

Communications.—There is regular communication by rail and river between Dakar, the principal port of Senegal, and Timbuktu, the journey occupying 10 to 12 days. A railway linking the Senegal and Niger rivers starts at Kayes on the Senegal, passes south-east through Bafulabé and Kita, whence it goes east to Bamako on the Niger, and follows the left bank of that river to Kulikoro, the terminus, from which point the Niger is navigable down stream all the year round for a distance of 900 m., while from Bamako the Niger is navigable up stream to Kurussa, a distance of 225 m., for most of the year. The Senegal-Niger railway, opened in 1905, is 347 m. long. Steamers ply on the Niger between Kabara, the port of Timbuktu, and Kulikoro and Bamako. There is a complete system of telegraphic communication with all the French colonies in West Africa.

Trade and Agriculture.—The chief exports are gum (which comes largely from the northern districts such as Kaarta), rubber, gold, kola nuts, leather and ostrich feathers. A goodly proportion of the exports from the middle Niger are shipped from Konakry in French Guinea. Under the direction of French officials, cotton-growing on scientific methods was begun in the Niger basin in 1904. American and Egyptian varieties were introduced, the American varieties proving well adapted to the soil. Indigenous varieties of cotton are common and are cultivated by the natives for domestic use, weaving being a general industry. Large works are planned at Segu, at Nyamina and at Sansandig, in view of cotton-growing on a large scale; the execution of the irrigation works is made difficult by the scarcity of labour. Gold is found in the basin of the Faleme and of the Tankisso. The people are great agriculturists, their chief crops being millet, maize, rice, cotton and indigo. Tobacco is cultivated by the river folk along the banks inundated by the floods. Wheat is grown in the neighbourhood of Timbuktu, the seed having been, in all probability, brought from Morocco at the time of the Moorish invasion. (*See* TIMBUKTU.) The oil of the karite or shea-butter tree, common in the southern and western regions, is largely used. Cattle are plentiful; there are several good breeds of horses; donkeys are numerous and largely used as transport animals; wool-bearing sheep—distinct from the smooth-haired sheep of the coast regions—are bred in many districts, the natives using the wool largely in the manufacture of blankets and rugs. The imports are valued at 86 millions, and the exports seem to reach nearly the same figure. (A. Be.)

SUDANIC LANGUAGES. This term is applied to a number of languages spoken by Negro and other peoples from Abyssinia to Nigeria. At present sixteen main divisions are recognized. 1) Nilo-Chad, a group with thirty languages, including Zebu, Kunama, Kanuri; 2) Nilo-Abyssinian (15 languages), including Shilluk, Nuer and Dinka. 3) Nilo-Equatorial (26 languages) including Bari, Turkana, Suk, Nandi, Masai. 4) Kordofan (10 languages) including Talodi and Lumun. 5) Nilo-Congo (19 languages) including Madi, Mangbetu and Lega. 6) Ubangian group (25 languages) including Zande, Gola and Seri. 7) Chari-Wadain (12 languages) including Bongo, Kaba and Sara. 8) Charian (15 languages) including Sokoro, Bwa, and Mana. 9) Nigero-Chad (31 languages) including Kuri, Fali, Bata, Angas and Hausa. 10) Nigero-Cameroons (66 languages) including Gwala, Nde, Kpe, Ejik, Ibo, Nupe, Yoruba. 11) Lower-Niger group consists of Idyo or Boni. In the 12th or Voltaic group are 53 languages including Tem, Mampuru, Kasena, Ga, Kulango, Semu. In the 13th or Ivory Coast Dahomy group are 48 languages inclusive of the Ewe group, the Tchi group and the Fanti and Abron. The 14th or Niger-Senegal group has 36 languages including Mandingo, Vai and Mende. The 24 languages spoken on the Ivory-Liberian coast (15th group) include Bete, Kwa and Ne. To the 16th or Senegal-Guinea group belong 24 languages, comprising Timne, Walof, Kisi. Certain traces are found of the noun classifications conspicuous in Bantu languages. The distinction between noun and verb is weak. Kanuri, Hausa and Peul are sometimes written by the use of Arabic letters.

See A. Meillet and M. Cohen, *Les Langues du Monde* (1924); W. Schmidt, *Die Sprachfamilien und Sprachen-Kreise der Erde* (1927).

SUDAN PLANTATIONS SYNDICATE, LTD., a British joint-stock company formed in 1904, with a capital of £80,000, as the Sudan Experimental Plantations Syndicate, Ltd. In 1928 the capital stood at £2,250,000.

By an agreement with the Sudan Government, the syndicate was to develop an area of about 100,000 acres of the Gezira plain, irrigated by a barrage across the Blue Nile. The Sudan Government had to provide the land and the major canalization, and the syndicate and the native tenant cultivator were each entitled to receive a share of the proceeds of the crops. The World War supervening, the building of the Sennar dam was delayed, but by means of additional pumping stations the area under cotton was increased to some 22,500 acres.

The agreement was to be in force until 1925, but since the completion of the Sennar dam a new agreement has taken its place, extending to 1950, and providing for certain reductions in the syndicate's share of the crop as compared with its participation of 25% under the old agreement. The syndicate prepares and irrigates the land, letting it to natives, who plant cotton and various leguminous crops under supervision, under three years' rotation. The syndicate acts as bankers to the tenants, to whom they make loans on the security of their crops.

The shipments of cotton to the United Kingdom have grown:

		Bales		Bales
1914–15	Gezira	3,935	Zeidab	3,109
1926–27	Gezira	113,168	Zeidab	3,042

The syndicate has in operation four factories of 80 gins each, handling 750 bales per day; two more factories are in course of erection. The cotton, of the Sakellaridis type, is a long and silky staple, commanding a high price. The area under cultivation is to be 150,000 acres in 1929–30. The cotton exported from the Sudan in 1911 was 22,823 bales; in 1926 it had increased to 122,130 bales, of the approximate value of £3,500,000.

(L. C. M.)

SUDATORIUM, in architecture, the vaulted sweating-room (*sudor,* sweat) of the Roman thermae, referred to in Vitruvius (v. 2), and there called the *concamerata sudatio.* In order to obtain the great heat required, the whole wall was lined with vertical terra-cotta flue pipes of rectangular section, placed side by side, through which the hot air and the smoke from the hypocaust, or hollow floor, passed to the roof. (*See* Baths.)

SUDBURY, SIMON OF (sometimes called Simon Theobald or Tybald) (d. 1381), archbishop of Canterbury, was born at Sudbury, in Suffolk, studied at the University of Paris, and became one of the chaplains of Pope Innocent VI., who sent him, in 1356, on a mission to Edward III. of England, and in 1361 appointed him bishop of London. From 1375, when he was made archbishop of Canterbury, he was a partisan of John of Gaunt. In July 1377 he crowned Richard II.; in 1378 John Wycliffe appeared before him at Lambeth. Chancellor of England from 1380, Sudbury was regarded by the peasants, who were in revolt, as one of the authors of their distress, and the Kentish insurgents damaged his property at Canterbury and Lambeth, and, dragging him from the Tower of London, beheaded the archbishop on Tower hill on June 14, 1381.

See W. F. Hook, *Lives of the Archbishops of Canterbury.*

SUDBURY, in northern Ontario, Canada, produces 90% of the world's supply of nickel and almost all the copper produced in Ontario. The smelter of the International Nickel company is at Copper Cliff, a suburb to the west, and the Mond company's smelter and sulphuric acid plant is 8 m. to the east at Coniston. A Government school of mines and a Jesuit college are situated here. Deposits of lead and zinc are also being opened up. Pop. (1921), 8,621.

SUDBURY, a market town of England, chiefly in Suffolk, but partly in Essex. Pop. (1921) 7,045. It lies on the river Stour (which is navigable up to the town). All Saints' parish church is chiefly Perpendicular—the chancel being Decorated. It possesses a fine oaken pulpit of 1490. St. Peter's is Perpendicular, with a finely carved nave roof. St. Gregory's, once collegiate, is Perpendicular. It has a rich spire-shaped font-cover of wood, gilded and painted. The grammar school was founded by William Wood in 1491. There are some old half-timbered houses, including one very fine example. Coco-nut matting is an important manufacture; silk manufactures were transferred from London during the 19th century, and horsehair weaving was established at the same time. Before the Conquest the borough was owned by the mother of Earl Morcar, from whom it was taken by William I., who held it in 1086. It was alienated from the Crown to an ancestor of Gilbert de Clare, 9th earl of Gloucester. In 1271 the earl gave the burgesses their first charter confirming to them all their ancient liberties and customs. They were incorporated in 1553. Weavers were introduced by Edward III.

SUDD, a vegetable obstruction on the Upper Nile. It is composed of compacted masses of plants consisting chiefly of a grass, *Vossia procera,* with *Saccharum Spontaneum,* which cover a large area of the Ghazal swamps. Loosened by storms, these plants reach the main channel near the Sobat R. junction, lodge on some obstruction and form a dam, sometimes 25 m. in length and nearly 20 ft. below the surface. These peaty blocks of decayed vegetation and soil are compressed by the current so that in parts they can support an elephant. At length the pressure of the water forms a side channel or causes the sudd to burst. (*See* Nile.)

See O. Deuerling, *Die Pflanzenbarren der afrikanischen Flüsse* (Munich, 1909), and H. G. Lyons, *The Physiography of the Nile and its Basin* (Cairo, 1906).

SUDERMANN, HERMANN (1857–1928), German writer, was born at Matziken, East Prussia, on Sept. 30, 1857, of a Mennonite family long settled near Elbing. His father owned a small brewery, but owing to a financial crisis was obliged to apprentice his son, at the age of 14, to a chemist. Young Sudermann was able, however, to study at Tilsit and afterwards at Koenigsberg university. He then went to Berlin, where he acted as tutor in several houses, and worked as a journalist on the Deutsches Reichsblatt (1881–2), afterwards turning to novel-writing. His novels *Im Zwielicht* (1886), *Frau Sorge* (1887), *Geschwister* (1888) and *Der Katzensteg* (1890) revealed neither beauty nor emotional power, but invariably showed keen observation, a vivid touch and dramatic technique. The tale is his chief concern, and he shows a masterly control of tension, as in *Iolanthes Hochzeit* (1892); *Es War* (1894) and *Das Hohe Lied* (1908) showed a falling off, but the old mastery reappeared in *Litauische Novellen* (1917).

More instantly popular, and later more bitterly decried, were plays, of which *Die Ehre* (1880) brought him immediate fame, and *Heimat* (1892), better known as *Magda*, made him known throughout Europe. Part of the great success of *Magda* was no doubt due to the fact that the title-rôle was interpreted by Modjeska, Bernhardt, Duse, and Mrs. Patrick Campbell. His dramas, *Sodoms Ende* (1891), *Johannisfeuer* (1900), *Es Lebe Das Leben* (1912), *Der Sturmgeselle Sokrates* (1903), *Stein Unter Den Steinen* (1915) and numerous others ending with *Der Hasenfellhändler* (1925) were uniformly successful on the stage. During the World War he wrote the cycle of three plays collectively entitled *Die Entygötterte Welt*. His last novels were *Der tolle Professor* (1926) and *Purzelchen* (1928). He belonged to the realistic movement of the last quarter of the 19th century, and was not very sympathetic to the new methods and new outlook of post-war literature. He died at Berlin on Nov. 22, 1928.

See W. Kawerau, *Sudermann* (1897); H. Landsberg, *Sudermann* (1902); H. Jung, *Sudermann* (1902); H. Schoen, *Sudermann, Poete dramatique et romancier* (1905); and I. Axelrod, *Sudermann* (1907). His dramatic works were collected in 1923. *See* also his autobiography *Das Bilderbuch meiner Jugend* (Eng. trans., N.Y. 1924).

SUE, EUGÈNE [JOSEPH MARIE] (1804–1857), French novelist, was born in Paris on Jan. 20, 1804. He was the son of a distinguished surgeon in Napoleon's army, and is said to have had the empress Josephine for godmother. Sue himself acted as surgeon both in the Spanish campaign undertaken by France in 1823 and at the battle of Navarino (1828). In 1829 his father left him a fortune, and he settled in Paris. His naval experiences supplied much of the materials of his first novels. In the quasi-historical style he wrote *Jean Cavalier, ou Les Fanatiques des Cevennes* (4 vols., 1840) and *Latréaumont* (2 vols., 1837). He was strongly affected by the Socialist ideas of the day, and these prompted his most famous works: *Les Mystères de Paris* (10 vols., 1842–1843) and *Le Juif errant* (10 vols., 1844–1845), which were among the most popular specimens of the *roman-feuilleton*. He followed these up with some singular and not very edifying books: *Les Sept péchés capitaux* (16 vols., 1847–1849), which contained stories to illustrate each sin, *Les Mystères du peuple* (1849–1856), which was suppressed by the censor in 1857.

Some of his books, among them the *Juif errant* and the *Mystères de Paris*, were dramatized. After the revolution of 1848 he sat for Paris (the Seine) in the Assembly, and was exiled after his protest against the *coup d'état* of Dec. 2, 1851. His later works were inferior. Sue died at Annecy (Savoy) on Aug. 3, 1857.

SUEBI or **SUEVI,** a collective term applied to a number of peoples in central Germany, the chief of whom were the Marcomanni, Quadi, Hermunduri, Semnones, and Langobardi; these tribes inhabited the basin of the Elbe. Tacitus uses the name Suebi in a wider sense to include not only the tribes of the basin of the Elbe, but all the tribes north and east of that river, including even the Swedes (Suiones).

From the 2nd to the 4th century A.D. the name Suebi is seldom used except with reference to events in the neighbourhood of the Pannonian frontier, and here probably means the Quadi. From the middle of the 4th century it appears in the regions south of the Main, and the names Alamanni and Suebi are used synonymously. The Alamanni (*q.v.*) seem to have been joined by one or more other Suebic peoples, some of whom accompanied the Vandals in their invasion of Gaul and founded a kingdom in north-west Spain. Besides the Alamannic Suebi we hear of a people called Suebi, who shortly after the middle of the 6th century settled north of the Unstrut. There is evidence also for a people called Suebi in the district above the mouth of the Scheldt. It is likely that both these settlements were colonies from the Suebi of whom we hear in the Anglo-Saxon poem *Widsith* as neighbours of the Angli. The question has been raised whether these Suebi should be identified with the people whom the Romans called Heruli. After the 7th century the name Suebi is practically only applied to the Alamannic Suebi (Schwaben), with whom it remains a territorial designation in Württemberg and Bavaria.

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SUECA, a town of eastern Spain, in Valencia. Pop. (1920), 17,915. Sueca is separated from the Mediterranean Sea (7 m. east) by the Sierra de Cullera. It is a modern town, although many of the houses have the flat roofs, view-turrets (*miradores*) and horseshoe arches characteristic of Moorish architecture. Sueca has a thriving trade in grain and fruit from the Júcar valley, which is irrigated by waterways created by the Moors.

SUEDE FINISH, a nap produced by separating the surface fibres of leather on a carborundum or emery wheel. Although this processing may be directed either at the grain of leather or the flesh surface, it is more often applied to the latter. Suede finish usually indicates chrome or alum tanning as opposed to vegetable tanning, and the resulting leather is soft, pliable and strong. It is used for shoes, hats, coats, gloves, belts and handbags.

SUESSULA, an ancient town of Campania, Italy. It commanded the entrance to the Caudine pass. (*See* CAUDINE FORKS.) Traces of the theatre may still be seen. Oscan tombs were excavated, and vases, bronzes, etc., have been found. Suessula lay on the Via Popilia. On the hills above Cancello to the east of Suessula was situated the fortified camp of M. Claudius Marcellus, used as an outpost against Hannibal in Capua. (*See* PUNIC WARS.)

SUETONIUS TRANQUILLUS, GAIUS, Roman historian, lived during the end of the 1st and the first half of the 2nd century A.D. He was the contemporary of Tacitus and the younger Pliny, and his literary work seems to have been chiefly done in the reigns of Trajan and Hadrian (A.D. 98–138). His father was military tribune in the XIIIth legion, and he himself began life as a teacher of rhetoric and an advocate. To us he is known as the biographer of the twelve Caesars (including Julius) down to Domitian. As Hadrian's private secretary (*magister epistolarum*), he must have had access to the Imperial archives, *e.g.*, the transactions of the senate. He was a correspondent of the younger Pliny, who as governor of Bithynia took Suetonius with him. Hadrian's biographer, Aelius Spartianus, tells us that Suetonius was deprived of his private secretaryship because he had not been sufficiently observant of court etiquette towards the emperor's wife during Hadrian's absence in Britain.

The *Lives of the Caesars* is rather a chronicle than a history. It gives no general picture of the period. It is the emperor who is always before us, yet the portrait is drawn without real insight. The personal anecdotes are very amusing; but the author panders too much to a taste for gossip. None the less he is next to Tacitus and Dio Cassius the chief (sometimes the only) authority. The language is clear and simple. Of his *De viris illustribus*, the lives of Terence and Horace, fragments of those of Lucan and the elder Pliny and the greater part of the chapter on grammarians and rhetoricians, are extant. Other works by him (now lost) were: *Prata* (=λειμῶνες=patch-work), in ten books, a kind of encyclopaedia; the *Roman Year, Roman Institutions and Customs, Children's Games among the Greeks, Roman Public Spectacles, On the Kings, On Cicero's Republic.*

Editio princeps, 1470; editions by great scholars: Erasmus, Isaac Casaubon, J. G. Graevius, P. Burmann; the best complete annotated edition is still that of C. G. Baumgarten-Crusius (1816); recent editions by H. T. Peck (New York, 1889); Leo Preud'homme (1906); M. Ihm (1907) of the *De viris illustribus*, R. P. Robinson, (Paris 1925). Editions of separate lives: *Augustus*, by E. S. Shuckburgh (with useful introduction, 1896); *Claudius*, by H. Smilda (1896); *Julius Caesar*, by Butler and Cary (Oxford 1927); *Vespasian*, by Braithwaite (Oxford 1927). The best editions of the text are by C. L. Roth (1886), and A. Reifferscheid (not including the *Lives*, 1860). On the *De viris illustribus, see* G. Körtze in *Dissert. philolog. halenses* (1900), vol. xiv.; and, above all, A. Macé, *Essai sur Suétone* (1900), with an exhaustive bibliography. There are English translations by Philemon Holland (reprinted in the *Tudor Translations*, 1900), by Thomson and Forester (in Bohn's *Classical Library*), and by Page and Rouse in the *Loeb* series (1912).

SUEZ, a port of Egypt on the Red Sea and southern terminus of the Suez Canal. Pop. about 20,000. Suez is supplied with water by the fresh-water canal, which starts from the Nile at Cairo and was opened in 1863. Before this, water had to be brought from "the Wells of Moses," a small oasis 3 m. distant. About 2 m. south of the town are the quays constructed on the Canal and connected with the town by an embankment. On one of the quays is a statue to Thomas Waghorn, the organizer of the "overland route" to India. The ground on which the port is built has all been reclaimed from the sea. The accommodation provided includes a dry dock 410 ft. long, 100 ft. broad and nearly 36 ft. deep. There are separate basins for warships and merchant ships, and in the roadstead at the mouth of the canal is ample room for shipping. Suez is a quarantine station for pilgrims from Mecca.

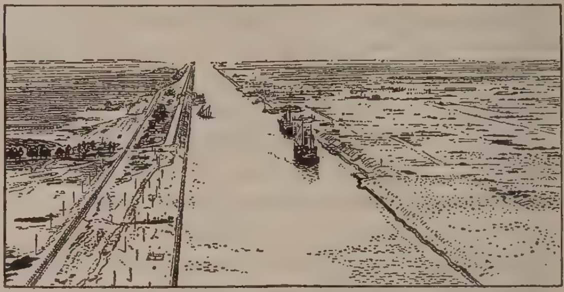
In the 7th century a town called Kolzum stood, on a site adjacent to that of Suez, at the southern end of the canal which then joined the Red Sea to the Nile. On the Ottoman conquest of Egypt in the 16th century Suez became a naval as well as a trading station, and here fleets were equipped which for a time disputed the mastery of the Indian Ocean with the Portuguese. According to Niebuhr, in the 18th century a fleet of nearly twenty vessels sailed yearly from Suez to Jidda, the port of Mecca and the place of correspondence with India. The overland mail route from England to India by way of Suez was opened in 1837. The regular Peninsular and Oriental steamer service began a few years later, and in 1857 a railway was opened from Cairo through the desert. The present railway follows the canal from Suez to Ismailia and Zagazig, whence branches diverge to Cairo and Alexandria.

SUEZ, COMPAGNIE UNIVERSELLE DU CANAL MARITIME DE. The first concession of territory to M. Ferdinand de Lesseps was in 1854 followed in 1856 by a second. In 1858 the Suez Canal Company was formed and the first ground was broken at Port Said on April 25, 1859. After many vicissitudes and in the face of much opposition the work was completed in ten years and on Nov. 17, 1869, 68 ships passed through from the Mediterranean to the Red Sea. The original public list opened on Nov. 5, 1858, and offered 400,000 shares at Fr. 500 per share.

Questions concerning the regulation of measurements and tonnage to fix the dues upon traffic passing through the canal were finally adjusted by the findings of an International Commission at Constantinople in 1873. Traffic through the canal has increased steadily year by year; in 1923 2,839 ships out of a total of 4,621 were British and the figures for 1927 were, total net tonnage 28,962,048; total number of ships, 5,545, British ships 3,085. Thus, in that year British ships represented a percentage of 57·1.

The canal is managed in Egypt. The number of employees there in 1928 was 3,011 and the work includes the prolongation of breakwaters, incessant dredging and the widening and straightening of the canal. There are 2,466 workmen so engaged and their salaries (including a share of the profits) amounted in 1928 to £800,000, as contrasted with the £200,000 paid in 1914 to 2,650 workmen. The concession to the Suez Canal Company expires on Nov. 17, 1968. For details as to the depth, width at bottom and breadth between the banks of the Suez Canal, *see* Lloyd's *Register of Shipping.* (L. F. O.)

SUEZ CANAL, an artificial waterway, about 100m. long, connecting Port Said, on the Mediterranean sea, and Suez, on the Red sea, which enables ocean-going ships to traverse the isthmus between Asia and Africa, thereby shortening the maritime route from Europe to the Orient by the sailing distance around the continent of Africa. At various eras such communication existed by way of the Nile. The fertile Wadi Tumilat extending east of the Nile valley almost to the head of the gulf (which in ancient times reached north to the Bitter lakes) afforded an easy road between the Nile and the Red sea. Aristotle, Strabo and Pliny attribute to the legendary Sesostris (*q.v.*) the distinction of being the first of the pharaohs to build such a canal. From an inscription at Karnak it seems that the canal existed in the time of Seti I. (1380 B.C.). The channel of this canal is still traceable in parts of the Wadi Tumilat, and its direction was frequently followed by the engineers of the fresh-water canal. Pharaoh Necho (609 B.C.) began to build another canal, but it was not completed—according to Herodotus 120,000 men perished in the undertaking. Darius (520 B.C.) continued the work of Necho, rendering navigable the channel of the Heroopolite gulf, which had become blocked. Up to this time there appears to have been no connection between the waters of the Red sea and those of the Bubastis-Heroopolis canal; vessels coming from the Mediterranean ascended the Pelusiac arm of the Nile to Bubastis and then sailed along the canal to Heroopolis, where their merchandise had to be transferred to the Red sea ships. Ptolemy Philadelphus (285 B.C.) connected the canal with the waters of the sea, and at the spot where the junction was effected he built the town of Arsinoë. The dwindling of the Pelusiac branch of the Nile rendered this means of communication impossible by the time of Cleopatra (31 B.C.). Trajan (A.D. 98) is said to have repaired the canal, and, as the Pelusiac branch was no longer available for navigation, to have built a new canal between Bubastis and Babylon (Old Cairo), this new canal being known traditionally as Amnis Trajanus or Amnis Augustus. According to H. R. Hall, however, "It is very doubtful if any work of this kind, beyond repairs, was undertaken in the times of the Romans; and it is more probable that the new canal was the work of 'Amr" (the Arab conqueror of Egypt in the 7th century). The canal was certainly in use in the early years of the Muslim rule in Egypt; it is said to have been closed *c.* A.D. 770 by order of Abū Ja'far (Mansur), the second Abbasid caliph and founder of Baghdad, who wished to prevent supplies from reaching his enemies in Arabia by this means. 'Amr's canal (of which the Khalig which passed through Cairo and was closed in 1897 is said to have formed part) had its terminus on the Red sea south of the Heroopolite gulf near the present town of Suez. It is not certain that it was ever restored, although it is asserted that in the year 1000 Sultan Hakim rendered it navigable. If so it must speedily have become choked up again. Parts of the canal continued to be filled during the Nile inundations until Mohammed Ali (A.D. 1811) ordered it to be closed; the closing, however, was not completely effected, for in 1861 the old canal from Bubastis still flowed as far as Kassassin. This part of the canal, after over 2500 years of service, was utilized by the French engineers in building the fresh-water canal from Cairo to Suez in 1861–63. This canal follows the lines of that of 'Amr (or Trajan).



BY COURTESY OF THE ROYAL AIR FORCE

GENERAL VIEW OF THE SUEZ CANAL NEAR ISMAILIA FROM THE AIR

On the left, the main railway line from Port Said to Cairo and Suez; the Arabian desert stretches away to the right

Maritime Canal Projects.—The idea of a canal across the isthmus of Suez was entertained as early as the 8th century A.D. by Hārūn al-Rashīd, who is said to have abandoned the scheme, being persuaded that it would be dangerous to lay open the coast of Arabia to the Byzantine navy. After the discovery of the Cape route to India at the close of the 15th century, the Venetians suggested the scheme to the Egyptians, but the Turks intervened. In 1671 Leibnitz in his proposals to Louis XIV. of France regarding an expedition to Egypt recommended the idea, and the Sheikh al-Balad Ali Bey (*c.* 1770) approved. Bonaparte when in Egypt in 1798 ordered a survey, and the engineer, J. M. Lepère, reported a difference in level of 29 ft. between the Red sea and the Mediterranean. This view was combated by Laplace and Fourier and was disproved in 1846–47 by the Société d'Études pour le Canal de Suez, organized in 1846 by Prosper Enfantin, the Saint Simonist. Canals at Panama and Suez were part of the Saint Simonist programme for the regeneration of the world. The expert commission appointed by this society reported by a majority in favour of Paulin Talabot's plan, according to which the canal would have run from Suez to Alexandria by way of Cairo.

De Lesseps, 1854.—The society was in a state of suspended animation when in 1854 Ferdinand de Lesseps came to the front as the chief exponent of the idea. He had been associated with the Saint Simonists. His opportunity came in 1854 when, on the death of Abbas Pasha, his friend Said Pasha became viceroy of Egypt. From Said on Nov. 30, 1854, he obtained a concession authorizing him to constitute the Compagnie Universelle du Canal Maritime de Suez, which should construct a ship canal through the isthmus, and soon afterwards in concert with two French engineers, Linant Bey and Mougel Bey, he decided that the canal should run in a direct line from Suez to the Gulf of Pelusium, passing through the depressions that are now Lake Timsa and the Bitter lakes, and skirting the eastern edge of Lake Menzala. In the following year an international commission appointed by the viceroy approved this plan with slight modifications, the chief being that the channel was taken through Lake Menzala instead of along its edge, and the northern termination of the canal moved some 17½m. westward where deep water was found closer to the shore. This plan, according to which there were to be no locks, was the one ultimately carried out, and it was embodied in a second and amplified concession, dated Jan. 5, 1856, which laid on the company the obligation of constructing, in addition to the maritime canal, a fresh-water canal from the Nile near Cairo to Lake Timsa, with branches running parallel to the maritime canal, one to Suez and the other to Pelusium. The concession was to last for 99 years from the date of the opening of the canal between the Red sea and the Mediterranean, after which, in default of other arrangements, the canal passes into the hands of the Egyptian Government. The confirmation of the sultan of Turkey being required, de Lesseps went to Constantinople to secure it, but found himself baffled by British diplomacy; and later in London he was informed by Lord Palmerston that in the opinion of the British Government the canal was a physical impossibility, that if it were made it would injure British maritime supremacy, and that the proposal meant French interference in the East.

Although the sultan's confirmation of the concession was not actually granted till 1866, de Lesseps in 1858 opened the subscription lists for his company, the capital of which was 200 million francs in 400,000 shares of 500 francs each. In less than a month 314,494 shares were applied for; of these over 200,000 was subscribed in France and over 96,000 were taken by the Ottoman empire. From other countries the subscriptions were trifling, and England, Austria and Russia, as well as the United States of America, held entirely aloof. The residue of 85,506 shares was taken over by the viceroy. (These formed part of the 176,602 shares which were bought for the sum of £3,976,582 from the khedive by England in 1875 at the instance of Lord Beaconsfield [*q.v.*].) On April 25, 1859, the work of construction was formally begun, the first spadeful of sand being turned near the site of Port Said, but progress was not very rapid. By the beginning of 1862 the fresh-water canal had reached Lake Timsa, and towards the end of the same year a narrow channel had been formed between that lake and the Mediterranean. In 1863 the fresh-water canal was continued to Suez.

Forced Labour.—So far the work had been performed by native labour; the concession of 1856 contained a provision that at least four-fifths of the labourers should be Egyptians, and later in the same year Said Pasha undertook to supply labourers as required by the engineers of the canal company, which was to house and feed them and pay them at stipulated rates. Although the wages and the terms of service were better than the men obtained normally, this system of forced labour was strongly disapproved of in England, and the khedive Ismail who succeeded Said on the latter's death in 1863 also considered it as being contrary to the interests of his country. Hence in July the Egyptian foreign minister, Nubar Pasha, was sent to Constantinople with the proposal that the number of labourers furnished to the company should be reduced, and that it should be made to hand back to the Egyptian Government the lands that had been granted it by Said in 1856. These propositions were approved by the sultan and the company was informed that if they were not accepted the works would be stopped by force. Naturally the company objected, and in the end the various matters in dispute were referred to the arbitration of the emperor Napoleon III. By his award, made in July 1864, the company was allowed 38 million francs as an indemnity for the abolition of the *corvée*, 16 million francs in respect of its retrocessions of that portion of the fresh-water canal that lay between Wadi, Lake Timsa and Suez (the remainder had already been handed back by agreement), and 30 million francs in respect of the lands which had been granted it by Said. The company was allowed to retain a certain amount of land along the canals, which was necessary for purposes of construction, erection of workshops, etc., and it was put under the obligation of finishing the fresh-water canal between Wadi and Suez to such dimensions that the depth of water in it would be 2½ metres at high Nile and at least 1 metre at low Nile. The supply of Port Said with water it was allowed to manage by any means it chose; in the first instance it laid a double line of iron piping from Timsa, and it was not till 1885 that the original plan of supplying the town by a branch of the fresh-water canal was carried out. The indemnity, amounting to a total of 84 million francs, was to be paid in instalments spread over 15 years.

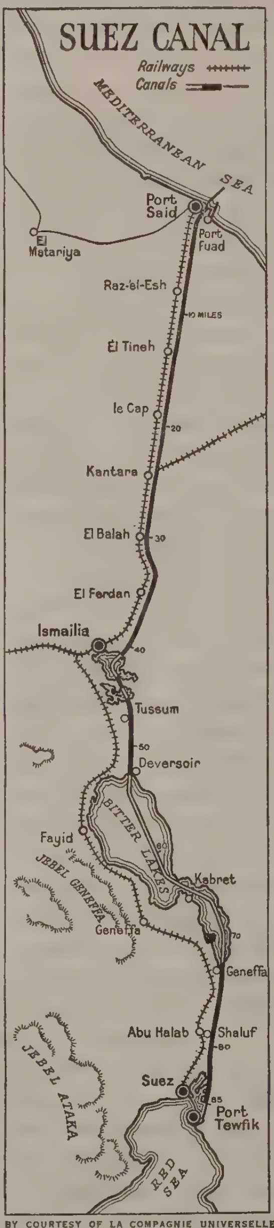
The abolition of forced labour was probably the salvation of the enterprise, for it meant the introduction of mechanical appliances and of modern engineering methods. The work was divided into four contracts. The first was for the supply of 250,000 cubic metres of concrete blocks for the jetties of Port Said; the second, for the first 60 kilometres of the channel from Port Said, involved the removal of 22 million cubic metres of sand or mud; the third was for the next length of 13 kilometres, which included the cutting through the high ground at El Gisr; and the fourth and largest was for the portion between Lake Timsa and the Red sea. The contractors for this last section were Paul Borel and Alexandre Levalley, who ultimately became responsible also for the second or 60 kilometres contract. For the most part the material was soft and therefore readily removed. At some points, however, as at Shaluf and Serapeum, rock was encountered. Much of the channel was formed by means of dredgers. At Serapeum, a preliminary shallow channel having been dug out, water was admitted from the fresh-water canal, the level of which is higher than that of the ship canal, and the work was completed by dredgers from a level of about 20ft. above the sea.

In 1865 de Lesseps, to show the progress that had been made, entertained over 100 delegates from chambers of commerce in different parts of the world, and conducted them over the works. In the following year the company, being in need of money, realized 10 million francs by selling to the Egyptian Government the estate of El Wadi, which it had purchased from Said, and it also succeeded in arranging that the money due to it under the award of 1864 should be paid off by 1869 instead of 1879. Its financial resources still being insufficient, it obtained in 1867 permission to invite a loan of 100 million francs; but though the issue was offered at a heavy discount it was only fully taken up after the attractions of a lottery scheme had been added to it. Two years later the company got 30 million francs from the Egyptian Government in consideration of abandoning certain special rights and privileges that still belonged to it and of handing over various hospitals, workshops, buildings, etc., which it had established on the isthmus. The Government liquidated this debt, not by a money payment, but by agreeing to forego for 25 years the interest on the 176,602 shares it held in the company, which was thus enabled to raise a loan to the amount of the debt. Altogether, up to the end of the year (1869) in which the canal was sufficiently advanced to be opened for traffic, the accounts of the company showed a total expenditure of 432,807,882 francs, though the International Technical commission in 1856 had estimated the cost at only 200 millions for a canal of larger dimensions.

The Opening, 1869.—The formal opening of the canal was celebrated in Nov. 1869. On the 16th there was an inaugural ceremony at Port Said, and next day 68 vessels of various nationalities, headed by the "Aigle" with the empress Eugénie on board, began the passage, reaching Ismailia (Lake Timsa) the same day. On the 19th they continued their journey to the Bitter lakes, and on the 20th they arrived at Suez. Immediately afterwards regular traffic began. In 1870 the canal was used by nearly 500 vessels, but the receipts for the first two years of working were considerably less than the expenses. The company failed to raise a loan of 20 million francs in 1871, and it was only saved from bankruptcy by a rapid increase in its revenues.

The total length of the navigation from Port Said to Suez is 100m. The canal was originally constructed to have a depth of 8 metres with a bottom width of 22 metres, but it soon became evident that its dimensions must be enlarged. Certain improvements in the channel were started in 1876, but a more extensive plan was adopted in 1885 as the result of the inquiries of an international commission which recommended that the depth should be increased first to $8\frac{1}{2}$ metres and finally to 9 metres, and that the width should be made on the straight parts a minimum of 65 metres between Port Said and the Bitter lakes, and of 75 metres between the Bitter lakes and Suez, increasing on curves to 80 metres. To pay for these works a loan of 100 million francs was issued. In the early days of the canal, except in the Bitter lakes, vessels could pass each other only at a few crossing places or gares, which had a collective length of less than a mile; but owing to the widenings that have been carried out, passing is now possible at any point over the greater part of the canal, one vessel stopping while the other proceeds on her way. From March 1887 navigation by night was permitted to ships which were provided with electric search-lights. By these measures the average time of transit, which was about 36 hours in 1886, has been reduced by more than one-half; in 1927 the average passage, including stoppages was only 15 hours 6 minutes. The maximum speed permitted in the canal itself is 12 kilometres an hour.

Dues; Neutrality.—The dues which the canal company was authorized to charge by its concession of 1856 were 10 francs a ton. In the first instance they were levied on the tonnage as shown by the papers on board each vessel, but from March 1872 they were charged on the gross register tonnage, computed according to the method of the British Merchant Shipping Act 1854. The result was that the shipowners had to pay more, and, objections being raised, the whole question of the method of charge was submitted to an international conference which met at Constantinople in 1873. It fixed the dues at 10 francs per net register ton (English reckoning) with a surtax of 4 francs per ton, which, however, was to be reduced to 3 francs in the case of ships having on board papers showing their net tonnage calculated in the required manner. It also decided that the surtax should be gradually diminished as the traffic increased, until in the year after the net tonnage passing through the canal reached 2,600,000 tons it should be abolished. De Lesseps protested against this arrangement, but on the sultan threatening to enforce it, if necessary by armed intervention, he gave in and brought the new tariff into operation in April 1874. By an arrangement with the canal company, signed in 1876, the British Government, which in 1875 by the purchase of the khedive's shares, had become a large shareholder, undertook negotiations to secure that the successive reductions of the tariff should take effect on fixed dates, the sixth and last instalment of 50 centimes being removed in Jan. 1884, after which the maximum rate was to be 10 francs per official net ton. But before this happened British shipowners had started a vigorous agitation against the rates, which they alleged to be excessive, and had even threatened to construct a second canal. In consequence a meeting was arranged between them and representatives of the canal company in London in Nov. 1883, and it was agreed that in Jan. 1885 the dues should be reduced to $9\frac{1}{2}$ francs a ton, that subsequently they should be lowered on a sliding scale as the dividend increased, and that after the dividend reached 25% all the surplus profits should be applied in reducing the rates until they were lowered to 5 francs a ton. Under this arrangement they were fixed at $7\frac{3}{4}$ francs per ton at the beginning of 1906. In 1928, as from April 1, the rates were reduced to 7 francs for loaded ships and 4·50 francs for ships in ballast, per Suez Canal net ton of 100 cubic feet. For passengers the dues remain at 10 francs a head, the figure at which they were originally fixed.



BY COURTESY OF LA COMPAGNIE UNIVERSELLE DU CANAL MARITIME DE SUEZ

THE SUEZ CANAL, SHOWING LOOK-OUT STATIONS ALONG ITS COURSE

By the concessions of 1854 and 1856 the dues were to be the same for all nations, preferential treatment of any kind being forbidden, and the canal and its ports were to be open "comme passages neutres" to every merchant ship without distinction of nationality. The question of its formal neutralization by international agreement was raised in an acute form during the Egyptian crisis of 1881–82, and in August of the latter year a few weeks before the battle of Tel-el-Kebir, navigation upon it was suspended for four days at the instance of Sir Garnet Wolseley, who was in command of the British forces. At the international conference which was then sitting at Constantinople various proposals were put forward to ensure the use of the canal to all nations, and ultimately at Constantinople on Oct. 29, 1888, Great Britain, Germany, Austria, Spain, France, Italy, the Netherlands, Russia and Turkey signed the Suez Canal Convention, the purpose of which was to ensure that the canal should "always be free and open, in time of war as in time of peace, to every vessel of commerce or of war, without distinction of flag." Great Britain, however, in signing, formulated a reservation that the provisions of the convention should only apply so far as they were compatible with the actual situation, namely the "present transitory and exceptional condition of Egypt," and so far as they would not fetter the liberty of action of the British government during its occupation of that country. But by the Anglo-French agreement of April 8, 1904, Great Britain declared her adherence to the stipulations of the convention, and agreed to their being put in force, except as regards a provision by which the agents in Egypt of the signatory Powers of the convention were to meet once a year to take note of the due execution of the treaty. (X.)

The World War.—In 1909, the Company approached the Egyptian Government with a request for the prolongation of their concession (due to expire in 1968). The Egyptian parliament unanimously rejected the offer. The World War in 1914 changed this situation. The defence and direction of the canal—its enormous plant and its expert personnel—were handed over to the British military authorities. The canal became the strategical frontier of Egypt, guarded by the armies and navies of France and of the British Empire. Its waterway was open to the ships of Allied and neutral powers for the whole of those four eventful years, except during a few hours of fighting on Feb. 3, 1915, when a Turkish army that had marched across the desert from Damascus to invade Egypt was routed—never to return. From end to end the banks of the canal resembled one long armed camp, of which all traces had in 1925 disappeared; and the only signs visible to future generations of that great upheaval will be the three war monuments at Port Said, Ismailia and Suez, and the railway which Lord Allenby laid from Kantara to Jerusalem for the subjugation of Palestine.

Development.—Since the war, the engineering programmes, which had been seriously interrupted, have been taken in hand with redoubled vigour. These programmes include the building of jetties and of "bassins," and the widening, deepening and straightening of the canal, a process which will be continued until the two largest ships that use Eastern and Far Eastern ports can cross one another in the canal without tying up.

Another great improvement is the creation of a new city opposite to Port Said, to which the name of Port Fuad has been given. To this new centre of activity all the company's engineering and repair shops were transferred, an operation which greatly reduced the congestion in Port Said. On this, the Asiatic side of the canal, all the employees and work-people now resident in Port Said will eventually live; and in this hope the company drew up a far-reaching scheme for a kind of garden city with avenues and boulevards, shops and schools, hospitals, churches and mosques, and with dwelling houses and apartments suitable for all classes of a very international community. This city was inaugurated by H.M. King Fuad in person in Dec. 1926.

Control and Finance.—Although the British Government holds seven-sixteenths of the shares, the company is, as a matter of fact, predominantly French for purposes of administration. On the board of management there are one Dutch, ten British and 21 French directors, and they work in closest harmony. Of the ten British directors, three represent the British Government in respect of their large holding of shares, and seven represent the shipping and commercial interests of Great Britain, which now supplies about 57% of the total traffic through the canal. Next in order of importance comes the Dutch mercantile marine, with 10% of the total; and third on the list we find Germany (whose flag was not seen on the canal between 1915 and 1920) providing 9·6%, France 6% and so on. The capital sum (£4,000,000) invested by Great Britain in Suez Canal shares in 1875 has been repaid about eight times in dividends and interest. In 1926 His Majesty's Government received £950,000 and in 1927 £1,550,000, free from all taxation at the source. The French Government owns no shares in this pre-eminently French enterprise, but it benefits to no small degree by the prosperity of the company, whose business was taxed in 1926 to the extent of about 77,000,000 francs. The value of a share (250 francs) was 18,000 francs in March 1928. (*See* PALESTINE, OPERATIONS IN.)

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SUFFOLK, EARLS AND DUKES OF. These English titles were borne in turn by the families of Ufford, Pole, Brandon, Grey and Howard. Robert, son of a Suffolk landowner, John de Peyton, acquired the lordship of Ufford in that county and was known as Robert de Ufford. He held an important place in the Government of Ireland under Edward I. and died in 1298; his son Robert (1279–1316) was created Baron Ufford in 1309. Robert's eldest surviving son, another Robert (*c.* 1298–1369), was created earl of Suffolk in 1337, and was present at the battles of Creçy and Poitiers. On the death, without heirs, of his son William, the 2nd earl, who took part in the suppression of the Peasants' Revolt in 1381, the earldom became extinct, his extensive estates reverting to the Crown.

In 1385 the earldom of Suffolk and the lands of the Uffords were granted by Richard II. to his friend Michael Pole (*c.* 1330–1389), a son of Sir William atte Pole. (*See* POLE FAMILY.)

In 1514 the title of duke of Suffolk was granted by Henry VIII. to Charles Brandon (*see* SUFFOLK, CHARLES BRANDON, 1ST DUKE OF) and it became extinct on the death of his second son Charles in July 1551. In the same year it was revived in favour of Henry Grey, marquess of Dorset, who had married Frances, a daughter of the first Brandon duke. Grey, who became marquess of Dorset in 1530, was a prominent member of the reforming party during the reign of Edward VI. He took part in the attempt to make his daughter, Jane, queen of England in 1553, but as he quickly made his peace with Mary he was not seriously punished. In 1554, however, he took part in the rising headed by Sir Thomas Wyat; he was captured, tried for treason and beheaded in February 1554, when the dukedom again became extinct. In 1603 Thomas Howard, Lord Howard de Walden, son of Thomas Howard, 4th duke of Norfolk, was created earl of Suffolk, and the earldom has been held by his descendants to the present day. (*See* SUFFOLK, THOMAS HOWARD, 1st earl of.)

SUFFOLK, CHARLES BRANDON, 1ST DUKE OF (*c.* 1484–1545), was the son of William Brandon, standard-bearer of Henry VII., who was slain by Richard III. in person on Bosworth Field. He was high in Henry VIII.'s favour, and held a succession of offices in the royal household. On May 15, 1513 he was created Viscount Lisle, having entered into a marriage contract with his ward, Elizabeth Grey, Viscountess Lisle in her own right, who, however, refused to marry him when she came of age. He distinguished himself at the sieges of Terouenne and Tournai in the French campaign of 1513. At this time Henry VIII. was secretly urging Margaret of Savoy, regent of the Netherlands, to marry Brandon, whom he created duke of Suffolk. Brandon took part in the jousts which celebrated the marriage of Mary Tudor, Henry's sister, with Louis XII. of France, on whose death he was sent to congratulate the new king Francis I. An affection between Suffolk and the dowager queen Mary had subsisted before her marriage, and Francis charged him with an intention to marry her. Henry was anxious to obtain from Francis the gold plate and jewels which had been given or promised to the queen by Louis and he practically made his acquiescence in Suffolk's suit dependent on his obtaining them. The pair cut short the difficulties by a private marriage. Suffolk was only saved from Henry's anger by Wolsey, and the pair eventually agreed to pay to Henry £24,000 in yearly instalments of £1,000, and the whole of Mary's dowry from Louis of £200,000, together with her plate and jewels. They were openly married at Greenwich on May 13. The duke had been twice married already, to Margaret Mortimer and to Anne Browne. Anne Browne died in 1511, but Margaret Mortimer, from whom he had obtained a divorce on the ground of consanguinity, was still living. He secured in 1528 a bull from Pope Clement II. assuring the legitimacy of his marriage with Mary Tudor, and of the daughters of Anne Browne. Suffolk was present at the Field of the Cloth of Gold in 1520, and in 1523 he was sent to command the English troops at Calais. He laid waste the north of France. Suffolk was in favour of Henry's divorce from Catherine of Aragon, and after Wolsey's disgrace his influence increased daily. He was sent with the duke of Norfolk to demand the great seal from Wolsey; the same noblemen conveyed the news of Anne Boleyn's marriage to Queen Catherine, and Suffolk acted as high steward at the new queen's coronation. He was commissioned by Henry to dismiss Catherine's household. He received a large share of the plunder after the suppression of the monasteries. In 1544 he was for the second time in command of an English army for the invasion of France. He died at Guildford on Aug. 24, 1545.

There is abundant material for the history of Suffolk's career in the *Letters and Papers of Henry VIII.* (ed. Brewer in the Rolls Series). *See* also Dugdale, *Baronage of England* (vol. ii. 1676); and G. E. C., *Complete Peerage.* An account of his matrimonial adventures is in the appendix to a novel by E. S. Holt, *The Harvest of Yesterday.*

SUFFOLK, CHARLES HOWARD, 9TH EARL OF (1675–1733), who succeeded to the title in June 1731, married Henrietta, a daughter of Sir Henry Hobart, bart., of Blickling, Norfolk. Both husband and wife were in the household of the prince of Wales, who, as George II., acknowledged Mrs. Howard as his mistress. She was formally separated from her husband before

1731 when she became countess of Suffolk. The earl died on Sept. 28, 1733, but the countess, having retired from court and married the Hon. George Berkeley (d. 1746), lived until July 26, 1767. Among Lady Suffolk's friends were the poets Pope and Gay and Charles Mordaunt (earl of Peterborough).

A collection of *Letters to and from Henrietta Countess of Suffolk, and her Second Husband, the Hon. George Berkeley*, was edited by J. W. Croker (1824). *See* also L. Melville, *Lady Suffolk and her Circle* (1924).

SUFFOLK, THOMAS HOWARD, 1st Earl of (1561-1626), second son of Thomas Howard, 4th duke of Norfolk, was born on Aug. 24, 1561. He behaved very gallantly during the attack on the Spanish armada and afterwards took part in other naval expeditions, becoming an admiral in 1599. Created Baron Howard de Walden in 1597 and earl of Suffolk in July 1603, he was lord chamberlain of the royal household from 1603 to 1614 and lord high treasurer from 1614 to 1618, when he was deprived of his office on a charge of misappropriating money. He was tried in the Star Chamber and was sentenced to pay a heavy fine. Suffolk's second wife was Catherine (d. 1633), widow of the Hon. Richard Rich, a woman whose avarice was partly responsible for her husband's downfall. She shared his trial and was certainly guilty of taking bribes from Spain. One of his three daughters was the notorious Frances Howard, who, after obtaining a divorce from her first husband, Robert Devereux, earl of Essex, married Robert Carr, earl of Somerset, and instigated the poisoning of Sir Thomas Overbury (*q.v.*). The earl died on May 28, 1626.

SUFFOLK, WILLIAM DE LA POLE, Duke of (1396–1450), second son of Michael de la Pole, second earl of Suffolk, was born on Oct. 16, 1396. Suffolk served in all the later French campaigns of the reign of Henry V., and in spite of his youth held high command on the marches of Normandy in 1421–22. In 1423 he joined the earl of Salisbury in Champagne, and shared his victory at Crevant. He fought under John, duke of Bedford, at Verneuil on Aug. 17, 1424, and throughout the next four years was Salisbury's principal lieutenant in the direction of the war. When Salisbury was killed before Orleans on Nov. 3, 1428, Suffolk succeeded to the command. After the siege was raised, Suffolk was defeated and taken prisoner by Jeanne d'Arc at Jargeau on June 12, 1429. He was soon ransomed, and during the next two years was again in command on the Norman frontier. He returned to England in November 1431, after over fourteen years' continuous service in the field.

Suffolk had already been employed on diplomatic missions by John of Bedford; anxious for peace, he attached himself to Cardinal Beaufort. The question of Henry VI.'s marriage brought him to the front. Humphrey of Gloucester favoured an Armagnac alliance. Suffolk brought about the match with Margaret of Anjou. When he returned to England in June 1444, after negotiating the marriage and a two years' truce, he received a triumphant reception. He was made a marquess, and in the autumn sent again to France to bring Margaret home. The French extorted from him a promise to surrender all the English possessions in Anjou and Maine, a fatal concession. Humphrey of Gloucester died in February 1447, within a few days of his arrest, and six weeks later Cardinal Beaufort died also. Rumour, though without sufficient reason, made him responsible for Humphrey's death, while the peace and its consequent concessions rendered him unpopular. So also did the supersession of Richard of York by Edmund Beaufort, duke of Somerset, in the French command. Suffolk's promotion to a dukedom in July 1448, marked the height of his power. The difficulties of his position may have led him to give some countenance to a treacherous attack on Fougères during the time of truce (March 1449). The renewal of the war and the loss of all Normandy were its direct consequences. When parliament met in Nov. 1449, the opposition showed its strength by forcing the treasurer, Adam Molyneux, to resign. Molyneux was murdered by the sailors at Portsmouth on Jan. 9, 1450. Suffolk boldly challenged his enemies in parliament, appealing to the long and honourable record of his public services. The Commons now presented articles of accusation dealing chiefly with alleged maladministration and the ill success of the French policy, there was a charge of aiming at the throne by the betrothal of his son to the little Margaret Beaufort. Suffolk denied the accusations as false, untrue and too horrible to speak more of. Ultimately the king sentenced him to banishment for five years. Suffolk left England on May 1. He was intercepted in the Channel by the ship "Nicholas of the Tower," and next morning was beheaded in a little boat alongside.

Popular opinion at the time judged Suffolk as a traitor. This view was accepted by Yorkist chroniclers and Tudor historians, who had no reason to speak well of a Pole. Later legend made him the paramour of Margaret of Anjou, which the story appears in the *Mirrour for Magistrates*, and Shakespeare's *2 Henry VI.* (Act. III. sc. ii.). Suffolk's best defence is contained in the touching letter of farewell to his son (*Paston Letters*, i. 142), and in his noble speeches before parliament (*Rolls of Parliament*, v. 176, 182). The policy of peace which he pursued was just and wise; he foresaw its risk to himself.

Suffolk's wife, Alice, was widow of Thomas, earl of Salisbury, and granddaughter of Geoffrey Chaucer. By her he had an only son John, second duke of Suffolk.

Bibliography.—Suffolk is necessarily prominent in all contemporary authorities. The most important are J. Stevenson's *Wars of the English in France*, Thomas Beckington's *Correspondence*, T. Wright's *Political Poems and Songs*, ii. 222–234 (for the popular view)—these three are in the Rolls Series; and the *Paston Letters*. Of French writers E. de Monstrelet and Jehan de Waurin are most useful for his military career, T. Basin and Matthieu d'Escouchy for his fall (all these are published by the Société de l'Histoire de France). For modern accounts *see* especially W. Stubbs, *Constitutional History* (favourable), *The Political History of England* (1906), vol. iv., by C. Oman (unfavourable), and G. du Fresne de Beaucourt's *Histoire de Charles VII*. *See* also H. A. Napier's *Historical Notices of Swincombe and Ewelme* (1858).

SUFFOLK, an eastern county of England. Area 1,488·6 sq. miles. Much of the county is formed by low hills, rising occasionally over 400 ft. They are a continuation of the Chilterns and they form the main watershed of the county. They consist of chalk, covered to the east by boulder clay, with glacial sand interspersed with patches of London clay, Pliocene deposits and alluvium. Alluvium also appears in the fens in the north-west. Subsidence has let the sea far into the land along the rivers.

Palaeolithic implements have been found in fair abundance in some of the gravels in the north-west of the county, less abundantly from there southward to the Stour and only sporadically in other parts of the county. In Neolithic times the middle of the county with its boulder clays was probably for the most part forested, and this accounts for the fact that most of the artefacts of this age have been found on the higher chalk lands of the west and on the lighter soils near the coast especially in the north and south extremities of the county. In other parts they are found generally along the river-valleys that are floored with gravel. A marked feature of pre-historic Suffolk is the number of beaker-pots of the late Neolithic or early Metal age which have been found there. These have been found particularly around the estuaries of the Stour, Orwell and Deben, where presumably, the immigrants landed first. It is thought that they then pushed up the rivers into the north-western part of the county and here a number of other beakers have been discovered. Bronze implements have been found in much the same places as the Neolithic, except that they are scarce in the north-east. In the centuries immediately preceding the Christian era Suffolk was invaded by Brythonic tribes, and traces of their handiwork have been found here. Along with Norfolk it formed part of the kingdom of the Iceni, and it was ravaged by the Romans after the unsuccessful revolt of Boudicca (Boadicea). The Roman road from Colchester to Venta Icenorum crossed the county from near Stratford St. Mary to Scole. Just north of the Gipping this road threw out a branch in the direction of Dunwich, whence it led north-west again to cross the Waveney near Bungay. To the west there ran from north to south from Norfolk the continuation of the Peddar's way. The ancient track of the Icknield way ran along the chalk hills of the north-west. On the Suffolk coast the Romans built two forts to guard the Saxon shore—the first has left traces at Burgh castle, the other, which was at Walton near Felixstowe, has been washed away by the sea.

The county of Suffolk (Sudfole, Suthfolc) was formed from the south part of the kingdom of East Anglia which had been settled by the Angles in the latter half of the 5th century. The most important Anglo-Saxon settlements appear to have been made at Sudbury and Ipswich. It suffered severely from the Danish incursions and after the treaty of Wedmore formed part of Danelaw. The whole shire lay within the diocese of Dunwich, which was founded *c.* 631. In 673 a new bishopric was established at Elmham to comprise the whole of Norfolk which had formerly been included in the see of Dunwich. The latter came to an end with the incursion of the Danes, and on the revival of Christianity in this district Suffolk was included in the diocese of Ely. The county has now become part of the new diocese of St. Edmundsbury and Ipswich. There were a number of religious houses in the county, and the most important remains are those of the great Benedictine abbey of Bury St. Edmunds; the college of Clare, originally a cell to the abbey of Bec in Normandy and afterwards to St. Peter's Westminster, converted into a college of secular canons in the reign of Henry VI., still retaining much of its ancient architecture, and now used as a boarding-school; the Decorated gateway of the Augustinian priory of Butley; and the remains of the Grey Friars monastery at Dunwich. A peculiarity of the church architecture is the use of flint for purposes of ornamentation. Another characteristic is the round towers, the principal examples being those of Little Saxham and Herringfleet, both Norman. The Decorated is well represented, but by far the greater proportion of the churches are Perpendicular. The church of Blythburgh in the east and the ornate building at Lavenham in the west may be noted as typical, while the church of Long Melford, another fine example, should be mentioned on account of its remarkable lady chapel. Special features are the open roofs and woodwork (as at St. Mary's, Bury St. Edmunds, Earl Stonham and Stonham Aspall, Ufford and Blythburgh), and the fine fonts.

The Normans built castles in the county at Eye and Walton, and there are remains of the entrenchments and part of the walls of Bungay, the ancient stronghold of the Bigods; the ruins of Mettingham, built in the reign of Edward III.; Wingfield, surrounded by a deep moat, with the turret walls and the drawbridge still existing; the ruin of Framlingham, with high and massive walls, originally founded in the 6th century, but restored in the 12th; the outlines of the fortress of Clare castle, anciently the baronial residence of the earls of Clare; and the Norman keep of Orford castle. Probably the establishment of Suffolk as a separate shire was scarcely completed before the Conquest, and although it was reckoned as distinct from Norfolk in the Domesday survey of 1086, the fiscal administration of Norfolk and Suffolk remained under one sheriff until 1575. The shire court was held at Ipswich. In 1086 Babergh was rated as two hundreds, Cosford, Ipswich and Parham as half hundreds, and Samford as a hundred and a half. Hoxne hundred was formerly known as Bishop's hundred and the vills which were included later in Thredling hundred were within Claydon hundred. More than half the county was included in the ecclesiastical liberties of St. Edmund and St. Aethelreda of Ely, and in these the king's writs did not run.

In 1173 the earl of Leicester landed at Walton with an army of Flemings and was joined by Hugh Bigod against Henry II. Since 1290 the county was constantly represented in Parliament by two knights. In 1317 and the succeeding years a great part of the county was in arms for Thomas of Lancaster. Queen Isabella and Mortimer having landed at Walton found all the district in their favour. In 1330 the county was raised to suppress the supporters of the earl of Kent; and again in 1381 there was a serious rising of the peasantry chiefly in the neighbourhood of Bury St. Edmunds. Although the county was for the most part Yorkist it took little part in the Wars of the Roses. In 1525 the artisans of the south strongly resisted Henry VIII.'s forced loan. It was from Suffolk that Mary drew the army which supported her claim to the throne. In the Civil Wars the county was for the most part parliamentarian, and joined the Association of the Eastern Counties. Within the county there are several interesting examples of domestic architecture of the reigns of Henry VIII. and Elizabeth. Hengrave hall (*c.* 1530), 4 m. N.W. from Bury St. Edmunds, is a building of brick and stone, enclosing a court-yard. Another is Helmingham hall, a Tudor mansion of brick, surrounded by a moat crossed by a drawbridge. West Stow manor is also Tudor with a fine gatehouse.

The Reform bill of 1832 gave four members to Suffolk, at the same time disfranchising the boroughs of Dunwich, Orford and Aldeburgh. For parliamentary purposes the county now constitutes five divisions, each returning one member, viz., Lowestoft division, Eye, Bury St. Edmunds, Sudbury and Woodbridge. Ipswich returns one member, and part of the borough of Great Yarmouth falls within the county.

Suffolk was early among the most populous of English counties. Fishing fleets had left its ports to bring back cod and ling from Iceland and herring and mackerel from the North sea, while it carried on a trade with Flanders. From the 14th to the 17th century it was among the chief manufacturing counties of England owing to its cloth-weaving industry, which was at the height of its prosperity during the 15th century. In the 17th and 18th centuries its agricultural resources were utilized to provide the rapidly-growing metropolis with food. In the following century various textile industries, such as the manufacture of sail-cloth, coconut fibre, horse-hair and clothing were established; silk-weavers migrated to Suffolk from Spitalfields, and early in the 19th century an important china factory flourished at Lowestoft.

In the 18th century Suffolk was famed for its dairy products, but the high price of grain during the wars of the French Revolution led to the breaking up of the pastures and it is now one of the principal grain-growing counties in England. In 1926 the acreage of land under crops and grass was 742,693; 552,383 of which were arable. Barley is the chief grain crop with 126,179 ac., wheat next, 97,866 ac., and then oats with about half as much acreage as wheat. Mangolds, turnips, and swedes occupied 47,271 acres and sugar beet 35,000 acres. Beans and peas covered nearly 50,000 acres. The acreage of clover and rotation grasses for hay was 55,589. Suffolk punch horses are famous and the native breed of cows is of the polled variety. Milk is sent to London and other towns, while a large number of cattle are also fattened in the county. Sheep, usually a cross between the old Norfolk horned and the Southdown are reared on the drier soils, while large numbers of pigs are also bred.

The most important manufactures relate to agriculture. They include that of agricultural implements, especially at Ipswich, Bury St. Edmunds and Stowmarket, and that of artificial manures at Ipswich and Stowmarket, for which coprolites are dug. Malting is extensive, with small manufactures, including silk, cotton, linen, woollen and horsehair and coconut matting.

The L.N.E. railway serves the county. Suffolk comprises 21 hundreds, and, since 1888, for administrative purposes is divided into the counties of East Suffolk (557,353 ac.), population (1921) 291,073, and West Suffolk (390,916 ac.), population, 108,985.

The following are the municipal boroughs:

(1) East Suffolk. Aldeburgh, Beccles, Eye, Ipswich, a county borough and the county town, Lowestoft, Southwold.

(2) West Suffolk. Bury St. Edmunds, Sudbury.

There is one court of quarter sessions for the two administrative counties, which is usually held at Ipswich for East Suffolk, and then by adjournment at Bury St. Edmunds for West Suffolk. The boroughs of Bury St. Edmunds, Ipswich and Sudbury have separate courts of quarter sessions.

See A. Suckling, *The History and Antiquities of Suffolk* (1846–48); William White, *History, gazetteer and directory of Suffolk* (1855); John Kirby, *The Suffolk Traveller* (1735); A. Page, *Supplement to the Suffolk Traveller* (1843); *Victoria County History: Suffolk;* Christopher Marlowe, *People and Places in Marshland* (1927).

SUFFOLK, a city of south-eastern Virginia. Pop. 9,123 in 1920 (40% negroes); estimated locally (including suburbs) at 17,500 in 1928. Suffolk peanut sales amount to $25,000,000 annually. There are seven peanut factories, several oyster-packing plants, and other industries. Suffolk was founded and incorporated in 1742, and chartered as a city in 1910. Since 1919 it has had a city-manager form of government. St. Luke's church near by (built in 1632) is one of the oldest churches in the United States.

SUFFRAGAN (1) a diocesan bishop in his relation to the metropolitan; (2) an assistant bishop. (*See* Bishop.)

SUFFRAGE, the right or the exercise of the right of voting in political affairs; in ecclesiastical use, the short intercessory prayers in litanies spoken or sung by the people as distinguished from those of the priest or minister. (*See* Electoral Systems; Electors; Representation; Vote and Voting; Registration: and, for the Women's Suffrage Movement, Women's Suffrage.)

SUFFREN SAINT TROPEZ, PIERRE ANDRÉ DE (1729–1788), French admiral, was born in the Château de Saint Canat (Aix) on July 17, 1729. He entered the Order of Malta and also the close and aristocratic corps of French naval officers as a cadet in October 1743, in the "Solide," one of the line of battleships which took part in the confused engagement off Toulon in 1744. He was next in the "Pauline" in the squadron of M. Macnémara on a cruise in the West Indies. In 1746 he went through the duc D'Anville's disastrous expedition to retake Cape Breton, which was ruined by shipwreck and plague. Next year (1747) he was taken prisoner by Hawke in the action with the French convoy in the Bay of Biscay. When peace was made in 1748 he went to Malta to perform the cruises with the galleys of the Order of Malta technically called "caravans," a reminiscence of the days when the knights protected the pilgrims going from Saint Jean d'Acre to Jerusalem. In Suffren's time this service rarely went beyond a peaceful tour among the Greek islands. Suffren was present at the taking of Minorca, but in 1757 he was again a prisoner of the English. After the peace, on the French ship "Caméléon," he chased the Barbary pirates, and from 1767 to 1771 he returned to his "caravan," becoming a commander of his Order.

In the years 1778 and 1779 he served with the squadron of D'Estaing (*q.v.*) on the coast of North America and in the West Indies. He led the line in the action with Admiral John Byron off Grenada, and his ship, the "Fantasque" (64), lost 62 men. His letters to his admiral show that he strongly disapproved of D'Estaing's half-hearted methods. In 1780 he was captain of the "Zèle" (74), in the combined French and Spanish fleets which captured a great English convoy in the Atlantic. His candour towards his chief had done him no harm in the opinion of D'Estaing. It is said to have been largely by the advice of this admiral that Suffren was chosen to command a squadron of five ships of the line sent out to help the Dutch who had joined France and Spain to defend the Cape against an expected English attack, and then to go on to the East Indies.

He sailed from Brest on March 22 on the cruise which has made him unique among French admirals, and he was by experience as well as by temperament impatient with the formal manoeuvring of his colleagues, which aimed at preserving their own ships rather than at taking the English. On April 16, 1781, he found the English expedition on its way to the Cape under the command of George Johnstone (1730–1787), at anchor in Porto Praya, Cape de Verde Islands. Remembering how little respect Boscawen had shown for the neutrality of Portugal at Lagos, he attacked at once. He pushed on to the Cape, which he saved from capture by Johnstone, and then made his way to the Île de France (Mauritius), then held by the French. D'Orves, his superior officer, died as the united squadrons, now eleven sail of the line, were on their way to the Bay of Bengal. The campaign, which Suffren now conducted against the English admiral Sir Edward Hughes (1720?–1794), included many severe encounters. Four actions took place in 1782: south of Madras (Feb. 17), near Trincomalee (April 12), off Cuddalore (July 6), and at Trincomalee (Sept. 3). The English lost no ships in these actions; neither did they take any. Suffren attacked with unprecedented vigour on every occasion, but was ill-supported by some of his captains. He maintained his squadron without a port to refit, and anchored at Trincomalee. His activity encouraged Hyder Ali, who was then at war with the Company. He refused to return to the islands to escort the troops coming out under command of Bussy, maintaining that his proper purpose was to cripple the squadron of Sir Edward Hughes.

During the north-east monsoon he would not go to the islands but refitted in the Malay ports in Sumatra, and returned with the south-west monsoon in 1783. Hyder Ali was dead, but Tippoo Sultan, his son, was still at war with the Company. Bussy arrived and landed. The operations on shore were slackly conducted by him, and Suffren was much hampered, but when he fought his last battle against Hughes (April 20, 1783), with fourteen ships to eighteen he forced the English admiral to retire to Madras, leaving the army then besieging Cuddalore in a very dangerous position. The arrival of the news that peace had been made in Europe put a stop to hostilities, and Suffren returned to France. While refitting at the Cape on his way home, several of the vessels also returning put in, and the captains waited on him. Suffren said in one of his letters that their praise gave him more pleasure than any other compliment paid him.

In France he was received with enthusiasm, and an additional office of vice-admiral of France was created for him. He had been promoted bailli in the Order of Malta during his absence. He died on Dec. 8, 1788, when he was about to take command of a fleet collected in Brest. Long afterwards it was stated that he was killed in a duel with the prince de Mirepoix in consequence of a refusal to restore to their naval rank two of his relatives who had been dismissed from the service.

The standard authority for the life of Suffren is the *Histoire du Bailli de Suffren* by Ch. Cunat (1852). The *Journal de Bord du Bailli de Suffren dans l'Inde,* edited by M. Mores, was published in 1888. There is an appreciative study in Captain Mahan's *The Influence of Sea Power upon History, 1660–1783* (1890).

ṢŪFĪISM (*taṣawwuf*) is formed from the Arabic word *Ṣūfī,* which was applied, in the 2nd century of Islam, to men or women who adopted an ascetic or quietistic way of life. The word *Ṣūfī* from *ṣūf* (wool) refers to garments worn by such persons.

Mysticism in Islam goes back to Mohammed who, notwithstanding his condemnation of Christian monkery, was led by the example of the hermits and of the Ḥanīfs, to preach the efficacy of ascetic exercises, such as prayer, vigils and fasting. Again, while Allah is described in the *Qur'ān* as the one God working his arbitrary will in unapproachable supremacy, other passages lay stress on his all-pervading presence and intimate relation to his creatures, *e.g.,* "Wherever ye turn, there is the face of Allah" (ii. 109), "We (God) are nearer to him (man) than his neck-vein" (l. 15). The germs of mysticism latent in Islam from the first rapidly developed in the two centuries following the prophet's death in consequence of Messianic hopes and presages, the luxury of the upper classes and the hard mechanical piety of the orthodox creed. The terrors of hell, so vividly depicted in the *Qur'ān* awakened in many an intense consciousness of sin, which drove them to seek salvation in ascetic practices. Ṣūfīism was originally a practical religion, not a speculative system, and the early *Ṣūfīs* were closely attached to the Muslim doctrine, but they took up and emphasized certain *Qur'ānic* terms, such as *dhikr* (praise of God) consisting of recitation of the *Qur'ān,* repetition of the Divine names, etc., and *tawakkul* (trust in God), now defined as renunciation of all personal initiative and volition, leaving one's self entirely in God's hands. Quietism soon passed into mysticism. Towards the end of the 2nd century the doctrine of mystical love was set forth in the sayings of a female ascetic, Rābi'a of Basra. Henceforward the use of symbolical expressions, borrowed from the vocabulary of love and wine, becomes increasingly frequent as a means of indicating holy mysteries which must not be divulged. This was not an unnecessary precaution, for in the course of the 3rd century, there sprang up a speculative and pantheistic movement which was essentially anti-Islamic. A little later Abū Sulaymān al-Dārānī in Syria and Dhu'l-Nūn in Egypt developed the doctrine of gnosis (*ma'rifat*) through illumination and ecstasy. The step to pantheism was first decisively taken by the Persian Abū Yazīd (Bāyezīd) of Bisṭām (d. A.D. 874), who introduced the doctrine of annihilation (*fanā*), *i.e.* the passing away of individual consciousness in the will of God.

ITS EVOLUTION

In the evolution of Ṣūfīism, influences outside of Islam made themselves powerfully felt. Christian influence had its source, not in the Church, but in the hermits and unorthodox sects, to whose ideal of unworldliness Ṣūfīism owed much. More than one Ṣūfī doctrine—that of *tawakkul* in particular—show traces of Christian teaching. The monastic strain which insinuated itself into Ṣūfīism in spite of Mohammed's prohibition was derived, partially at any rate, from Christianity. But Buddhistic influence may also have been at work. Buddhism flourished in Balkh, Transoxiana and Turkestan before the Mohammedan conquest, and in later times Buddhist monks carried their religious practices and philosophy among the Muslims who had settled in these countries. The use of rosaries, the doctrine of *fanā,* which is probably a form of Nirvāna, and the system of "stations" (*maqāmāt*) on the road thereto, would seem to be Buddhistic in their origin. The third great foreign influence on Ṣūfīism is the Neoplatonic philosophy. Between A.D. 800 and 860 the tide of Greek learning, then at its height, streamed into Islam. The so-called "Theology of Aristotle," which was translated into Arabic about A.D. 840, is full of Neoplatonic theories, and the mystical writings of the pseudo-Dionysius were widely known throughout western Asia. It is not mere coincidence that the doctrine of Gnosis was first worked out in detail by the Egyptian Ṣūfī, Dhu'l-Nun (d. A.D. 859), for Ṣūfīism on its theosophical side was largely a product of Alexandrian speculation.

By the end of the 3rd century Ṣūfī mysticism was fast becoming an organized system, with rules of discipline and devotion which the novice was bound to learn from his spiritual director, to whose guidance he submitted himself absolutely, as to one regarded as being in intimate communion with God. At the head of these directors stood a mysterious personage called the *Quṭb* (Axis); on the hierarchy of saints over which he presided the whole order of the universe was believed to depend. During the next two hundred years (A.D. 900–1100), various manuals of theory and practice were compiled: the *Kitāb al Luma'* by Abū Naṣr al-Sarrāj, the *Qūt al-Qulūb* by Abū Ṭālib al-Makkī, the *Risāla* of Qushayrī, the Persian *Kashf al-Maḥjūb* by 'Alī ibn 'Uthmān al-Hujwīrī, and the famous *Iḥyā* by Ghazālī. They all expatiate on the discipline of the soul and describe the process of purgation which it must undergo before entering on the contemplative life. The traveller journeying towards God passes through a series of ascending "stations"; in the oldest extant treatise these are: (1) repentance, (2) abstinence, (3) renunciation, (4) poverty, (5) patience, (6) trust in God, (7) acquiescence in the will of God. After the "stations" comes a parallel scale of "states" of spiritual feeling (*aḥwāl*), such as fear, hope, love, etc., leading up to contemplation (*mushāhadat*) and intuition (*yaqīn*). It only remained to provide Ṣūfīism with a metaphysical basis, and to reconcile it with orthodox Islam. The double task was finally accomplished by Ghazālī (*q.v.*). He made Islamic theology mystical, and since his time the revelation (*kashf*) of the mystic has taken its place beside tradition (*naql*) and reason (*'aql*) as a source and fundamental principle of the faith.

MANY SHADES OF OPINION

The Ṣūfīs comprise many shades of opinion—from asceticism and quietism to pantheism. The pantheistic type which prevails in Persia throws the transcendental and visionary aspects of Ṣūfīism into undue relief, as in the sayings attributed to Bāyazīd (d. A.D. 874), *e.g.*, "I am the winedrinker and the wine and the cup-bearer"; "I went from God to God, until they cried from me in me, 'O Thou I.'" The peculiar imagery which distinguishes the poetry of the Persian Ṣūfīs was developed by Abū Sa'īd ibn Abi'l-Khayr (d. A.D. 1049) in his quatrains which express the relation between God and the soul by glowing and fantastic allegories of earthly love, beauty and intoxication. Henceforward, the great poets of Persia, with few exceptions, adopt this symbolic language. The whole doctrine of Persian Ṣūfīism is expounded in the celebrated *Mathnawī* of Jalāluddīn Rūmī (*q.v.*) but in a discursive and unscientific manner; its leading principles may be stated briefly as follows:—

God is the sole reality (al-Ḥaqq) and is above all names and definitions. He is not only absolute Being, but also absolute Good, and therefore absolute Beauty. It is the nature of beauty to desire manifestation; the phenomenal universe is the result of this desire, according to the famous Tradition in which God says, "I was a hidden treasure, and I desired to be known, so I created the creatures in order that I might be known." As things can be known only through their opposites, Being can only be known through Not-being, wherein as in a mirror Being is reflected; and this reflection is the phenomenal universe, which accordingly has no more reality than a shadow cast by the sun.

The Ṣūfī theosophy as it appears in Persian and Turkish poetry tends to abolish the distinction between good and evil—the latter is nothing but an aspect of not-being and has no real existence—and it leads to the deification of the hierophant who can say, like Ḥusain b. Manṣur al-Ḥallāj, "I am the Truth." Ṣūfī fraternities, living in a convent under the direction of a shaykh, became widely spread before A.D. 1100 and gave rise to Dervish orders, most of which indulge in the practice of exciting ecstasy by music, dancing, drugs and various kinds of hypnotic suggestion (*see* DERVISH).

BIBLIOGRAPHY.—The foremost authority is Professor R. A. Nicholson, whose writings [*Selected poems from the Dīvāni Shamsi Tabrīz*, translated with an introduction, etc. (Cambridge, 1898); *Enquiry concerning the origin and development of Ṣūfīism* (J.R.A.S., 1906, 303 *sqq.*); *Translation of the Kashf al-Mahjūb, the oldest Persian treatise on Ṣūfīism* (London, 1911); *Studies in Islamic Mysticism* (Cambridge, 1921); *The Idea of Personality in Ṣūfīism* (Cambridge, 1923); together with his more popular treatise *The Mystics of Islam* (London, 1914)] have caused most previous works to have merely an antiquarian interest. He also published the text and translation of *The Mathnawí of Jalálu'ddín Rúmí* (Books I. and II., London, 1925, 1926). An excellent introduction to the study of Islamic mysticism is given in E. J. W. Gibb's *History of Ottoman Poetry*, I, 33 *sqq.* (London, 1900). Professor L. Massignon's *La Passion d'al-Ḥallaj, martyr mystique de l'Islam*, followed by *Essai sur les origines du lexique technique de la mystique musulmane* (Paris, 1922), is a mine of erudition. Some account of Ṣūfīism is also given by D. B. Macdonald, *The religious attitude and life in Islam* (Chicago, 1909), and I. Goldziher, *Vorlesungen über den Islam* (Heidelberg, 1925).

SUGAR. This name applies to over 100 substances, having distinctive properties and scientific names; for example, sucrose, glucose, fructose, lactose, maltose.

Of the numerous sugars which occur in plants, sucrose (*q.v.*) is the most abundant and has been extracted commercially from sugar cane, sugar beet, maple tree, Indian maize, sorghum grass, and several species of palm. As it occurs in solution in the sap or juice, man's task is to extract the juice, and to convert the dissolved sucrose into the marketable crystals we call *sugar.* Therefore, cane sugar, beet sugar, maple sugar, etc., consist essentially of sucrose, admixed with small percentages of impurities derived from the plant-juices. These impurities account for differences in colour, odour, and flavour of raw cane and beet sugars. When refined these sugars are colourless and odourless, have equal sweetening power, contain about 99·8% of sucrose, and cannot be distinguished by chemical analysis. After further purification in the laboratory, they both contain 100% of sucrose.

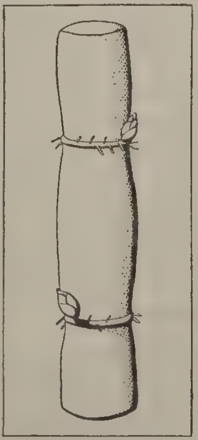
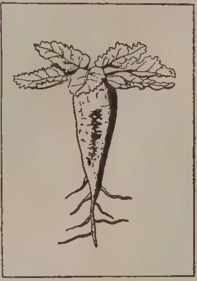

FROM HERIOT, "MANUFACTURE OF SUGAR" (LONGMANS GREEN & CO.)

FIG. 1.—SUGAR CANE STEM

The Sugar Cane.—This plant is a gigantic grass, sometimes attaining, under favourable conditions of growth, a height of 20 ft. (*See* Plate, fig. 1.) The average length of stalk is about 12 ft. The plant belongs to the natural order *Gramineae*, genus *Saccharum*, and is a perennial. It requires a moist and warm climate. Some varieties can only thrive in the tropics, others can be grown successfully in sub-tropical countries. The time required to reach maturity varies with climate and averages 13 months. The stems of different varieties vary in diameter from one half to nearly three inches, and are divided transversely by nodes (fig. 1).

The stem has a hard, very thin skin or rind, varying in colour from pale yellow or green to deep purple and sometimes striped with two colours. The interior of the stem is solid, consisting of colourless fibrous tissue in which the juice is stored. The leaves are from 3 to 4 ft. in length and from 2 to 3 in. in width, a single leaf springing from each node, and on alternate sides of the stem. Although the plant usually bears flowers and seed, it has always been propagated from cuttings of the stem, the attached "eyes" or buds (fig. 1) then forming a cluster or *stool* of canes.

When harvested, the canes are cut at the ground-level, the leafy upper joints (*tops*) cut off and reserved for planting material, and the long stems transported to the sugar factory. They contain from 11 to 16% of sucrose, with a general average of 13%. The root-stock, left in the ground, remains alive and sends up new stems in successive years. On reaching maturity, most varieties produce an immense number of flowers, of microscopic size, forming a feathery plume called the *arrow*. This is borne on a stalk which grows erect from the top of the stem, to a height of 2 or 3 ft.



FROM HERIOT, "MANUFACTURE OF SUGAR" (LONGMANS GREEN & CO.)

FIG. 2.—SUGAR BEET

Since 1890, great efforts have been made to produce improved varieties of cane, following the example set in the beet sugar industry. For this purpose, the cane was raised from seed, and hybrid varieties obtained with greater resistance to disease.

The Sugar Beet.—This plant belongs to the natural order *Chenopodiaceae*, genus *Beta*, and belongs to the same family as the red garden beet and mangel-wurzel. The modern sugar beet (fig. 2) was evolved from a white beet (*Beta Alba*) formerly grown as a forage crop in Silesia. By systematic seed-selection, extending over many years, the sucrose content was gradually increased from about 5% in the Silesian root, to 20%, or even more. At the same time, the tap-root was much reduced in size, and the purity of the sap increased by a reduction in the saline impurities. The plant is a biennial, developing root and foliage and storing up sucrose during the first year's growth. During the second year, it sends up tall, branched shoots which flower and bear seed, after which the plant dies.

The tap-root consists of colourless parenchyma tissue, in which the juice is stored, and alternate layers of fibrous tissue. The external skin is usually white, but, in some varieties, pink. Fine root-threads extend from the sides and apex of the tap-root, to supply the plant with water and mineral plant-foods. The large leaves spring from the top, or crown of the tap-root, and spread laterally just above the ground. The flowers are very small, greenish in colour, and finally develop into the fruit or seed-ball. This is commonly called the *seed*, but contains from one to seven embryos (true seeds), and is used for propagating the plant.

All modern varieties are derived from two standard types of "improved" sugar beet, namely, *Vilmorin's Blanche Ameliorée* produced in France, and *Klein Wanzleben* produced in Germany. Although some varieties may contain over 20% of sucrose, the average sucrose-content is 16%, as compared with 13% for the sugar cane.

The Cane and Beet Compared.—The record production for beet was 2·19 tons of commercial sugar per acre in Germany in 1910–11, and for cane 5·5 tons per acre in Java in 1925–26; or about 2½ times that for beet. The corresponding crops were 12 tons of washed beets and 42 tons of canes per acre.

For the Chemistry of the Sugars, *see* articles: CARBOHYDRATES; SUCROSE; GLUCOSE; and FRUCTOSE.

MANUFACTURING AND REFINING

Formerly, white sugar could be produced only by the combined operations of the "raw sugar factory" and the "refinery." Raw sugars, made from cane and beet juices, contain about 96% of sucrose. Refined white sugars, made by further treatment of raw sugars, contain about 99·8% of sucrose. With progress in sugar technology, it became possible to produce white sugars, of high purity, from cane and beet juices by a direct process (not used in the refinery). They are termed "direct consumption sugars."

Extraction from the Cane.—From the earliest times, the juice has been extracted by crushing the canes between rollers, and a simple form of mill consists of three horizontal rollers, one being placed above the other two (*see* one of the four mills shown in section in fig. 3). Slow rotary motion of the top-roller is transmitted to each of the two lower rollers (front and back rollers) by toothed gearing, causing the three rollers to rotate at the same speed of 2 to 2½ rev. per min. The canes are crushed between the top and front rollers, and again, between the top and back rollers; while the extracted juice flows down the surfaces of the two lower rollers and falls into a receiver below, whence it flows to a strainer and pump.

The modern cane-mill, fig. 3, is a combination of three or more of these mills, with mechanical transporters for carrying the crushed cane (*megass* or *bagasse*) from one mill to the next, and from the last mill to the furnaces, where it is used as fuel. In order to prepare a uniform and compact *feed* entering the first mill, the canes are first reduced to small pieces by passing through one or more machines, called *knives, crushers* and *shredders*. In fig. 3, the first mill is preceded by a crusher, consisting of two rollers having interlocking teeth which cut the canes into short lengths, squeezing them and extracting much juice.

The heavy pressure applied by the mill-rollers is produced by hydraulic power acting on the sliding bearings of each top-roller, forcing these rollers vertically downwards upon the *feed* passing over the lower rollers. One top-roller may thus apply a pressure of over 500 tons.

The extraction is greatly increased by spraying water upon the bagasse as it passes from one mill to the next, thus diluting the unextracted juice in the bagasse, and facilitating its extraction in the following mill. In fig. 3, water is sprayed upon the bagasse behind the third mill; the very dilute juice extracted by the fourth is pumped to a spraying-pipe behind the second (*see* pipe-line and arrow); and the dilute juice extracted by the third mill is pumped to a spraying-pipe behind the first. The juice extracted by the crusher and first two mills flows to a tank from which it is pumped to another part of the factory. By this system of spraying with water and dilute juice, the mill shown in fig. 3 will extract from 95 to 96% of the total sucrose in the canes. The addition of a shredder between the crusher and the first mill will increase the extraction to 97 or even 98%, according to the quantity of saturation water applied between the mills. A more powerful milling plant consists of two sets of knives, followed by a crusher, a shredder and five mills, and extracting about 99% of the sucrose in the canes.

The bagasse, leaving the last mill, contains about 45% water, 50% fibre, and 2 to 4% unextracted sucrose. Under normal conditions, no other fuel is required for steam production.

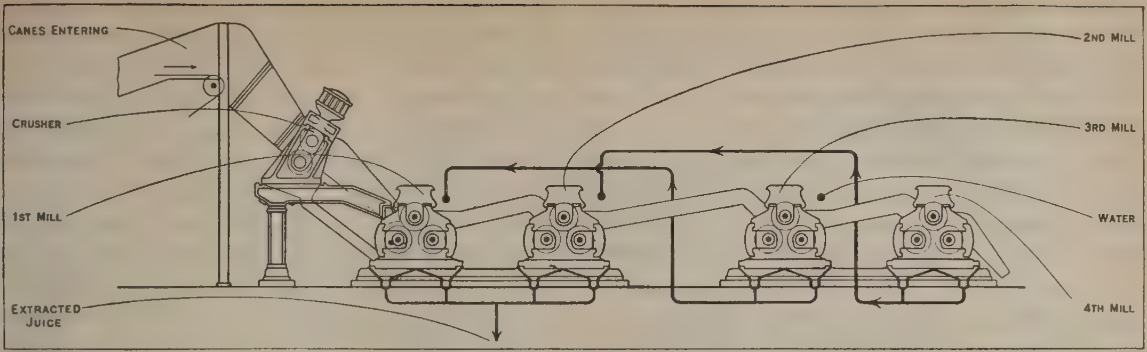
The extracted juice is a dark, opaque liquid, having an acid reaction. It contains from 12 to 16% of dissolved sucrose, and small percentages of glucose, fructose, organic acids, colouring matters, nitrogen compounds, pectin, gum and mineral matters. It also holds in suspension finely divided fibre, wax, clay and air-bubbles; the last slowly rising to the surface, forming a thick white foam.

Chemical Treatment of the Juice.—As the dissolved non-sugars are colloidal (*see* COLLOIDS), the juice must undergo some form of chemical treatment before it can be filtered satisfactorily. The natural acidity of the juice must also be neutralized, because sucrose decomposes on heating acid juices, the sucrose combining with water and breaking up into two simpler sugars, glucose and fructose, as shown in the equation:—

$$C_{12}H_{22}O_{11}+H_2O=C_6H_{12}O_6+C_6H_{12}O_6.$$

This is termed *inversion* of sucrose, and the resulting mixture of glucose and fructose is termed *invert sugar*.

The object of chemical treatment is fourfold:—(1) To neutralize the natural acidity (as just explained); (2) to remove suspended impurities, thus rendering the juice transparent; (3)



BY COURTESY OF THE MIRLEES WATSON CO.

FIG. 3.—MULTIPLE CANE-MILL

to precipitate dissolved non-sugars, thus increasing the purity of the juice; and (4) to decolourize the juice in the manufacture of white sugar.

The chemical agents used are:—quicklime (CaO), usually added in the form of lime-cream (CaH_2O_2); sulphur dioxide gas (SO_2); carbon dioxide gas (CO_2); and, occasionally, phosphoric acid (H_3PO_4). The effect of these chemical agents is completed by heating the juice to boiling point in an apparatus called a *juice-heater,* the juice flowing continuously through a number of brass tubes heated externally by steam. Certain impurities, previously dissolved in the juice, are thus rendered insoluble and form a dark coloured precipitate which can be separated in various ways: (*a*) by causing it to rise to the surface (with the escaping air-bubbles), forming a *scum* which is removed by skimming ladles; (*b*) by allowing it to subside (after separation of the air) and removing it as a *sediment;* (*c*) by filtration through cloth or other filtering media; (*d*) by centrifugal action.

In the manufacture of *raw sugar,* about two gals. of lime-cream (15° Beaumé) are added per 1,000 gals. of juice; the mixture is heated to boiling point and discharged into settling tanks (*subsiders* or *clarifiers*), each holding 1,000 gal. or more, and filled in rotation. After subsidence for about an hour, the clear juice is drawn off into one gutter, and the sediments into another. The sediments are usually resubsided in additional tanks, more clear juice being then drawn off. The final sediments are pumped through filter-presses (*see* article FILTRATION), yielding clear filtered juice and cakes of solid matter. The clear juices flowing from the first subsiders, resubsiders and filter-presses, are mixed and pass to the multiple-effect evaporator (to be described later).

In the manufacture of *white sugar,* a more thorough purification of the juice is essential, and two methods are used, (a) *acid sulphitation* and (b) *carbonation.* As the latter method is mainly used for treating beet juice it will be described under that heading. In the former, *a*, from 4 to 5 gal. of lime-cream are added per 1,000 gal. of juice, and sufficient sulphur dioxide gas to precipitate this lime, with the formation of a granular precipitate of calcium sulphite ($CaSO_3$), as shown in the equation

$$CaO+SO_2=CaSO_3.$$

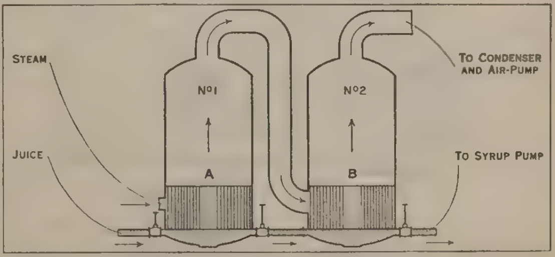
The gas may be added either before or after liming, the final result being the same. The juice is then heated and subsided.

Evaporation of Water.—A large quantity of water must be evaporated from the purified juice before the dissolved sucrose can begin to crystallize. To avoid destruction of sucrose at high temperatures the juice is boiled in closed vessels under a vacuum, thus lowering the boiling point. Further, in order to economize fuel, *multiple effect evaporators* are used.

Fig. 4 is a sectional view of a *double-effect* evaporator. The lower part of each vessel contains numerous vertical brass tubes, their open ends passing through perforations in two horizontal plates. The space between these plates forms a steam-drum, with steam-inlet. The shaded space below the drum and inside the tubes is filled with the boiling juice. The large space above the drum is filled with steam generated by the boiling juice. Steam entering the drum of No. 1 condenses on the exterior of the tubes, transmitting its latent heat to the juice inside the tubes and causing it to boil. The steam thus generated passes into the steam-drum of No. 2 and there acts in the same manner. The steam generated here by the boiling juice passes to a condenser and air-pump, which maintain a vacuum of about 25 inches in No. 2. This vacuum fixes the boiling point of the juice here, also the temperature at which steam (leaving No. 1) can condense on the tubes in No. 2, also the pressure of that steam and the boiling point of the juice in No. 1. Consequently, the high vacuum and low boiling point in No. 2 produce a lower vacuum and higher boiling point in No. 1. Multiple effect evaporation is applicable to any number of connected vessels.

In fig. 4 the level of the boiling juice in No. 2 is maintained constant at B by drawing in juice from No. 1; similarly, the level in No. 1 is maintained constant at A by drawing in juice from an external supply-tank. At the same time, concentrated juice, or syrup, is drawn off continuously from No. 2 by a pump, and at such a rate that the density of the syrup in No. 2, and of that drawn off, remains constant at about 30° Beaumé. This syrup contains from 55 to 60% of dissolved solids (including sucrose). It is, therefore, an unsaturated solution, free from crystals.

Crystallization of the Syrup.—The final stage of evaporation, accompanied by the crystallization of the syrup, is carried out in the Vacuum Pan. This apparatus is shown in the Plate, fig. 5 (centre). Part of the interior, with steam-heated tubes, is shown on the left. Above, and to the right, is the condenser (shown in section) wherein the vapour generated by the boiling syrup is condensed by sprays of water. A vacuum of about 26″ is maintained inside the pan by the combined action of the condenser and air-pump (to right of pan), thereby lowering the boiling point of the syrup to about 130° F. Cane and beet sugar factories are equipped with three or four pans, each discharging from 10 to 20 tons of crystals after each boiling operation is completed.



FROM HERIOT, "MANUFACTURE OF SUGAR" (LONGMANS GREEN & CO.)

FIG. 4.—DOUBLE-EFFECT EVAPORATOR (VERTICAL SECTION)

Sufficient syrup is first drawn into the pan to occupy only a part of its total capacity, and steam is admitted to the coils which are covered by the syrup. After a period of rapid boiling, the syrup becomes supersaturated and microscopic crystals begin to form. This is called the *graining point,* and it is important to produce a sufficient quantity of *grain* as rapidly as possible, in order that the crystals may be of nearly uniform size during all stages of growth. Having formed the grain, the operator reduces the supersaturation by drawing in small charges of unsaturated syrup from the supply-tank, at suitable intervals, thus preventing further formation of grain but causing the previously formed grain to grow until the pan is filled in from 3 to 4 hours. To make a large-grained final product, the operator starts with a smaller volume of syrup, yielding a proportionally smaller quantity of grain, thereby increasing the rate of growth of each grain. Conversely, to make a small-grained final product, he starts with a larger volume of syrup, yielding a larger quantity of grain, thereby reducing the rate of growth of each grain.

The time available for growth can be extended by transferring half the contents of a full pan to a second, empty pan, the two halves being then boiled simultaneously with further additions of syrup to each, causing continued growth of the original grain until both pans are filled. During the process of boiling, the operator is guided by the appearance of small samples of the crystallized syrup which he removes from the pan at short intervals by means of a *proofstick.* The samples are spread upon a sheet of glass and examined by transmitted light from a lamp. When the pan is full, the mixture of crystals and mother-liquor (called *massecuite*) is finally concentrated until it contains from 9 to 11% of water. It is then semi-fluid and contains about 65% by weight of crystals and 35% of mother-liquor. Air is now admitted to the pan, the bottom gate opened, and the massecuite discharged.

Separation of Crystals from Mother-liquor.—This operation, called *curing the sugar,* is effected by centrifugal action in a number of machines operating simultaneously. Each consists of a vertical metal drum, or "basket," which can be rotated on a central vertical spindle at a speed of 800 to 1,200 revs. per min. The cylindrical wall of the drum is made of perforated steel plate and fitted with a lining of woven copper-gauze. After the drum is set in motion, a charge of massecuite enters through a central opening at the top, and the centrifugal action forces the massecuite against the wire-gauze liner which acts as a strainer, allowing the fluid mother-liquor to pass through but retaining the crystals. The separation is complete in about 2 mins. The plate shows the positions of the vacuum pan, massecuite-receiver, centrifugals and band-conveyor.

In the manufacture of *raw sugar,* the above treatment yields sugar containing from 95 to 98% of sucrose and about 1% of water. The colour, moisture and odour of this sugar are due to residual mother-liquor adhering to the crystals and which cannot be completely separated by centrifugal action alone. The band-conveyor (Plate, fig. 5) carries the sugar from the centrifugals to a storage-bin from which the sugar gravitates through chutes into bags placed upon weighing machines.

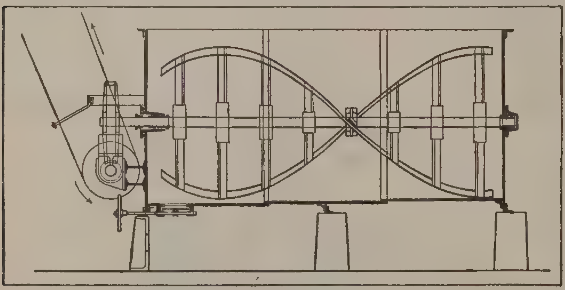


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FIG. 5.—CRYSTALLISER (VERTICAL SECTION)

In the manufacture of *white sugar,* the separation of the mother-liquor is carried much further by spraying water over the layer of sugar in the centrifugal drum whilst this is rotating at full speed. Indeed, two sets of centrifugals may be employed. To conceal any yellowish tint in the sugar, this is sprayed with ultramarine and water (called *blueing the sugar*) before the machine is stopped. After passing through a rotary *drier* (described later) the dry white sugar contains from 99·5 to 99·9% of sucrose.

The mother-liquor separated in the centrifugals contains a high percentage of sucrose. It is reboiled in the vacuum pan where it crystallizes, forming *second grade massecuite.* This is treated in centrifugals where it separates into *second grade crystals* and *second grade mother-liquor.* The last is reboiled in the vacuum pan to form *third grade massecuite* which is discharged into large cylindrical *crystallizers,* each fitted with a slowly rotating central shaft carrying stirrers (fig. 3). The mother-liquor, from which no more sucrose can crystallize, is called *molasses.* It is a highly concentrated solution containing sucrose and various organic and inorganic impurities derived from the original cane juice.

By-products.—These include: (*a*) the crushed cane (*bagasse* or *megass*) which is used as fuel; (*b*) filter-press cakes, which are used as fertilizer; (*c*) molasses, which is used for the production of alcohol, or as fertilizer, cattle-food, or fuel.

THE MANUFACTURE OF SUGAR FROM THE BEET

The *diffusion process* extracts sucrose from the beet juice (*see* Dialysis). The roots are reduced to thin shreds (*slices* or *cossettes*) and the slices immersed in warm water in vertical cylindrical vessels (*diffusers*). These have a capacity of from 500 to 2,500 gals. each, according to the size of the factory, from 10 to 14 diffusers forming one battery. Fig. 6 represents a plan of a circular battery of 12 diffusers, and fig. 7 shows a vertical section of two of the diffusers, with connecting pipes. Each has a small door at top for charging with fresh slices, and a large discharge-door at bottom for removing the spent slices. Liquids pass from the bottom of any one diffuser to the top of the next (*see* arrows in fig. 7), the slices remaining stationary in each. As all the water used for diffusion must afterwards be evaporated before the contained sucrose can crystallize, this water is passed through many diffusers, extracting sucrose from the slices in each, until it attains a sufficiently high density and sucrose-content to be drawn off, being then called *diffusion juice.*

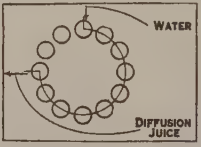

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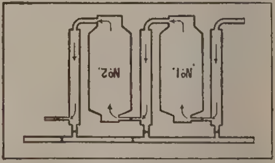
FIG. 6.—PLAN OF A CIRCULAR DIFFUSION BATTERY

In fig. 6 diffuser No. 1 has been longest in action, so that the extraction is nearly complete. It is less complete in No. 2, still less in No. 3, and so on up to No. 10 where extraction is just beginning, this diffuser having just been filled with fresh slices and also with liquid entering it from No. 9. Water is entering No. 1 (*see* arrow in fig. 6) in order to complete the extraction, and this water displaces an equal volume of liquid (already in No. 1) into No. 2, that already in No. 2 into No. 3, and so on up to No. 10, where it displaces an equal volume of diffusion juice (*see* arrows and dotted line in fig. 4). A part of this displaced juice flows through a pipe leading to a measuring tank, and the remainder passes forward into No. 11 (just filled with slices), causing diffusion to begin in No. 11. The extraction in No. 1 is now complete, and the spent slices are discharged. Water is now forced into No. 2, causing displacements of liquids from No. 2 into No. 3, from No. 3 into No. 4, and so on up to No. 11, where it displaces an equal volume of diffusion juice. Part of this juice passes to the measuring tank and the remainder goes forward into No. 12 (just filled with slices), causing diffusion to begin here. The extraction in No. 2 is now complete, and the spent slices are discharged. Water is now forced into No. 3 (continuing as before). The same series of operations is repeated round and round the battery. Fresh water is added to each diffuser in turn at one part of the battery; diffusion juice is drawn off from each diffuser in turn at another part; spent slices are discharged from each diffuser in turn; and fresh slices enter each diffuser in turn. A diffusion battery may sometimes be arranged in two parallel lines



FROM HERIOT, "MANUFACTURE OF SUGAR" (LONGMANS GREEN & CO.)

FIG. 7.—TWO DIFFUSERS (VERTICAL SECTION)

instead of in a circle. The tops of the diffusers project just above the floor, and the battery is operated from this position. The motions of the liquids are controlled by three valves attached to the top of each diffuser.

The efficiency of extraction is proportional to the number of diffusers in action at one time and to the volume of water added to the battery per 100 kilo. of fresh slices. An extraction of 99% of the sucrose in the roots is easily obtained. Several forms of apparatus for continuous diffusion have been patented, the most successful being the *Raabe System.* It is a long, cylindrical vessel, divided transversely into numerous compartments, through which the slices and diffusion liquids move in opposite directions.

Chemical Treatment of the Juice.—The method used is called *Double Carbonation,* and its essential feature is the formation of an abundant precipitate of calcium carbonate ($CaCO_3$) in the juice, after the addition of quicklime (CaO) and carbon dioxide gas (CO_2). These chemical agents are produced simultaneously in a lime-kiln attached to the factory. A mixture of limestone ($CaCO_3$) and coke is added at the top of the kiln and gravitates very slowly to the bottom. The combustion of the coke produces a temperature of 1,000° to 1,300° C and the limestone decomposes, as shown in the equation:—$CaCO_3 = CaO + CO_2$. The gases rising to the top of the kiln are drawn off by a pump and forced through a *gas-washer* and thence through pipes to the tanks containing the juice. The quicklime is removed from the bottom of the kiln in small quantities at suitable intervals.

The raw diffusion juice is pumped through heaters into *liming* tanks where from 2 to 3% of lime is added, either in the form of quicklime (CaO) or as lime-cream (CaH_2O_2). After thorough stirring, the mixture gravitates to tall, rectangular, closed tanks (*carbonation tanks*), fitted with a gas-distributor at bottom for injecting the carbon dioxide gas, juice inlet and outlet cocks, a steam-coil for regulating the temperature of the juice, and a chimney at top for carrying off any unabsorbed gas. As the gas bubbles through the strongly alkaline juice, a gelatinous precipitate is first formed, this gradually decomposing with the formation of a granular precipitate of calcium carbonate, the final result being represented by the equation:—$CaO + CO_2 = CaCO_3$. This treatment (*first carbonation*) is continued until the alkalinity of the juice is reduced to about 0·1% of lime, when the opaque juice is pumped through filter-presses (*see* FILTRATION). The clear, filtered juice is still alkaline and passes to another set of *carbonation tanks* for a second treatment with the gas (*second carbonation*). This is continued until the alkalinity is reduced to 0·03 or 0·06% lime, causing a further precipitation of calcium carbonate, which is removed by a second filtration, yielding a transparent, light-coloured juice which, in some factories, is treated with sulphur dioxide gas (SO_2), followed by filtration, in order to bleach it.

The subsequent operations—evaporation of water, crystallization of the syrup, and separation of crystals from the mother-liquor—have been described above under "cane sugar."

By-products.—These include: (*a*) beet-pulp, used as fodder, either in the moist state or after drying; (*b*) filter-press cakes, which are sometimes used as fertilizer but more usually discarded; (*c*) molasses, which is used in the production of alcohol and cattle-fodder; (*d*) waster waters of no commercial value.

REFINING OF RAW CANE AND BEET SUGARS

This consists of three main operations: (1) dissolving the raw sugar in water; (2) decolourizing the resulting solution; and (3) re-crystallization.

Dissolving (or "Melting") the Raw Sugar.—This usually includes two operations. First, washing the raw sugar crystals to remove adhering molasses. Second, dissolving the washed raw sugar in hot water and filtering the resulting liquor to remove insoluble impurities. The raw sugar is mixed with syrup to form a magma which is fed into centrifugal machines (described above). These separate the magma into two parts:—(*a*) *washed raw sugar crystals* and (*b*) *affination syrup* or *wash-syrup.* The crystals are sprayed with water in the centrifugal to remove adhering wash-syrup, after which the machine is stopped and the washed raw sugar discharged. From 100 tons of *raw sugar* (96% sucrose) about 90 tons of *washed crystals* (99% sucrose) are obtained by the separation of 10 tons of dissolved sugar and impurities in the *wash-syrup.* This is called the *affination* process.

The washed raw sugar then passes to large cylindrical vessels (*melting tanks*) each holding from 5 to 10 tons of sugar and sufficient hot water to give a liquor containing about 60% by weight of sugar when all has dissolved. The melting tanks are fitted with mechanical stirrers and perforated steam-coils for heating. The resulting solution is termed *washed raw sugar liquor.* It is dark brown in colour and contains numerous insoluble impurities in suspension. To remove these, it is filtered through cloth in *leaf-filters, filter-presses* or *bag-filters* (*see* article FILTRATION). The filtered liquor is transparent but strongly coloured.

Decolourizing the Liquor.—This is effected by the action of bone-char (*q.v.*) in *char-filters,* large vessels measuring from 20 to 50 ft. in height, and from 5 to 10 ft. in diameter. The dark-coloured liquor enters at the top, and percolates through the char in from 3 to 6 hours, the rate of descent being regulated by the inlet-cock. In passing through the char, the liquor is completely decolourized and flows into a gutter leading to the *first liquor* tank.

After operating for several hours, the char begins to lose its power, and the treated liquor becomes slightly tinted, this being run into a second gutter leading to the *second liquor* tank. When the tint increases to a predetermined limit, the liquor-inlet cock is closed, and a cock admitting hot water is opened, this water displacing the tinted liquor remaining in the char, and gradually diluting it. When the outflowing tinted liquor begins to decrease in density it flows into two other receivers, one for *light liquor* until the density falls to 18° Beaumé, and another for *char water* until the density falls to 0·5° Beaumé. About 1 ton of water is required per ton of char, and the operation is called *sweetening off.* After further washing with hot water, which runs to waste, the char is dried and strongly heated in a *char-kiln,* thereby restoring its activity so that it can be used again. This cycle of operations is repeated several times a week for a few years; at the end of this time the char is of poor decolourizing power and is therefore discarded as *"spent char."*

Crystallization.—The colourless *first liquor* is boiled and crystallized in the vacuum pan (Plate, fig. 5) in the same manner as cane syrup, but the size to which the crystals grow depends on the class of refined sugar to be made. A very large grain is required for *crystal* or *coffee sugar;* a medium grain for *granulated;* and a mixed small grain for *cube* (or *loaf*) and *caster* sugars. In each case, the product discharged from the vacuum pan is a mixture of crystals and mother-liquor (*massecuite*) which must undergo further treatment.

In the manufacture of *granulated, crystal* and coarse *caster* sugars, the massecuite from the vacuum pan is treated as in the manufacture of white granulated sugar direct from cane and beet juices. The final operations of drying, sifting and bagging are shown in Plate, fig. 3. The moist white sugar leaving the centrifugals is carried by the band-conveyor (Plate, fig. 5 [bottom]) to the raised extremity of the revolving sugar drier (Plate, fig. 3 [top]). The interior of the drier is fitted with narrow shelves (parallel to its axis) so that as the drum rotates, the sugar is repeatedly carried upwards on the shelves and then dropped, whilst a current of hot air is drawn through the drum by means of a fan (shown on the right). On reaching the lower extremity of the drum, the sugar becomes dry and contains about 99·9% of sucrose. It gravitates to the revolving sifter below, Plate, fig. 3, which is made in three sections, each section having wire-gauze of different mesh. The crystals are thus sorted into three sizes or grades:—*fine, medium* and *coarse* which fall into three cone-shaped hoppers below. Any lumps (accidentally produced) pass beyond the sieve and fall into a fourth hopper. The sifted sugar next gravitates from these hoppers to automatic weighing machines from which bags are suspended (Plate, fig. 3). The attendant opens a shutter which allows the sugar to flow into a bag, and, when the correct weight has entered, the machine automatically closes the shutter. The attendant then unfastens a strap holding the bag to the machine and the filled bag drops a few inches upon a band-conveyor which carries it to a sewing machine by which it is stitched up.

Cube sugar, sometimes called *loaf sugar,* is made by two alternative methods which can only be very briefly described here. *Method* (*a*). The production of rectangular slabs of white sugar, measuring about $20'' \times 10'' \times \frac{3}{4}''$, these being then cut up into single cubes by machinery. This method includes the Scheibler process (now little used) and the more modern Adant and Hubner processes. In the Adant process, the hot massecuite is run into a number of rectangular metal moulds, where it sets during partial cooling. The filled moulds are then transferred to a centrifugal machine of special construction, the mother-liquor separated by spinning, and the slabs of sugar washed with pure syrup entering at the centre of the machine. The latter is then stopped, the moulds removed, and the slabs of white sugar dried and cut up into small cubes (*see* Plate, fig. 4). The Hubner process is a modification of Adant's, and, whilst it economizes time and labour, gives a slightly reduced yield.

Method (*b*). The sugar is moulded directly into cubes instead of into slabs. The massecuite discharged from the vacuum pan is spun in the ordinary type of centrifugal (Plate, fig. 5 [bottom]). The crystals are washed white and discharged into a *mixer* where they are thoroughly mixed with white sugar-liquor to form a magma. This flows into rows of small cubical pockets on the surface of a slowly rotating horizontal drum.

During every half-revolution of this drum, the magma is compressed inside each pocket forming single cubes, and rows of these cubes are ejected from the drum when the pockets reach their lowest positions. The empty pockets are refilled with magma on further rotation to their highest positions. The cubes fall from the drum upon a travelling band which carries them slowly through a drying chamber to the packing cases without any handling.

Icing sugar and the finest grade of *caster sugar* are made from some of the foregoing grades by grinding in mills.

By-products.—These include: (*a*) spent char, which is used as fertilizer; (*b*) molasses which may be fermented to yield alcohol or used in the manufacture of cattle-food, or purified to make edible syrup, or *treacle.*

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PRODUCTION AND TRADE

Sugar is produced in Europe, Asia, Africa, America and Australia. In Europe and in parts of North America it is made from the sugar beet and in the other continents, from the sugar cane. When impurities have been removed by refining, no difference can be detected either by taste or smell, the chemical analysis of refined beet and cane sugar being identical.

Output.—The quantities of cane and beet sugar produced in recent years have been, according to Willett and Gray:—

	1927–28	1926–27	1925–26	1913–14
	Tons	Tons	Tons	Tons
Cane	16,300,000	16,100,000	16,300,000	9,900,000
Beet	9,000,000	7,700,000	8,300,000	8,800,000
	25,300,000	23,800,000	24,600,000	18,700,000

The large increase in cane-sugar is due to high prices during the World War. The European beet sugar crops, on the other hand, were curtailed severely and in 1919–20 amounted to only 2,600,000 tons as compared with 8,000,000 tons made in 1913–14 —a decrease of $67\frac{1}{2}\%$. The chief producing countries are:—

	Tons	Year
Cuba	4,480,000 cane	1927–28
British India	3,600,000 ,,	1927–28
Java	2,950,000 ,,	1928–29
Germany	1,785,000 beet	1928–29
Russia	1,360,000 ,,	1927–28
Czechoslovakia	1,364,000 ,,	1927–28
United States	1,174,000 ,,	1927–28

Cuba is capable of producing more sugar, but prices of recent years have not been sufficiently remunerative to encourage increased production. During 1927 and 1928 an attempt was made by the Cuban Government to raise and stabilize the price of sugar by artificial crop restriction. This experiment failed and the crop restriction policy has been dropped.

British Sugar.—About one-fifth of the total production of sugar is produced in British Dominions, as under:—

	1927–28	1913–14
	Tons	Tons
British West Indies	253,000	120,000
Demerara	114,000	102,000
Australia	493,000	255,000
Fiji	95,000	100,000
Mauritius	215,000	250,000
Natal	221,000	86,000
Canada	27,000	10,000
United Kingdom	208,000	Nil
	1,626,000	923,000
British India	3,200,000	2,291,000
	4,826,000	3,214,000

British India consumes the whole of her crop, but the other parts of the Empire export nearly all the sugar they make, and this forms an increasing proportion of the raw material for the refineries of the United Kingdom and Canada.

The imports of empire-produced raw sugar into the United Kingdom have increased from 67,000 tons in 1913, to 333,000 tons in 1925 and to 556,000 tons in 1928. This increase has been largely brought about by Imperial Preference (*q.v.*).

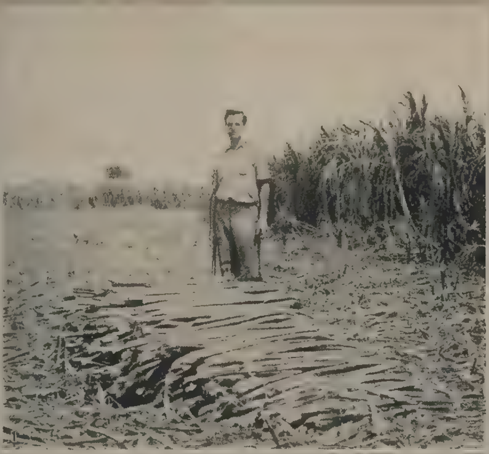
The quantity of sugar produced from an acre of land varies with conditions of weather, soil, labour and quality of cane. In parts of India, where primitive methods are still employed, less than one ton of sugar is made from one acre of cane. On the other hand, the production in Java sometimes exceeds 5 tons to the acre, and in parts of the Hawaiian Islands as much as 12 tons per acre have been produced. The following figures show some approximate average yields:—

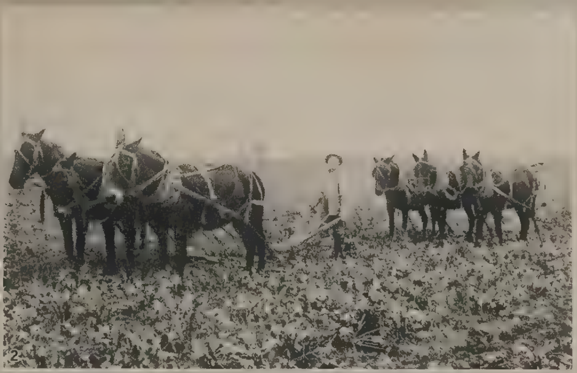
	tons per acre
Hawaii (cane)	5 ,,
Java (cane)	5 ,,
Cuba (cane)	2 ,,
India (cane)	$1\frac{1}{8}$,,
Philippines (cane)	$\frac{7}{8}$,,
Europe (beet)	$1\frac{1}{4}$ to 2 ,,
United Kingdom (beet)	$\frac{7}{8}$ to $1\frac{1}{4}$,,

State Assistance.—This assistance may be either by way of a direct subsidy, as in England and the Irish Free State, or by means of a customs duty as in most of the European beet-growing countries. Producers in such countries often form a "Cartel," by which is meant an agreement among themselves to raise the price of sugar to the consumer in their own country to a level just within the limit of the duty. Any sugar which they may make in excess of their home requirements is then exported at or below the world's price. The producers may lose on the sugar exported, but the profits made on their sales at home are ample to recoup them for their loss.

In the United Kingdom, the beet sugar industry, stimulated by the subsidy and preference in Excise Duty provided under the British Sugar (Subsidy) Act of 1925, has expanded, and in the season 1927–28 the production of sugar was 225,000 tons. The total amount of assistance granted by the Government to the British beet sugar industry during the period commencing Oct. 1, 1924 and ending Sept. 30, 1928 was 26/10$\frac{1}{2}$d. per cwt. of sugar produced, made up as follows:—

	On each cwt. of sugar produced
Subsidy on sugar	19/6d.
Subsidy on molasses equivalent to	3/1$\frac{1}{2}$
The excise duty being lower than the duty on imported refined sugar by	4/3
	26/10$\frac{1}{2}$d.





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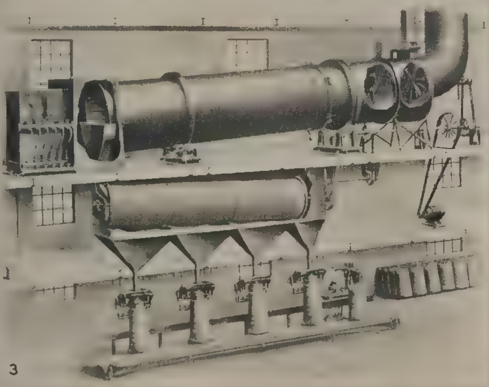

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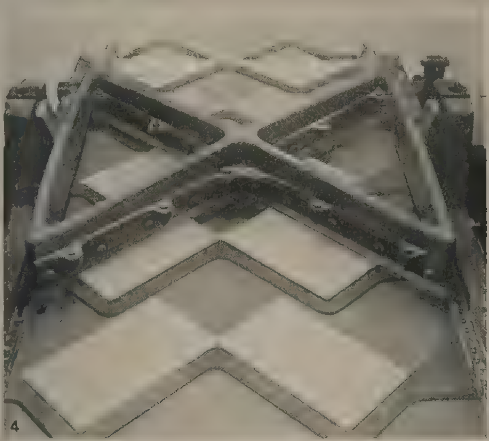

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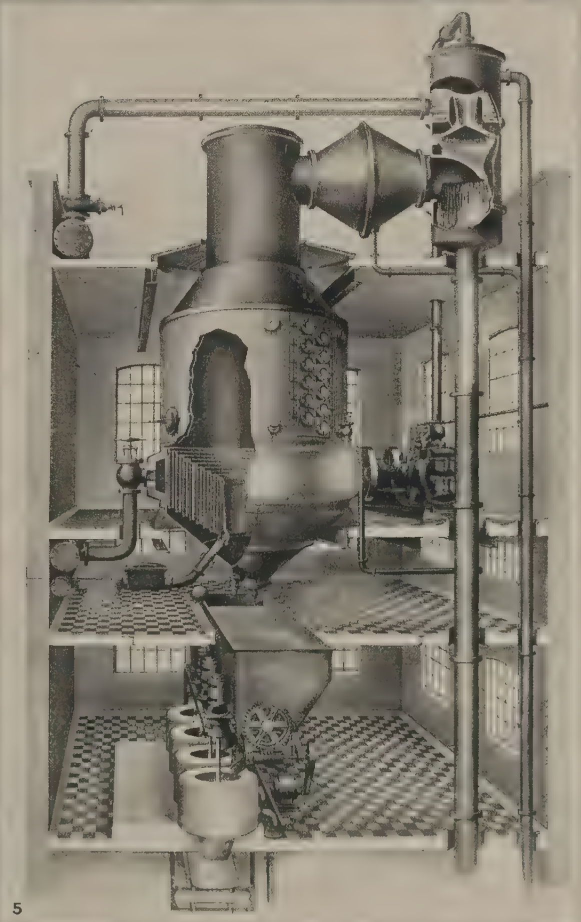
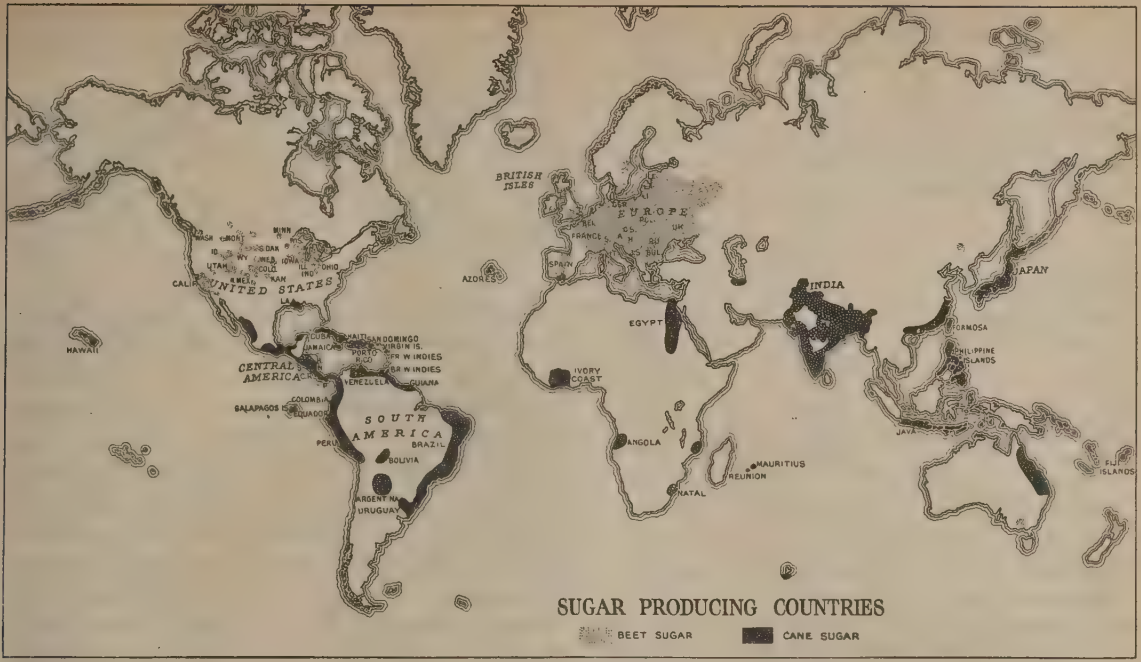


5

BY COURTESY OF GEOFFREY FAIRRIE FROM "SUGAR"

STEPS IN SUGAR MANUFACTURE

1. Field of sugar cane. The large bundle of stalks in the foreground is piled across strong ropes. It will be hoisted on carts and transported to the factory
2. First step in harvesting field of sugar beets. Ploughs drawn by mules cut tap-root where it is small and loosen surrounding earth so that beets may be pulled easily by hand
3. Machinery used in the final operations of sugar making. While moist, sugar is carried to revolving sugar drier (top) fitted with narrow shelves. Sugar is carried repeatedly upward on shelves while current of hot air is drawn through drum for drying. Sugar next drops into revolving sifter (centre) where it is sorted into three sizes or grades. It then gravitates to automatic weighing machines (bottom) from which bags are suspended
4. Cutting sugar slabs into cubes with modern machinery
5. Vacuum pan (top) where colourless first liquor is boiled and crystallized. Different pans are required for different grades of sugar. The product discharged from the vacuum pan goes into the Massecuite Receiver (bottom) where it undergoes further treatment


SUGAR PRODUCING COUNTRIES
BEET SUGAR
CANE SUGAR
WASH
MONT
MINN
ID
S.DAK
WY
NEB
IOWA
UTAH
COLO
ILL
OHIO
IND
N.MEX
KAN
CALIF
UNITED STATES
LA
HAWAII
CUBA
HAITI
SAN DOMINGO
JAMAICA
VIRGIN IS.
PORTO RICO
FR W INDIES
BR W INDIES
CENTRAL AMERICA
VENEZUELA
GUIANA
COLOMBIA
GALAPAGOS IS
ECUADOR
SOUTH AMERICA
PERU
BRAZIL
BOLIVIA
ARGENTINA
URUGUAY
AZORES
BRITISH ISLES
EUROPE
BEL
FRANCE
SPAIN
CS.
UK
RU
BUL
EGYPT
IVORY COAST
ANGOLA
NATAL
MAURITIUS
REUNION
INDIA
JAPAN
FORMOSA
PHILIPPINE ISLANDS
JAVA
FIJI ISLANDS

BY COURTESY OF FARR & CO., N.Y.

MAP SHOWING THE SUGAR PRODUCING COUNTRIES OF THE WORLD

As from Oct. 1, 1928 the assistance was reduced to 19/4d. per cwt. and on Oct. 1, 1931 a further reduction to 11/9½d. per cwt. will take place. The primary object of the act was to aid agriculture, and the grant of the subsidy is contingent upon the factories paying certain minimum prices for their beets.

The United Kingdom and Canada aid sugar producers within the Empire by preferential tariffs. That is to say, sugar produced in the British Empire pays a lower import duty than other sugar when it enters the United Kingdom or Canada. In the United Kingdom this preference amounts to 3/9d. per cwt. on raw sugar and in Canada to about 1/– per cwt. more.

The United States in order to encourage the production of:—

(1) Beet sugar in the U.S.A.
(2) Cane sugar in Louisiana
(3) „ „ „ the Philippines } all American Colonies
(4) „ „ „ Porto Rico }
(5) „ „ „ Hawaii }

levies no duty upon the sugar produced by these countries, whereas an import duty of 11/– per cwt. is charged upon sugar imported from other localities. Cuban sugar is allowed to enter the United States on paying 20% less duty than other foreign sugar.

Prominent among the countries which receive no artificial stimulus is Java, where production has steadily increased, due partly to the fact that labour is cheap, and also to the highly organized state of the industry.

Sugar Consumption.—Before the war, the world's consumption of sugar increased with almost clock-like regularity. The average yearly increase over a period of 60 years was 3½% and in 1913 the quantity used was 19,000,000 tons. This expansion was arrested by the war, but consumption now shows definite signs of expansion, and in 1927 amounted approximately to 26,000,000 tons distributed roughly, as follows:—

	Tons
Europe	9,650,000
America	8,150,000
Asia	7,200,000
Africa	675,000
Oceania	450,000
	26,125,000

The United States, the United Kingdom, and British India together consume nearly one-half of this amount.

The countries which consume the largest quantity of sugar per head of the population are Australia, New Zealand, the United States and Denmark. In each about 1 cwt. per person is used, the tonnage being:—

	Tons
United States	5,500,000
Australia	325,000
New Zealand	70,000
Denmark	185,000

The next largest consumers are:—

	Per head in lb.
United Kingdom	95
Canada	92
Switzerland	85
Argentine	73
Holland	68
Sweden	66
Austria	65

In the Far East the question of prices is a more important factor than anywhere else in determining the consumption of sugar, and a rise in price in the western markets is invariably checked by the drifting thither of sugar not required by the Far East. In most countries it is consumed after it has been refined, a noticeable exception being India, where sugar is still largely consumed in a primitive form known as "Gur," practically the same as the old-fashioned sugar candy.

The United Kingdom consumes annually about 1,750,000 tons of sugar, and as she produces only a small crop herself, has to import large quantities. It is drawn from all parts of the world, and is imported partly in the refined form, but chiefly as raw sugar to be refined in London, Liverpool and the refinieries of the Clyde.

The following are details of the imports of sugar into the United Kingdom, showing sources of refined and unrefined sugar for 1928 as compared with 1913:—

	1928	1913
Refined	Tons	Tons
Czechoslovakia	100,425	198,064
Holland	88,101	178,567
Germany	1,079	465,453
Others	7,651	79,276
Total all Europe	197,256	921,360
From places outside Europe	24,488	1,185
Total Refined	221,744	922,545
Unrefined		
Germany	..	472,026
Czechoslovakia	21,282	160,858
Total above and other places in Europe	44,555	682,730
Cuba	702,780	224,227
San Domingo	208,359	9,412
Peru	99,933	27,487
Mauritius	133,675	20,075
B.W.I.	150,604	47,736
Australia	450,000	..
Total above and other places outside Europe	2,337,365	363,985
Total Raws	2,381,920	1,046,715
Total Raw and Refined	2,603,664	1,969,260

Sugar Taxes.—Sugar is taxed in most countries for the purposes of revenue, and in some a protective tax on imported sugar is levied. In the United Kingdom the import duty is payable according to polarization, and during the present century, the amount charged upon sugar exceeding 98° polarization has varied as follows:—

	Year	Amount of duty per cwt.
April	1901	4/2d.
May	1908	1/10
September	1915	9/4
April	1916	14/–
April	1918	25/8
April	1924	11/8

Raw sugar not exceeding 98° polarization produced in the British Empire pays a duty lower by £3.11.3 per cwt. than non-European sugar of the same polarization; this preferential tariff has been stabilized for ten years ending in 1935, and the excise duty payable upon beet sugar produced in the United Kingdom under the British Sugar (Subsidy) Act, 1925, is the same as the import duty on sugar of empire origin. The budget of 1928 reduced the import duty on raw sugar not exceeding 98° polarization by the equivalent of ¼d. per lb. on refined sugar.

Import and Excise duties in other parts of the world are as follows, expressed in shillings per cwt.:—

	Import duty	Additional excise duty payable alike by home produced and imported sugar
Holland	Nil	23/9d.
Czechoslovakia	21/–	9/3
Poland	14/2	8/9
France	8/3	10/3
Germany	7/6	5/3
Sweden	5/7	4/6
Belgium	4/9	2/4
U.S.A.	11/–	Nil
Canada	8/9	Nil

Sugar Prices.—Prior to 1914 the price of raw sugar fluctuated between 9/– and 11/6d. per cwt., which was sufficiently remunerative to maintain the equilibrium between supply and demand. Occasional crop failures raised prices above that level, and the effect upon production was immediate.

The highest price for raw sugar in recent years, was paid on May 19, 1920, when Cuban raw sugar was sold to New York at a price equal to 140/– per cwt. After violent fluctuations during 1921–24 there was a decline through overproduction, and at the end of May 1929 the price was 8/6 per cwt.

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SUGAR IN COOKERY

As sugar is an important soluble carbohydrate and is easily assimilable, it is valuable in the diet. Candy contains a high proportion of sugar (or glucose), but no dish for the table should do so. In adding sugar to fruit, more is needed if it is cooked with the fruit than if added when the cooking is completed.

Cane and Beet Sugars (Sucrose).—These are the principal sugars used in cookery. They dissolve in one-third their own bulk of cold water, and in a smaller amount of hot water. Their melting point is 320° F. If cooled at that point, they become barley sugar; if cooked beyond that point they become burnt sugar or caramel. Fine granulated or castor sugar is generally used in cookery. For icings, méringues and whips, powdered or pulverized (icing) sugar is used, the finest form being confectioners' sugar. All powdered sugars must be rolled and sifted fine before using. These sugars are all pure white refined products. Brown and yellow sugars, which are produced by evaporation, are also used in cookery when there is no objection to a dark colour, and some of them have a delicious flavour. They vary in both colour and flavour, the best known being Demerara or coffee sugar, and dark brown or Barbadoes sugar.

Other Sugars.—Glucose is less sweet than sucrose, and the commercial form is cheaper. It is used in many manufactured candies, jams and syrups to economize, but is not much used in the home. Commercial grape sugar is a dextrose. Maple sugar (sucrose) is much prized for its special flavour, but is made in comparatively small quantity, as is also palm sugar. Ame is a Japanese sweetening material that contains dextrin and maltose. Saccharin is not a sugar, and has no food value, but it is very sweet and is sometimes substituted for sugar, usually on a physician's orders.

Caramel or Burnt Sugar.—This is marketed ready prepared, for use as "browning" for sauces, gravies, stews and the like, and also as a flavouring in such dishes as caramel custard (custard with caramel below or around it). It can be prepared at home by melting granulated sugar in a saucepan over a low fire, with constant stirring. It may be used at once as it is, or after removing from the fire, boiling water (¼ cup water to 1 cup sugar) may be added very slowly, again with constant stirring. Return this mixture to the fire and cook to a rich dark brown (8 to 10 minutes). This hardens on standing, but can be melted over hot water. (*See* also TREACLE, HONEY.)

SUGAR BEET: *see* BEET.

SUGAR-BIRD, the English name of the West India birds of the genus *Certhiola* (belonging to the Passerine family *Coerebidae*) for their habit of frequenting the curing-houses where sugar is kept, attracted thither by the flies. In their figure and motions they resemble a nuthatch, while their coloration—black, yellow, olive, grey, and white—recalls a titmouse.

SUGER (*c.* 1081–1151), French ecclesiastic, statesman and historian entered the abbey of St. Denis about 1091. Until about 1104 he was educated at the priory of St. Denis de l'Estrée, and there first met his pupil King Louis VI. In 1118 he was sent by Louis VI. to the court of Pope Gelasius II. at Maguelonne, and lived from 1121 to 1122 at the court of his successor, Calixtus II. On his return Suger was appointed abbot of St. Denis, devoting himself to reforms. During the second crusade he was a regent of the kingdom.

Suger wrote a panegyric on Louis VI. (*Vita Ludovici regis*), and was part-author of the *Historia gloriosi regis Ludovici* (Louis

VII.). In his *Liber de rebus in administratione sua gestis*, and its supplement *Libellus de consecratione ecclesiae S. Dionysii*, he treats of the improvements he had made to St. Denis, describes the treasure of the church, and gives an account of the rebuilding. Suger's works served to imbue the monks of St. Denis with a taste for history, frequently resulting in quasi-official chronicles.

See O. Cartellieri, *Abt Suger von Saint-Denis* (Berlin, 1898); A. Luchaire, *Louis le Gros* (Paris, 1890); F. A. Gervaise, *Histoire de Suger* (Paris, 1721).

SUGGESTION. By the older writers on psychology the words "suggest" and "suggestion" were generally used in senses very close to those of common speech. Modern studies in mental pathology and hypnotism (*q.v.*) have led to the use of these words by psychologists in a special and technical sense. The hypnotists of the Nancy school rediscovered and gave general currency to the doctrine that the most essential feature of the hypnotic state is the unquestioning obedience and docility with which the hypnotized subject accepts, believes and acts in accordance with every command or proposition of the hypnotizer. These commands were called "suggestions"; and the subject that accepted them in this fashion was said to be "suggestible." It is made clear, chiefly by French physicians, that a high degree of "suggestibility" is a leading feature of hysteria.

It is also becoming widely recognized that the suggestibility of hypnosis and of hysteria is conditioned by a peculiar state of the brain, namely a cerebral or mental dissociation, which in hypnosis is temporarily induced by the operations of the hypnotist, and in hysteria arises from some deficiency of energy in the whole psycho-physical system. But as to the range of suggestion great differences of opinion still obtain. Firstly, it is maintained (notably by Professor Pierre Janet, whose studies of hysterical patients are celebrated) that suggestibility is a condition peculiar to hysterical subjects. In view of assertions of physicians that they find more than 90% of all subjects hypnotizable, it would seem that this stigmatization of suggestibility as in every case a morbid symptom, is erroneous. A second group consists of writers who admit that suggestion may operate in normal minds, but that it is a process of very exceptional nature. They hold that suggestion, whether it occurs in morbid or in healthy subjects, always implies the coming into operation of some obscurely conceived faculty or region of the mind which is present in all men, but which usually lies hidden beneath our more commonplace mental activities. This submerged faculty is variously called the secondary or submerged stratum of consciousness, the subconscious or subliminal self (*see* SUBLIMINAL SELF). These writers insist upon the more startling of the effects producible by suggestion, such as paralysis, contracture, hyperaesthesia, increased power of recollection, hallucinations (*q.v.*), etc.; and they regard dissociation as the process by which the supernormal faculty (or faculties) is liberated from the normal waking self.

A third view connects itself with, and bases itself upon, the view of Professor Bernheim and his colleagues of the Nancy school of hypnotism. According to this view all men are normally suggestible under favourable conditions, and the hypnotic subject and the hysteric patient differ from the normal human being chiefly in that their normal suggestibility is more or less (sometimes very greatly) increased, owing to the prevalence of the state of cerebral dissociation.

According to this third view, suggestion may be defined as the communication of any proposition from one person (or persons) to another in such a way as to secure its acceptance with conviction, in the absence of adequate logical grounds for its acceptance. The idea or belief so introduced to the mind of the recipient is held to operate powerfully upon his bodily and mental processes in proportion to the degree of its dominance over all other ideas or mental processes; and the extraordinary character of the effects, both bodily and mental, of suggestion in hypnotic and hysterical subjects is held to be due to the fact that, in these conditions of mental dissociation, the dominance of the suggested idea is complete and absolute; whereas in the absence of such dissociation the operation of the suggested idea is always subject to some weakening or inhibition through the influence of many opposed or incompatible tendencies and ideas, even if these do not rise into explicit consciousness.

This third view seems justified by the facts that no sharp line can be drawn between the suggestibility of normal men and that of hypnotized or hysterical subjects, and that under favourable conditions many of the most striking results of suggestion (*e.g.*, hallucinations, contractures, inability to move, insensibility of various sense-organs, and so forth) may be produced in subjects who present at the time no other symptom of the hypnotic or hysterical condition.

If, then, we recognize, as we must, that the alogical production of conviction is the essence of suggestion, and that this frequently occurs in normal minds as well as in those suffering from various degrees of dissociation, it becomes necessary to define the conditions which are resident, on the one hand, in the recipient of the suggestion, and, on the other hand, in the source from which the suggestion comes.

(*a*) Defect of knowledge. The usual well-trained mind is relatively insuggestible, firstly because it possesses large stores of knowledge and belief; secondly, because this mass of knowledge and belief is systematically organized in such a way that all its parts hang together and mutually support one another. On the other hand, the young child, the uncultured adult, and especially the savage, are apt to be suggestible in regard to very many topics, firstly, because they have relatively little knowledge; secondly, because what little they have is of a low degree of organization; *i.e.*, it does not form a logically coherent system whose parts reciprocally support one another. Suggestion in such cases may be said to be conditioned by primitive credulity or the suggestibility of ignorance. (*b*) But the same person will not be found to be equally suggestible at all times under similar external conditions. A man is least suggestible when his mind works most efficiently; every departure from this state, due to fatigue, bodily ill-health, emotional perturbation, drugs or any other cause, favours suggestibility. (*c*) Persons of equal degrees of knowledge or ignorance will be found, even at their times of greatest mental efficiency, to be unequally suggestible owing to differences of native disposition; one person is by nature more open than another to personal influence, more easily swayed by others, more ready to accept their dicta and adopt their opinions for his own. Differences of this kind are probably the expression of differences in the native strength of one of the fundamental instinctive dispositions of the human mind.

Considered from the side of the agent, suggestion is favoured by whatever tends to render him impressive to the subject or patient—great bodily strength or stature, fine clothes, a confident manner, superior abilities of any kind, age and experience, any reputation for special capacities, high social position or the occupation of any position of acknowledged authority; in short, all that is summed up by the term "personality," all that contributes to make a personality "magnetic" or to give it prestige renders it capable of evoking on the part of others the submissive suggestible attitude. A group of persons in agreement is capable of evoking the suggestible attitude far more effectively than any single member of the group, and the larger the group the more strongly does it exert this influence. Hence the suggestive force of the popularly accepted maxims and well-established social conventions; such propositions are collective suggestions which carry with them all the immense collective prestige of organized society, both of the present and the past; they embody the wisdom of the ages. It is in the main through the suggestive power of moral maxims, endowed with all the prestige of great moral teachers and of the collective voice of society, that the child is led to accept with but little questioning the code of morals of his age and country; and the propagation of all religious and other dogma rests on the same basis. The normal suggestibility of the child is thus a principal condition of its docility, and it is in the main by the operation of normal suggestion that society moulds the characters, sentiments and beliefs of its members, and renders the mass of its elements harmonious and homogeneous to the degree that is a necessary condition of its collective mental life. Normal suggestion produces its most striking effects in the form of mass-suggestion, *i.e.*, when it operates in large assemblies or crowds, especially if the members have but little positive knowledge and culture.

Conditions very favourable to mass-suggestion prevailed during the middle ages of European history; for these "dark ages" were characterized by the existence of dense populations, among whom there was free intercourse but very little positive knowledge of nature, and who were dominated by a church wielding immense prestige. Hence the frequent and powerful operations of suggestion on a large scale. From time to time fantastic beliefs, giving rise to most extravagant behaviour, swept over large areas of Europe like virulent epidemics—epidemics of dancing, of flagellation, of hallucination, of belief in the miraculous powers of relics or of individuals, and so forth. At the present time, modified instances are the popular pilgrimages to Lourdes, Holywell and other places that acquire reputations for miraculous curative powers.

Auto-suggestion.—Although auto-suggestion does not strictly fall under the definition of suggestion given above, its usage to denote a mental process which produces effects very similar to those producible by suggestion is now so well established that it must be accepted. In auto-suggestion a proposition is formulated in the mind of the subject rather than communicated from another mind, and is accepted with conviction in the absence of adequate logical grounds. Generally the belief is initiated by some external event or some bodily change, or through some interpretation of the behaviour of other persons; *e.g.*, a man falls on the road and a wagon very nearly passes over his legs, perhaps grazing them merely; when he is picked up, his legs are found to be paralysed. The event has induced the conviction that his legs are seriously injured, and this conviction operates so effectively as to realize itself. Or a savage, suffering some slight indisposition, interprets the behaviour of some person in a way which leads him to the conviction that this person is compassing his death by means of magical practices; accordingly he lies down in deep despondency and, in the course of some days or weeks, dies, unless his friends succeed in buying off, or in some way counteracting, the malign influence. Or, as a more familiar and trivial instance of auto-suggestion, we may cite the case of a man who, having taken a bread pill in the belief that it contains a strong purgative or emetic, realizes the results that he expects.

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SUHL, a town in Prussian Saxony, situated on the Lauter, in the Thuringian Forest. Pop. (1925) 15,557. Suhl, which obtained civic rights in 1527, formed a part of Saxony assigned to Prussia by the Congress of Vienna in 1815. The armourers of Suhl, mentioned in the 9th century, enjoyed their highest vogue from 1550 to 1634. The knights of south Germany especially prized the swords and armour of this town.

SUICIDE, the act of intentional self-destruction. At the present time it is held to be reprehensible, if not indeed criminal, in ethics and in law. This was not always the case. Even in European countries it is not so very long ago that suicide was esteemed infinitely more honourable than disgrace.

Factors Affecting.—Much has been written as to the striking differences in the suicide-rate between one country and another. As to "occupational" suicide, the data are too meagre to allow of definite inferences. Climatic influences appear to be uniformly at work in most countries, the rate rising with the lengthening of the days and the increase of temperature and declining to minimum in winter. Religion appears to have a modifying influence on suicide, Jews being less prone to self-destruction than Roman Catholics and Roman Catholics than Protestants, when living under similar conditions. Thus in Switzerland, the suicide-rate is invariably much higher in the Protestant than in the Roman Catholic cantons. According to the late Dr. Ogle, suicide is more common among the educated than the illiterate classes, and the latest statistics for England and Wales show it to be considerably higher in the two highest groups arranged according to social well-being than in the three lower ones. In the United States the suicide-rate for whites is considerably higher than that for negroes. Loss of interest in life itself is probably a powerful factor. There is the striking fact that the rate for unoccupied males in England and Wales is enormously greater than for those who are occupied. Generally speaking the rate is higher in the cities and large towns than in the rural areas.

Suicide by Sex and Age.—Men are much more prone to commit suicide than are women. In England and Wales, the proportions are about three to one—the rate for males in the quinquennium 1921–25 being 154 per million against 54 for females. In New Zealand, the disproportion was even greater, the respective rates being 192 and 46. In Germany, Italy and the Netherlands the ratio of male to female suicides was nearly as high as in England and Wales. Even in Japan, the male suicide rate is fifty per cent above that for females. In Europe, as in other parts of the world for which statistics are available, the suicide rate rises with age, the maximum being attained after 50. With women, however, the rise is not so regular as with men, there being a more decided rise at the earlier years 15 to 20 years. In 1926 the figures at age-groups were in England and Wales:—

	10–15	15–20	20–25	25–35	35–45	45–55	55–65	Over 65
Males	3	54	117	297	522	779	780	547
Females	3	58	80	203	272	340	258	136

Methods Employed.—The modes adopted by suicides to bring about their own destruction follow fairly well defined lines, men adopting the cruder methods and women avoiding in general those modes which involve the spilling of blood or personal disfigurement. There are, however, what may be termed new fashions in suicide, while a determining factor is often the accessibility of the means to achieve the desired end. The following brief table shows what happened in England and Wales in the case of the adoption of coal-gas as a means of self destruction.

Suicides in England and Wales
(Years 1900–6)

	Males		Females		Both sexes	
		%		%		%
Total	17,455	100	5,752	100	23,207	100
By hanging . . .	5,124	30	940	16	6,064	26
,, drowning . . .	3,305	19	1,937	33	5,242	23
,, cutting	3,231	18	600	10	3,831	16
,, corrosives . . .	2,240	13	1,517	26	3,757	16
,, gaseous poisons . .	98	0·6	28	0·5	126	0·5

(Years 1920–6)

	Males		Females		Both sexes	
		%		%		%
Total	21,680	100	7,782	100	29,462	100
By hanging . . .	4,391	20	1,072	14	5,463	18
,, drowning . . .	3,704	17	2,362	30	6,066	21
,, cutting	3,942	18	725	9	4,677	16
,, corrosives . . .	1,656	8	1,366	17	3,022	10
,, gaseous poisoning .	1,658	8	1,218	15	2,876	9

The most notable feature is, of course, the enormous rise in the suicides from gaseous poisoning during the present century. The following are, in order of preference, the methods adopted in recent years in some other countries

Males		
United States	**Italy**	**Switzerland**
1 Firearms	1 Firearms	1 Hanging
2 Hanging	2 Hanging	2 Firearms
3 Poison gas	3 Drowning	3 Drowning
4 Corrosives	4 Poison	..
Females		
United States	**Italy**	**Switzerland**
1 Poison gas	1 Poison	1 Drowning
2 Corrosives	2 Drowning	2 Hanging
3 Firearms	3 Hanging	3 Poison
4 Drowning	..	..

In the cases of Italy and Switzerland, "poison" appears to include poisoning by corrosives and by gas. In Japan, hanging (1) and drowning (2) are the favourite methods for both sexes.

The Suicide-rate.—A careful investigation gives the impression that, from a variety of causes, the numbers of actual suicides is understated to a greater or less extent. For example, in England and Wales where an inquest has been held and an "open" verdict is returned, the death is not classified as suicide. In how many cases do we find the verdict "found drowned"? In most cases, probably, suicide is to be inferred. The suicide-rates here given err, therefore, on the side of understatement. But the variations in the suicide rate seem to be in an upward direction, at any rate up to the beginning of the present century.

For England and Wales the rates were:—

1871–75	66 per million living
1881–85	75 „ „ „
1891–95	88 „ „ „
1901–05	100 „ „ „
1911–14	99 „ „ „

In the following table the quinquennial suicide rate per million living is given for certain countries from 1871–75 onwards.

Country	Period				
	1871–75	1881–85	1891–95	1901–05	1911–14
Scotland	36	53	59	58	57
Ireland	18	22	29	33	32
Australia	99	98	117	125	131
Italy		50	60	64	85
Netherlands	31	50	60	64	63
Sweden	80	97	145	154	174
Switzerland	190	236	213	232	249

The variation in the suicide rate between the various countries for which statistics are available is very great:

Chile (1923)	24 per million living
Spain (1923)	37 „ „ „
Netherlands (1925)	62 „ „ „
Iceland (1925)	63 „ „ „
Colombia (1920)	84 „ „ „
Italy (1925)	92 „ „ „
Union of South Africa (whites only) (1923)	113 „ „ „
England and Wales (1926)	114 „ „ „
Australia (1926)	118 „ „ „
United States (1926)	128 „ „ „
New Zealand (1925)	130 „ „ „
Belgium (1922)	131 „ „ „
Denmark (1925)	136 „ „ „
Uruguay (1923)	136 „ „ „
France (1925)	200 „ „ „
Austria (1922)	228 „ „ „
Germany (1925)	243 „ „ „
Hungary (1922)	275 „ „ „

It has been stated that in any given country suicide is more frequent in the hotter months of the year and one would naturally conclude that in warmer countries the rate would be higher than in the colder ones. A glance at the above table shows that such is far from being the case. Within the United States the range of the rate from State to State was as great as that shown in the preceding table. The four States with the lowest and with the highest rates in 1925 were:—

South Carolina	32	Oregon	195
Mississippi	35	Wyoming	201
North Carolina	46	Washington	211
Alabama	50	California	267

In the larger cities it ranged from 68 in Cambridge, 72 in Lowell to 296 in Oakland and 388 in San Francisco. In Chicago it was 153, in New York 143.

Influence of the World War.—Complete records for the war period do not exist. However, the following figures, relating as they do to nine of the belligerent countries and two non-belligerents closely affected by war conditions show beyond any possibility of doubt the profound effect produced upon the suicide-rate by the World War. To the theory that nervous strain is one of the prime causes which lead to self-destruction, they give a complete and emphatic contradiction—while on the other hand, they furnish the most weighty volume of indirect evidence that, as stated earlier, lack of interest in life itself should be regarded as one of, if not *the*, most potent of the factors at work.

The following table shows the suicide rate per 1 million in the years immediately preceding, during and after the World War:

Country	Period		
	1911–14	1915–18	1921–25
England and Wales	99	73	101
Scotland	57	46	66
Australia	131	106	109
New Zealand	124	113	123
Union of South Africa	93	67	82
United States	162	138	116
Germany	222	168	221
Italy	85	73	88
Japan	200	180	217
Sweden	174	122	140
Switzerland	249	198	230

In every case the war-period is marked by a notable decline in the suicide-rate. And, in looking at these figures it must be borne in mind that the men withdrawn from civil life and consequently from the population under statistical review were not at the ages at which suicide becomes most prevalent. Had suicide remained at even the same level amongst the civilian population as before, the *general* rate would have risen owing to the smaller numbers at ages where suicide is at a lower level. Incidentally, although the fall in the rate was greater among men than among women, the latter did show a quite distinct decline. Here are the rates, by sexes for England and Wales:

	Per million living	
	Men	Women
1911–14	152	40
1915–18	111	44
1921–25	154	54

Thus, while the fall during the war for men was one of 37 per cent, for women it was 10 per cent. Here, finally are the percentage declines in the general suicide-rate during the years 1915–18 in the eleven countries under review:

	%		%
New Zealand	9	Switzerland	21
Italy	9·5	Germany	24
Japan	10	England and Wales	26
United States	15	Union of South Africa	28
Scotland	19	Sweden	30
Australia	19		

(S. DE J.)

SUIDAS, Greek lexicographer. Nothing is known of him, except that he must have lived before Eustathius (12th–13th century), who frequently quotes him. Under the heading "Adam" the author of the lexicon (which a prefatory note states to be "by Suidas") gives a brief chronology of the world, ending with the death of the emperor John Zimisces (975), and under "Constantinople" his successors Basil and Constantine are mentioned. It would thus appear that Suidas lived in the latter part of the 10th century. The lexicon of Suidas is arranged alphabetically with some slight deviations. It partakes of the nature of a dictionary and encyclopaedia. It includes numerous quotations from ancient writers; the scholiasts on Aristophanes, Homer, Sophocles and Thucydides are also much used. The work deals with scriptural as well as pagan subjects, and doubtless the writer was a Christian. A prefatory note gives a list of earlier dictionaries. Although the work is uncritical, interpolated, and very unequal, it contains much information on ancient history and life.

Editio princeps, by Demetrius Chalcondyles (1499); later editions by L. Küster (1705), T. Gaisford (1834), G. Bernhardy (1834–53) and I. Bekker (1854); *see* A. Daub, *De S. Biographicorum origine et fide* (1880) and *Studien zu den Biographika des S.* (1882); and J. E. Sandys, *Hist. of Classical Scholarship* (1906), p. 407.

SUI-FU (SU-CHOW-FU), a Chinese river port at the junction of the Minkiang and the Kin-sha-kiang, in south-west Szechwan. In the south of the province are favourable conditions for breeding the wax insect on the insect trees. The insects are taken at the end of April, travelling by night along the hillsides, to secure coolness and delay hatching, to the district of Kia-ting-fu, on the Minkiang, north of Sui-fu, where the insects are put on the trees, appear to contract a disease and secrete wax. The wax is dealt in at Sui-fu. The town receives medicinal herbs and extracts, musk, etc., from Tibet, and metals from Yunnan; it exports cotton goods, chiefly to Yunnan. A recent estimate of the population gives a total of 125,000.

SUIJO-SUNAYE (sand-picture-on-water): *see* BON-SEKI.

SUINA, a group of non-ruminating artiodactyle ungulate mammals typified by the swine (*Suidae*), but also including the hippopotamus (*Hippopotamidae*), and certain extinct forms. (*See* ARTIODACTYLA; HIPPOPOTAMUS; PECCARY; SWINE.)

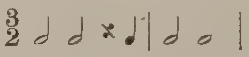
SUI-SEKI (stone-in-water): *see* BON-SEKI.

SUITE (*Suite de pièces; Ordre; Partita*), in music, a group of dance tunes in melodic forms (*see* SONATA FORMS). It consists essentially of four principal movements with the insertion of one or more lighter movements between the third and the last.

The first movement is the *allemande*, in slow common time and rich flowing rhythm, beginning with one or three short notes before the first full bar.

The second movement is the *courante*, of which there are two kinds. The French *courante* begins with one or three notes before the main beat, and is in a triple time ($\frac{3}{2}$) which, invariably at the cadences and sometimes elsewhere, drops into a crossing triple rhythm of twice the pace ($\frac{6}{4}$). In homage to Couperin, Bach often uses the French *courante*, but he is happier with the Italian type of *corrente*, a brilliant continuously running piece in quick triple time ($\frac{3}{4}$ or $\frac{3}{8}$).

The *sarabande* is a slow movement in triple time beginning on the full bar, and with at least a tendency to the rhythm



of which Handel's aria *Lascia ch'io pianga* is a familiar example. Bach's *sarabandes* are among the most simply eloquent and characteristic of his smaller compositions.

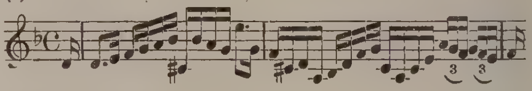
Then come the *galanteries*, from one to three in number. These are the only suite-movements (except some of Couperin's *courantes*) which can have an alternative section and a *da capo*. The commonest *galanteries* are: (1) the *minuet*, often with a second minuet which is called "trio" only when it is in real three-part writing; it is a little faster than the stately minuet in Mozart's *Don Giovanni*, and it always begins on the full bar. (2) The *gavotte*, a lively dance in a not too rapid *alla breve* time; the gavotte always begins on the half-bar. A second alternating gavotte is frequently founded on a pedal or drone-bass, and is then called *musette*. (3) The *bourrée*, which is not unlike the gavotte, but quicker, and beginning on the last quarter of the bar. (4) The *passepied*, a lively dance in quick triple time, beginning on the third beat. These dances are not always cast in binary form, and there are famous examples of gavottes and passepieds *en rondeau*. Other less common *galanteries* are: (5) the *loure*, a slow dance in $\frac{6}{4}$ time and dotted rhythm; (6) the *polonaise*, a leisurely triple-time piece, with cadences on the second instead of (as in later polonaises) the third beat of the bar; (7) the *air*, a short movement, quietly flowing, in a more florid style than its name would suggest. It sometimes precedes the sarabande.

The suite concludes with a *gigue*, in the finest examples of which the melodic binary form is combined with a light fugue style. The gigue is generally in some triplet rhythm, *e.g.*, $\frac{3}{8}$, $\frac{6}{8}$, $\frac{9}{8}$, $\frac{12}{8}$; but examples in a graver style may be found in slow square time with dotted rhythms, as in Bach's first French suite and the sixth Partita of the *Klavierübung*. In Couperin's first volume of *Ordres*, the *gigue* is followed by an enormous number of pieces which cannot have been intended to be all played on the same occasion, though they were all in the same key.

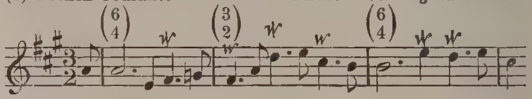
Suites on a large scale begin with a prelude in some larger form. Bach's French Suites have no preludes; his English Suites all have a great first movement which, except in the first suite, is in full *da capo* concerto form. His *Partitas* cover a wider range both in their preludes and their other contents. Some large suites have finales after the gigue, the great chaconne for violin solo being the finale of a partita (*see* VARIATIONS).

Examples illustrating the suite:

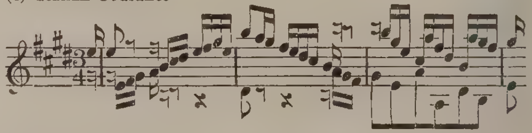
(a) Allemande BACH. *Fourth Violin Solo.*



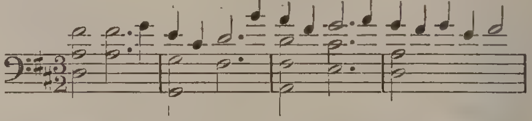
(b) French Courante BACH. *First English Suite.*



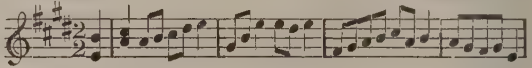
(c) Italian Courante



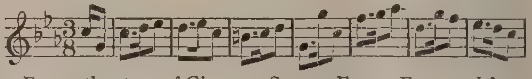
(d) Sarabande BACH. *Sixth Violoncello Suite.*



(e) Bourrée BACH. *Sixth Violin Solo.*



(f) Gigue Bach. *Second French Suite*



For another type of Gigue see SONATA FORMS, Ex. 1, and for a Gavotte see RONDO, Ex. 1.

In later times the term "suite" is more loosely employed.
(D. F. T.)

SUK, JOSEF (1874–), Czech violinist and composer, was born at Křečovice, Bohemia, on Jan. 4, 1874. He studied at Prague conservatorium, taking composition with Dvořák, whose daughter Ottilie he afterwards married. He was a member of the celebrated Bohemian Quartet. He became (1924) director of the Conservatorium at Prague. His principal works are the symphonic poems: *Prague*, op. 26, *Asrael*, op. 27, *Summer Tale*, op. 29, and *Zrani*, op. 34 (1924); incidental music to the dramatized fairy-tale, *Raduz and Mahulena; Meditation on the choral St. Wenceslaus, Legend of Dead Victors* (a war work); piano pieces, settings of Serbian folk-songs, and chamber music, including a string quartet op. 35a.

SUKHOMLINOV, VLADIMIR (1848–1926), Russian general and war minister, was born in 1848. He took part in the Russo-Turkish war as a staff officer (1877–78), and was head of the officers' cavalry school in St. Petersburg from 1886–97, being now promoted general. He was Russian war minister from 1909–16, and it was under him that the Russian orders for mobilization were given at the outbreak of the World War. He played a disastrous role in the administration of the Russian army, but it was only in 1916, under pressure of public opinion, that the Tsar Nicholas II. dismissed him from office. He was finally tried and sentenced to penal servitude on the charge of treason, but was freed by an amnesty granted by the Bolsheviks and went to Finland. In 1921 he began the publication of his memoirs, which were completed in 1924.

SUKHUM-KALEH, a Russian seaport on the Black Sea. It is in the Abkhasian S.S.R. Pop. (1926) 20,032. Sukhum Bay is sheltered by mountains and is never frozen, but the anchorage is poor. There is no railway link with the interior, though a line is under construction (1928); the site is marshy and malarial. It is the ancient Greek Dioskurias, and was in Turkish possession until 1829, since when it has been Russian except for temporary Turkish occupation in 1854 and 1877.

SUKKUR, a town and district in Sind, Bombay. The town stands on the right bank of the Indus 24 mi. S.E. of Shikarpur. Pop. (1921) 42,759. The river is now crossed by a cantilever bridge carrying the North-Western railway to Kotri.

The DISTRICT OF SUKKUR was created in 1901 out of part of Shikarpur district, the remainder of which was formed into the district of Larkana. Area, 5,606 sq.m.; pop. (1921) 510,292. It is chiefly alluvial plain, but there are slight hills at Sukkur and Rohri. A considerable part of the district is irrigated, the principal crops being wheat, millets, rice, pulses and oil seeds. Earthen, leathern and metal ware, cotton cloth and tussore silk are manufactured, also pipe-bowls, snuff-boxes and scissors. Lines of the North-Western railway serve the district, and there is a branch from Sukkur towards Quetta. Sukkur is the site of the proposed Lloyd Barrage of the Indus. The scheme, which is estimated to cost £12,000,000 will provide irrigation for 5·3 million acres.

SULA ISLANDS, a chain of islands (Sulla, Xulla, Dutch *Soela*), east of Celebes, Dutch East Indies, really an extension of the eastern peninsula of that island. There are three large islands, Taliabu, Mangola and Sula Besi, and several smaller ones. Taliabu and Mangola, very long and narrow, extend west and east (with Lisamatula), 135 miles. Both are mountainous, thickly forested, and thinly populated. Taliabu, the largest in area, very little known, is said to contain mountains from 3,000 to 4,000 ft. high, and hot springs. Mangola, which is much narrower than Taliabu, has Mt. Buja in its western part. Sula Besi, the smallest of the three, is well populated and cultivated. Wallace considers there is an approximation between the birds of the Sula isles and those of Buru, indicating that intervening land has disappeared. The babirusa and crested baboon of Buru are found in the Sula islands. Weber's Line, suggested as an alternative division between the Oriental and Australian zoological regions, in place of the Wallace Line, passes east of the Sula Islands, but west of Buru. The islands produce good timber for shipbuilding and the natives are good navigators. Damar is collected in the forests; rice, maize, tobacco and sugar-cane are grown on Sula Besi, where cultivation is far superior to that of the other islands, and the sago palm is common, forming the staple food on Taliabu and Mangola. Coal of inferior quality is found on Sula Besi, where the natives weave sarongs and plait mats. The population of the islands is estimated at 16,458, with 20 Europeans and Eurasians. The people resemble the natives of Buru and Ceram; Wallace thinks the Sula islanders are Malays from eastern Celebes. Most of the natives are pagans, but Mohammedanism is making headway, particularly in Sula Besi, the capital of which island, Sanana (pop. 1,725) is the residence of the *Gezaghebber* in charge of the islands, which form part of the residency of Ternate. Sanana, formerly the haunt of pirates, has a good roadstead, and is a port of call for vessels of the Royal Packet Navigation company. The Banggai or Peling islands, which lie off the western end of Taliabu, and also form part of the residency of Ternate, are little known, except that Peling is mountainous and well forested, with bays affording anchorage, but also with reefs. They furnish trepang and turtle. The people, who are mostly pagan, though Mohammedans live along the coast, are poor and miserably housed. Royal Packet Navigation vessels call at Banggai. The Sula and Banggai isles once formed part of the territory of the Sultan of Ternate and came under Dutch influence when, in 1683, the Dutch stripped the Sultan of his possessions.

(E. E. L.)

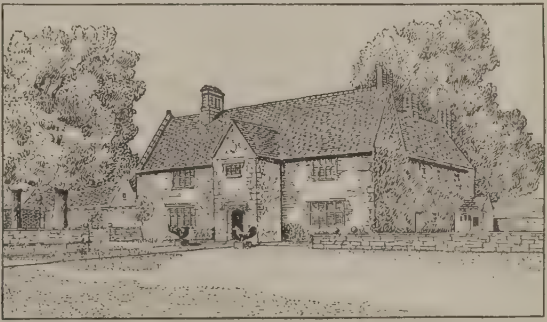
SULCI, an ancient town (mod. S. Antioco), on an island on the south-west of Sardinia and of Carthaginian origin. Its walls, of rectangular blocks of stone, can be traced for more than a mile. Phoenician and Roman antiquities, including statues, inscriptions, gems and a cistern of fine masonry, perhaps dating from the Punic period, have been found. The Phoenician tombs are cut in the rock, each measuring about 14 ft. square and 8 ft. high, and approached by a staircase: some are converted into dwellings. Curious sculptured *stelae* found in these tombs are in the museum of Cagliari. The goddess Tanit is represented, often in a form resembling Isis. The Roman tombs are simply rock trenches. There are catacombs originally Punic tombs, connected by passages in which was discovered the body of the martyr St. Antiochus, from whom the modern town takes its name. The church is cruciform, with heavy pillars and a dome: it is Byzantine. A fort occupies the highest point—the acropolis of the Punic period. The isthmus which, with bridges, connects the island with the mainland, is in part artificial. At Tratalías, on the mainland is the fine Romanesque church of S. Maria (12th–13th cent.), formerly the cathedral. At Sulci, the Carthaginian admiral Hannibal took refuge after his defeat by C. Sulpicius, but was crucified. (*See* PUNIC WARS.) In 46 B.C. the city was punished by Caesar for having helped Pompey's admiral Nasidius.

(T. A.)

SULEIMAN: *see* SOLIMAN.

SULEIMANIYE, an Iraqi town on the Persian frontier, on the caravan route from Baghdad to Tabriz. Pop. (mostly Kurds) probably somewhat over 10,000. There was formerly a large trade with Persia. The town gives its name to the administrative division.

SULGRAVE MANOR, the early English home of the ancestors of George Washington. Situated 2½m. N.W. of Helmdon in Northamptonshire, England, it is a notable shrine. Laurence Washington, twice mayor of Northampton, bought the property from King Henry VIII. in 1539, on the dissolution of the smaller religious houses. It had previously belonged to the priory of St. Andrew, Northampton. Laurence Washington, from whom George Washington was seventh in direct descent, and his children and grandchildren lived in the manor house until 1610.



SULGRAVE MANOR, NORTHAMPTONSHIRE, THE ANCESTRAL HOME OF GEORGE WASHINGTON

Sulgrave Manor was purchased, in Jan. 1914, for £8,400, by the British committee for the celebration of 100 years of peace between Great Britain and the United States (1814–1914), and is vested in three ex-officio trustees: the American ambassador in London, the British ambassador in Washington and the regent of the Mount Vernon Ladies' Association of the Union.

It is partly restored to its original condition, and furnished with choice furniture of the period. A formal reopening took place, on June 21 1921. In 1927 the restoration was completed by the rebuilding of the western wing, which had been demolished in the 18th century. The funds were collected by the American Society of Colonial Dames, which body had, two years previously, raised a permanent endowment of over £20,000.

On the gable of the central porch are the royal arms of the Tudors; and in the right spandrel of the arch of the main doorway, the Washington Arms, three mullets and two bars, which were the origin of the Stars and Stripes, the American national flag. The furnishings are gifts from British and American donors, and include an original Gilbert Stuart portrait of George Washington and many other treasures. (L. of F.)

SULIDAE: *see* Gannet.

SULIMAN HILLS, a mountain system on the north-west frontier of India. The chief mass of the range is known as Takht-i-Suliman or Solomon's throne. The legend of the mountain is that Solomon visited Hindostan to marry Balkis, and that as they were returning through the air, on a throne supported by genii, the bride implored the bridegroom to let her look back for a few moments on her beloved land. Solomon directed the genii to scoop out a hollow for the throne on the summit of the mountain. The hollow is a cavity some 30 ft. square cut out of the solid rock, at the southern extremity of the mountain and is a place of pilgrimage for both Hindus and Mohammedans. The shrine is about 2 m. S. of the highest peak. The whole mountain culminates in two points, 11,070 ft. and 11,300 ft. high.

SULINA, the second Black sea port of Rumania, and the only free port for imports. Pop. (1928) 8,000. Grain is brought down the Danube for ocean-going steamers. The port is under the European Danube Commission. The depth of water at the Sulina entrance to the Danube is 24 feet. The mouth is generally blocked with ice in the winter.

SULITJELMA, a mountain (6,158 ft.) on the frontier between Norway and Sweden. It is covered with a snow-field from which many glaciers descend. The mountain is famous as a source of pyrites, rich in copper, which occurs as lodes in schists. From Sjönstaa steamers on the Langvand and a light railway give communication between the sea and Furulund, the mining centre.

SULLA, LUCIUS CORNELIUS (138–78 B.C.), surnamed Felix, Roman general, politician and dictator, belonged to a minor and impoverished branch of the famous patrician Cornelian gens. He was quaestor in 107 under Marius, for whom he commanded the cavalry in the Jugurthian war. The surrender of Jugurtha was made to Sulla, and was the beginning of the rivalry with Marius. Sulla won the enthusiastic devotion of his troops. From 104 to 101 he served again under Marius in the war with the Cimbri and Teutons and fought in the last great battle in the Raudian plains near Verona. In 93 he was elected praetor after a lavish squandering of money and he delighted the populace with an exhibition of a hundred lions from Africa. Next year (92) he went as propraetor of Cilicia with special authority from the senate to make Mithradates VI. of Pontus restore Cappadocia to Ariobarzanes, one of Rome's dependants in Asia. This he did, subsequently receiving an embassy from the Parthians asking alliance with Rome. In 91 he returned to Rome, now one of the leading men on the senatorial side. He outshone Marius in the Social War by defeating the Samnites and taking Bovianum.

Consul.—Sulla was consul in 88, and finished the revolt by the capture of Nola. Meanwhile he had obtained by lot the command against Mithradates; Marius wanted that, and in order to get it entered into a coalition with Sulpicius Rufus, who had a plan of revolutionary legislation to carry out. Sulpicius, quite unconstitutionally, transferred the command to Marius by vote of the assembly. Rioting took place at Rome at the prompting of the popular leaders, Sulla narrowly escaping to his legions in Campania, whence he marched on Rome, being the first Roman who entered the city at the head of a Roman army. Sulpicius was put to death, and Marius fled. Sulla, leaving things quiet at Rome, quitted Italy in 87, and for the next four years he was winning victory after victory against the armies of Mithradates and accumulating boundless plunder. Athens, the headquarters of the Mithradatic cause, was taken and sacked in 86; and in the same year, at Chaeroneia, the scene of Philip II. of Macedon's victory more than two and a half centuries before, and in the year following, at the neighbouring Orchomenus, he scattered immense hosts of the enemy with trifling loss to himself. Crossing the Hellespont in 84 into Asia, he was joined by the troops of C. Flavius Fimbria, who soon deserted their general, a man sent out by the Marian party, now again in the ascendant at Rome. The same year peace was concluded with Mithradates.

Sulla returned to Italy in 83, landing at Brundisium. Marius had died in 86, and the revolutionary party, specially represented by L. Cornelius Cinna, Cn. Papirius Carbo and the younger Marius, had massacred Sulla's supporters wholesale, confiscated his property, and declared him a public enemy. They had large forces ready to meet him, but Sulla's declaration that he did not intend to deprive the Italians of the franchise cut the ground from under their feet, and only the Samnites remained in arms.

In the following year (82) he won a decisive victory over the younger Marius near Praeneste (mod. Palestrina) and then marched upon Rome, where again, just before his defeat of Marius, there had been a great massacre of his adherents, in which the learned jurist Q. Mucius Scaevola perished. Rome was at the same time in extreme peril from the advance of a Samnite army, and was barely saved by Sulla, who, after a hard-fought battle, routed the enemy under Pontius Telesinus at the Colline gate of Rome. With the death of the younger Marius, who killed himself after the surrender of Praeneste, the civil war was at an end, and Sulla was master of Rome. Then came the memorable "proscription," when for the first time in Roman history a list of men declared to be outlaws and public enemies was exhibited in the forum, so starting a reign of terror.

Dictator.—The title of "dictator" was revived and Sulla was in fact emperor of Rome. After celebrating a splendid triumph for the Mithradatic War and assuming the surname of "Felix" he carried in 80 and 70 his great political reforms (*see* Rome: *History*). Their effect was to establish the senate by law in the position which it had held unchallenged by custom until the Gracchi, to systematise the provincial arrangements, and to set up a permanent organization for the courts of justice. The mainstay of his political system was to be the military colonies which he had established with grants of land throughout every part of Italy, to the final ruin of Italian agriculture.

In 79 Sulla resigned his dictatorship and retired to Puteoli (mod. Pozzuoli), where he died in the following year, probably, from the bursting of a blood-vessel in a fit of passion. The "half-lion, half fox," as his enemies called him, the "Don Juan of politics" (Mommsen), the man who carried out a policy of "blood and iron" with a grim humour, amused himself in his last days with actors and actresses, with dabbling in poetry and completing his *Memoires* (*see* H. Peter, *Historicorum romanorum reliquiae*).

He was accorded a magnificent public funeral, his body being removed to Rome and buried in the Campus Martius. His monument bore an inscription written by himself, to the effect that he had always fully repaid the kindnesses of his friends and the wrongs done him by his enemies. His reforms, mechanically excellent, were all falling to pieces before his death, except the *quaestiones perpetuae,* which became the basis of Roman criminal justice. He tried in vain to put the clock back.

Bibliography.—The ancient authorities for Sulla and his time are his *Life* by Plutarch (who made use of the *Memoirs*); Appian, *Bell. civ.*; for the references in Cicero *see* Orelli's *Onomasticon Tullianum.* Modern treatises by C. S. Zachariä, *L. Cornelius S. als Ordner des römischen Freystaates* (1834); T. Lau, *Lucius Cornelius Sulla* (1855); E. Linden, *De bello civili Sullano* (1896); P. Cantalupi, *La Guerra civile Sullana in Italia* (1892); C. W. Oman, *Seven Roman Statesmen* (1902); F. D. Gerlach, *Marius und Sulla* (1856); J. M. Sunden, "De tribunicia potestate a Lucio Sulla imminuta" in *Skrifter utgifna af k. humanistika Vetenskapssamfundet i Uppsala,* v., 1897, in which it is argued against Mommsen that Sulla did not deprive the tribunes of the right of proposing rogations. *See* also Mommsen's *History of Rome,* vol. iii., bk. iv., ch. 8, 9; Drumann, *Geschichte Roms,* 2nd ed. by Groebe, ii. 364–432; Pauly-Wissowa, *Realencyklopädie,* iv.

SULLIVAN, SIR ARTHUR SEYMOUR (1842–1900), English composer, was born in Lambeth on May 13, 1842, being the son of a cultivated Irish musician who was bandmaster at the Royal Military College, Sandhurst, from 1845 to 1856, and taught at the Military School of Music at Kneller Hall from 1857 till his death in 1866. His mother, *née* Mary Coghlan (1811–1882), had Italian blood in her veins. Arthur Sullivan was brought up to music from boyhood, and he had learnt to play every wind instrument in his father's band by the age of eight. He also had a fine treble voice, and became a chorister of the Chapel Royal. In 1856 he won the Mendelssohn scholarship at the Royal Academy, where he studied under Sterndale Bennett, Arthur O'Leary and John Goss. In 1858 he was sent to study at Leipzig, where he had for teachers Moscheles and Plaidy for pianoforte, Hauptmann for counterpoint, Rietz and Reinecke for composition, and F. David for orchestral playing and conducting.

After two years' hard study he returned to London in April 1861 and at his instigation Schumann's first symphony was introduced at one of the Crystal Palace winter concerts. The following year his own *Tempest* music was performed at the same concerts. Then followed his *Kenilworth* cantata (remembered chiefly for the charming duet, "How Sweet the Moonlight"), the *Sapphire Necklace* overture, and the five beautiful songs from Shakespeare, which include "Orpheus with his Lute," "Oh Mistress Mine" and "The Willow Song." His attractive personality, combined with his undoubted genius and brilliant promise, brought him many friends. Costa, who was conductor at Covent Garden, gave him the post of organist, and in 1864 he produced there his *L'Île Enchantée* ballet. Other works followed, and in 1867 he first showed his genius for light operatic music in his collaboration with F. C. Burnand in *Cox and Box* and in *Contrabandista*.

In 1871 Sullivan had become acquainted with W. S. Gilbert (*q.v.*), and in 1872 they collaborated in a piece for the Gaiety Theatre, called *Thespis; or, The Gods Grown Old,* which was a great success in spite of the limited vocal resources of the performers. In 1875 R. D'Oyly Carte, then acting as manager for Selina Dolaro at the Royalty, suggested to Gilbert collaboration with Sullivan in a piece for that theatre. Gilbert had already suggested to Sullivan an operetta with its scene in a law court, and within three weeks of his completing the libretto of *Trial by Jury* the music was written. The piece succeeded beyond all expectation; and on the strength of its promise of further successes D'Oyly Carte formed his Comedy Opera Company and took the Opéra Comique Theatre. There in 1877 *The Sorcerer* was produced, George Grossmith and Rutland Barrington being in the cast. In 1878 *H.M.S. Pinafore* was brought out at the Opéra Comique, and ran for 700 nights. In America it was enthusiastically received and pirated right and left and the two authors, with D'Oyly Carte, went over to the States in 1879, with a company of their own, in order to produce it in New York. To secure the American rights for their next opera, they brought out *The Pirates of Penzance* first at New York in 1879. In 1880, in London, it ran for nearly 400 nights. In 1881 *Patience* was produced at the Opéra Comique, and was transferred later in the year to the Savoy Theatre. There all the following operas came out: *Iolanthe* (1882), *Princess Ida* (1884), *The Mikado* (1885), *Ruddigore* (1887), *The Yeomen of the Guard* (1888), *The Gondoliers* (1889). The vogue of the new type of light opera owed something to such admirable performers as George Grossmith, Rutland Barrington, Miss Jessie Bond, Miss Brandram, and later W. H. Denny and Walter Passmore; but these artistes only took advantage of the opportunities provided by the two authors. In place of the old adaptations of French *opéra bouffe* they had substituted a genuinely English product, humorous and delightful, without a tinge of vulgarity or the commonplace. But disagreements arose between them which caused a dissolution of partnership. Sullivan's next Savoy opera, *Haddon Hall* (1892), had a libretto by Sydney Grundy; and the resumption of Gilbert's collaboration in 1893 in *Utopia, Limited,* and again in 1896 in *The Grand Duke,* was not as successful as before. Sullivan's music, however, still showed its characteristic qualities in *The Chieftain* (1894)—largely an adaptation of *Contrabandista; The Beauty Stone* (1898), with a libretto by A. W. Pinero and J. Comyns Carr; and particularly in *The Rose of Persia* (1900), with Basil Hood.

In 1872 Sullivan's *Te Deum* for the recovery of the prince of Wales was performed at the Crystal Palace. In 1873 he produced at the Birmingham Musical Festival his oratorio *The Light of the World,* in 1877 he wrote his incidental music to *Henry VIII.*, in 1880 his sacred cantata *The Martyr of Antioch,* and in 1886 *The Golden Legend* was brought out at the Leeds Festival. In 1891, for the opening of D'Oyly Carte's new English opera-house in Shaftesbury Avenue, now the Palace Theatre, he wrote his "grand opera" *Ivanhoe* to a libretto by Julian Sturgis. The attempt to put an English opera on the stage for a long run was doomed to failure, but *Ivanhoe* contains many admirable pages. In 1892 he composed incidental music to Tennyson's *Foresters.* In 1897 he wrote a ballet for the Alhambra, called *Victoria and Merrie England.* Among his numerous songs, the best known are "Orpheus with his Lute," "Thou'rt Passing Hence" and, most famous of all, "The Lost Chord." This last, hackneyed as it became, was probably the most successful English song of the 19th century. The hymn tune, "Onward, Christian Soldiers!" (1872) shows Sullivan in another light. In 1876 he accepted the principalship of the National Training School of Music, which he held for six years; this was the germ of the subsequent Royal College. He was conductor of the Leeds Festivals from 1879 to 1898, besides being conductor of the Philharmonic Society in 1885. He died on Nov. 22, 1900 and was buried in St. Paul's cathedral. Among works which he left unpublished may be mentioned a *Te Deum* written for performance at the end of the Boer War, and an unfinished Savoy opera to a libretto by Basil Hood, which, completed by Edward German, was produced in 1901 as *The Emerald Isle.*

Sullivan was the one really popular English composer of any artistic standing in his time. One of the most agreeable companions, broad-minded, and free from all affectation, he was intensely admired and loved in all circles of society; and though he suffered during many years from a painful ailment, he enjoyed life without being spoilt by success.

See A. Lawrence, *Sir Arthur Sullivan: Life Story, Letters and Reminiscences* (1899); H. Saxe-Wyndham, *Arthur Seymour Sullivan* (1926); Herbert Sullivan and Newman Flower, *Sir Arthur Sullivan, His Life, Letters and Diaries* (1928).

SULLIVAN, JOHN (1740–1795), American soldier, was born in Somersworth (now Rollinsford), N.H., on Feb. 17, 1740. He practised law at Berwick, Maine, and at Durham, N.H., was a member of the New Hampshire Provisional Assembly (1774), and also a member of the first Continental Congress. In June, 1775, he was appointed brigadier-general in the Continental Army, and aided in the siege of Boston. In the same year, he took command of the American army in Canada, and exhibited great skill in effecting a retreat from that province. Soon afterward, having been superseded in command by General Gates, he rejoined Washington's army and took part in the battle of Long Island, where he was taken prisoner In December he was exchanged, and succeeded General Charles Lee in command as major-general of the right wing of Washington's army. In the battle of Trenton he led an attack on the Hessians, and on Aug. 22, 1777, he led a night attack against the British and Loyalists on Staten Island. He commanded the American right in the battle of Brandywine and took part in the battle of Germantown. In March 1778 he was placed in command in Rhode Island, and in the following summer plans were made for his co-operation with the French fleet under Count d'Estaing in an attack on Newport.

The Indian raids in western New York, especially the atrocities in the Wyoming and Cherry valleys caused a retaliatory expedition to be sent to "chastise and humble the Six Nations," and Sullivan was chosen to lead the expedition. With about 4,000 men, he defeated the Iroquois and their Loyalist allies at Newtown (now Elmira, N.Y.), burned their villages, and destroyed their orchards and crops. Although severely criticized for his conduct of the expedition, he received the thanks of Congress in October 1779, and in November resigned from the army. Sullivan was again a delegate to the Continental Congress in 1780–81 and from 1782 to 1785 he was attorney-general of New Hampshire. He was president of the State in 1786–87 and in 1789, and in 1786 suppressed an insurrection at Exeter immediately preceding the Shays Rebellion in Massachusetts. He presided over the New Hampshire convention which ratified the Federal Constitution in June 1788. From 1789 until his death at Durham, on Jan. 28, 1795, he was United States district judge in New Hampshire.

See O. W. B. Peabody, "Life of John Sullivan" in Jared Sparks's *Library of American Biography,* vol. iii. (1844); G. S. Conover, *Journals of the Military Expedition of Major John Sullivan against the Six Nations* (1887); Oscar E. Rising, *A New Hampshire Lawyer in General Washington's Army* (Geneva, N.Y., 1915).

SULLIVAN, a city of south-western Indiana, U.S.A., on federal highway 41, 26 m. S. of Terre Haute; the county-seat of Sullivan county. It is served by the Chicago and Eastern Illinois, the Chicago, Milwaukee, St. Paul and Pacific, and the Illinois Central railways. The population was 4,489 in 1920 (97% native white). It is in one of the principal coalfields of the State, and there are oil-wells near by. The city was founded in 1842 and incorporated in 1909.

SULLY, JAMES (1842–1923), English psychologist, was born on the 3rd of March 1842 at Bridgwater, and was educated at the Independent college, Taunton, the Regent's Park college, Göttingen and Berlin. He was originally destined for the Nonconformist ministry, but in 1871 adopted a literary and philosophic career. He was Grote professor of the philosophy of mind logic at University college, London, from 1892 to 1903, when he was succeeded by Carveth Read. An adherent of the associationist school of psychology, his views had great affinity with those of Alexander Bain. His monographs, as that on pessimism, are ably and readably written, and his text-books, of which *The Human Mind* (1892) is the most important, are models of sound exposition. He died at Richmond, Surrey, on Oct. 31, 1923.

WORKS.—*Sensation and Intuition* (1874), *Pessimism* (1877), *Illusions* (1881; 4th ed., 1895), *Outlines of Psychology* (1884; many editions), *Teacher's Handbook of Psychology* (1886), *Studies of Childhood* (1895), *Children's Ways* (1897), and *An Essay on Laughter* (1902).

SULLY, MAXIMILIEN DE BÉTHUNE, DUC DE (1560–1641), French statesman, was born at the château of Rosny near Mantes, on Dec. 13, 1560, son of François de Béthune, baron de Rosny (1532–1575). Brought up in the Reformed faith, Maximilien joined the court of Henry of Navarre in 1571. He was taken to Paris by his patron, and was studying at the college of Bourgogne at the time of the St. Bartholomew massacre, from which he escaped by discreetly carrying a book of hours under his arm. On the outbreak of civil war in 1575 he enlisted in the Huguenot army. In 1576 he accompanied the duke of Anjou on an expedition into the Netherlands in order to regain the former Rosny estates, but being unsuccessful he attached himself for a time to the prince of Orange. Later rejoining Henry of Navarre in Guienne, he displayed particular ability as an engineer. In 1583 he was Henry's special agent in Paris. In 1584 he married Anne de Courtenay, a wealthy heiress, who died, however, in 1589. On the renewal of civil war Rosny again joined Henry of Navarre, and at the battle of Ivry (1590) was seriously wounded. He counselled Henry IV.'s conversion to Roman Catholicism, but steadfastly refused himself to become a Roman Catholic.

Rosny became a member of the king's council of finance in 1596, and appears to have been sole superintendent as early as 1598. He authorized the free exportation of grain and wine, reduced legal interest from 8⅓ to 6¼%, established a special court for trial of cases of peculation, forbade provincial governors to raise money on their own authority, and otherwise removed many abuses of tax-collecting, abolished several offices, and by his honest, rigorous conduct of the country's finances was able to save between 1600 and 1610 an average of a million livres a year. His achievements were by no means solely financial. In 1599 he was appointed grand commissioner of highways and public works, superintendent of fortifications and grand master of artillery; in 1602 governor of Mantes and of Jargeau, captain-general of the queen's gens d'armes and governor of the Bastille; in 1604 governor of Poitou; and in 1606 duke and peer of Sully, ranking next to princes of the blood. He declined the office of constable because he would not become a Roman Catholic. Sully encouraged agriculture, urged the free circulation of produce, promoted stock-raising, forbade the destruction of the forests, drained swamps, built roads and bridges, planned a vast system of canals and actually began the canal of Briare. He strengthened the French military establishment; under his direction Évrard began the construction of a great line of defences on the frontiers. Sully opposed the king's colonial policy as inconsistent with the French genius, and likewise showed little favour to industrial pursuits, although on the urgent solicitation of the king he established a few silk factories. He fought in company with Henry IV. in Savoy (1600–1601) and negotiated the treaty of peace in 1602; in 1603 he represented Henry at the court of James I. of England; and throughout the reign he helped the king to put down insurrections of the nobles, whether Roman Catholic or Protestant. It was Sully, too, who arranged the marriage between Henry IV. and Marie de Médicis.

The political rôle of Sully practically ended with the assassination of Henry IV. on May 14, 1610. Although a member of the council of regency, his colleagues were not disposed to brook his domineering leadership, and after a stormy debate he resigned as superintendent of finances on Jan. 26, 1611, and retired to private life. The baton of marshal of France was conferred on him on Sept. 18, 1634. He died at Villebon, on Dec. 22, 1641.

Sully was hated by Catholics because he was a Protestant, by Protestants because he was faithful to the king. He was an excellent man of business, inexorable in punishing malversation and opposed to the ruinous expenditure which was the bane of European monarchies. He was implicitly trusted by Henry IV., and contributed greatly to the recovery of France.

Sully left a curious collection of memoirs bearing the title, *Mémoires des sages et royales oeconomies d'estat, domestiques, politiques, et militaires de Henry le Grand. . . .* The *Mémoires* are very valuable for the history of the time, though they contain fictitious matter such as a mission by Sully to England in 1601, and the "grand design" for a Christian republic. The best edition of the original is that in J. F. Michaud and J. J. F. Poujoulat, *Nouvelle collection des mémoires relatifs à l'histoire de France* (1854), vols. xvi.–xvii. An English translation by Charlotte Lennox appeared in 1756 and was later revised and republished (4 vols., London, 1856).

See E. Lavisse, *Sully* (Paris, 1880); G. Fagniez, *Économie sociale de la France sous Henri IV.* (Paris, 1897).

SULLY, THOMAS (1783–1872), American artist, was born at Horncastle, England, on June 8, 1783. His parents, who were actors, took him to America, when he was nine years old, settling at Charleston (S.C.), and he was first instructed in art by a French miniature painter. Afterwards he was a pupil of Gilbert Stuart in Boston, and in 1809 he went to London and entered the studio of Benjamin West. He returned in 1810, and made Philadelphia his home, but in 1837 again visited London, where he painted a full-length portrait of Queen Victoria for the St. George's Society of Philadelphia. Sully was one of the best of the early American painters. He died in Philadelphia on Nov. 5, 1872. Among his portraits are those of Comm. Decatur (City Hall, New York); the actor, George Frederick Cooke, as Richard III. (Pennsylvania Academy of the Fine Arts, Philadelphia); Lafayette (Independence Hall); Thomas Jefferson (U.S. Military Academy, West Point, N.Y.) and Charles and Frances Anne Kemble, and Reverdy Johnson.

SULLY-PRUDHOMME, RENE FRANÇOIS ARMAND PRUDHOMME (1839–1907), French poet, born in Paris, March 16, 1839, was educated at the Lycée Bonaparte, where he took his degree as Bachelier ès Sciences. An attack of ophthalmia interrupted his studies and necessitated an entire change in the course of his career. He found employment for a time in the Schneider factory at Creuzot, but he soon abandoned an occupation to which he was eminently unsuited. He subsequently entered a notary's office in Paris. It was during this period that he composed those early poems which were not long in acquiring celebrity among an ever-widening circle of friends. In 1865 he published his first volume of poems, which was favourably reviewed by Sainte-Beuve, to whose notice it had been brought by Gaston Paris. It was at this moment that the small circle of which Leconte de Lisle was the centre were preparing the *Parnasse,* to which Sully-Prudhomme contributed several pieces. In 1866 Lemerre published a new edition of the *Stances et poèmes* and a collection of sonnets entitled *Les Épreuves* (1866). From this time forward Sully-Prudhomme devoted his life entirely to poetry. It was in the volume of *Les Épreuves* that the note of melancholy which was to dominate through the whole work of his life was first clearly discernible. In 1869 he published a translation of the first book of Lucretius with a preface, and *Les Solitudes.* In 1870 a series of domestic bereavements and a serious paralytic illness resulting from the strain and fatigue of the winter of 1870, during which he served in the Garde Mobile, shattered his health. In 1872 he published *Les Écuries d'Augias, Croquis italiens, Impressions de la guerre* (1866–72) and *Les Destins, La Révolte des heurs* in 1874, in 1875 *Les vaines Tendresses,* in 1878 *La Justice,* in 1886 *Le Prisme,* and in 1888 *Le Bonheur.* All these poems were collected and republished under the title of *Poésies,* occupying four volumes of his *Oeuvres* (6 vols., 1883–1904). After the publication of *Le Bonheur* he practically ceased to produce verse, and devoted himself almost entirely to philosophy. He published two volumes of prose criticism *L'expression dans les beaux arts* (1884) and *Réflexions sur l'art des vers* (1892). Various monographs by him appeared from time to time in the philosophical reviews, and among them a remarkable series of essays (*Revue des deux mondes,* Oct. 15th, Nov. 15th, 1890) on Pascal, and a valuable study on the "Psychologie du libre arbitre" in the *Revue de métaphysique et de morale* (1906). He was elected to the Academy on the 8th of December 1881. On the 10th of December 1901 he was awarded the Nobel prize for literature, and devoted most of the money to the foundation of a prize for poetry to be awarded by the *Société des gens de lettres.* He was one of the earliest champions of Captain Dreyfus. In 1902 he wrote, in collaboration with Charles Richet, *Le Problème des causes finales.* During his later years he lived at Châtenay in great isolation, a victim of perpetual ill-health, and mainly occupied with his *Vraie religion selon Pascal* (1905). He had been partially paralysed for some time when he died suddenly on the 6th of September 1907. He left a volume of unpublished verse and a prose work, *Le Lien social,* which was a revision of an introduction which he had contributed to Michelet's *La Bible de l'humanité. See* C. Hémon, *La Philosophie de Sully-Prudhomme* (1907), *Sully-Prudhomme* by E. Zyromski (Paris 1907).

SULMONA (anc. *Sulmo*), a city of the Abruzzi, Italy. Pop. (1921), 16,676 (town), 18,797 (commune). Sulmona is situated at a height of 1,322 ft. above the sea on the Gizio, a tributary of the Pescara, which supplies water-power to its paper-mills, fulling-mills and copper-works. Its cathedral of San Panfilo has a 14th-century portal, and an 11th-century crypt. S. Maria della Tomba is a good Gothic church. S. Francesco della Scarpa occupies the site of an older and larger church, the Romanesque portal of which still stands at the end of the Corso Ovidio, and forms the entrance to the market. Opposite is a picturesque aqueduct of 1256 with pointed arches, which supplies the Renaissance Fontana del Vecchio (1474). S. Agostino has a good Gothic portal. The Palazzo dell' Annunziata, begun in 1320, shows an interesting and successful mixture of Gothic and Renaissance styles. In the court of the grammar school is a fine 15th-century statue of Ovid, the most celebrated native of the town, whose memory is preserved among the peasants in songs and folk-lore, and outside is a good monument to him by Ettore Ferrari (1925). The Porta Napoli is an interesting gate of the 14th century. Innocent VII. was a native of the town. In the vicinity of the town is Monte Morrone where Pietro da Morrone lived as a hermit and founded a monastery for his hermits, who after his elevation to the papacy as Celestine V. (1294) took the name of Celestines; the monastery (S. Spirito) is now a prison.

Sulmo was devastated by Hannibal (211 B.C.). It was famous for its ironsmiths. Charles V. bestowed it on Charles Launoy, who had captured Francis I. at the battle of Pavia. The town has suffered much from earthquakes.

SULPHONAL GROUP, THE. This group of hypnotics includes *sulphonal, methyl sulphonal* known under the trade name of "trional" and *ethyl sulphonal* known as "tetronal," both of which are scheduled as poisons.

Sulphonal, or acetone diethyl sulphone $(CH_3)_2C(SO_2C_2H_5)_2$, crystallizes in prisms melting at 125° C, which are practically insoluble in cold water, but dissolve in 15 parts of hot and also in alcohol and ether. It is the *sulphonalum* of the B.P. and the *sulphomethanum* of the U.S.P. It is prepared by condensing acetone (*q.v.*) with ethyl mercaptan in the presence of hydrochloric acid, the mercaptol $(CH_3)_2C(SC_2H_5)_2$ formed being subsequently oxidized by potassium permanganate. Dose 10 to 30 grains. *Trional* $(CH_3)(C_2H_5)C(SO_2C_2H_5)_2$ is slightly more soluble in cold water than Sulphonal (1 in 320). Dose 10 to 20 grains. *Tetronal* $(C_2H_5)_2C(SO_2C_2H_5)_2$ is less soluble in cold water than sulphonal (1 in 550). Dose 10 to 20 grains. All three substances are white crystalline powders, odourless and almost tasteless.

Sulphonal was discovered by Baumann and introduced into medical practice in 1888. The derivatives trional and tetronal were introduced soon afterwards. These drugs came into general use as hypnotics and were found specially valuable in calming motor excitement. They have been very largely used in mental cases and asylum practice. Their low solubility and slow absorption cause a delayed action. They have been recommended for calming the motor excitement in chorea, but great care is necessary if they are used for this purpose owing to the tender age of choreic patients and to the toxic action of the drugs.

Cumulative action may occur if the drugs are given in frequently repeated doses since owing to the slow absorption a large quantity may accumulate in the alimentary tract. Absorption over a large area may then occur and give rise to toxic symptoms some time after the initial doses were administered. They should be taken with a large quantity of hot water about four hours before the time it is desired that sleep should ensue. Constipation should be guarded against to avoid retention of the unabsorbed drug.

Owing to their slow absorption and consequent somewhat uncertain and delayed action in producing sleep these drugs have in recent years become largely displaced by the barbituric acid (*q.v.*) hypnotics which have a rapid and more certain action.

Toxic Effects.—When first introduced it was thought that the sulphonal group were harmless hypnotics. But an overdose will cause a condition of deep stupor followed by loss of consciousness from which the patient cannot be roused (coma). This comatose condition may last some days and there is in this stage great danger of the development of fatal broncho-pneumonia.

Chronic sulphonal poisoning may follow the continued daily use of full therapeutic doses, and symptoms may occur which simulate organic disease of the nervous system. Thus headache, drowsiness, vertigo and severe mental depression may result. The speech may become thick and articulation indistinct. The gait may become ataxic and reeling in type like that of alcoholic intoxication or cerebellar disease. Paralytic symptoms such as squint, ptosis, diplopia, nystagmus or facial weakness may occur. Skin rashes have frequently occurred in patients who have been taking sulphonal in repeated doses; they may be of urticarial or erythematous type and are often associated with severe itching and irritation (prurigo). Vesicular and bullous eruptions and purpura have been described. A common symptom of chronic sulphonal poisoning is the presence of altered blood pigment in the urine (haematoporphyrinuria), the urine becoming claret coloured. In some cases albumen and casts may appear in the urine due to the irritating action of the drugs on the kidneys. (W. H. WI.)

Drug addiction (*q.v.*) is common. The mental depression not infrequently leads to the taking of a large overdose.

SULPHONIC ACIDS, organic acids containing sulphur and having the general formula, $R{\cdot}SO_3H$, where R is either an alkyl or an aryl radical. (*See* CHEMISTRY, ORGANIC.)

Aromatic Sulphonic Acids.—The acids of this more important group are obtained generally by digesting aromatic compounds with concentrated sulphuric acid, the process being called sulphonation. Such operations are frequently conducted on a manufacturing scale as in the preparation of the sulphonic acids of benzene (*q.v.*), naphthalene (*q.v.*) and anthraquinone (*q.v.*).

The sodium salt of benzenesulphonic acid is of importance since on fusion with caustic soda it yields phenol. During the World War large quantities of synthetic phenol were made by this process in order to eke out the supply of coal tar phenol, which was then insufficient for the wholesale production of the explosive, picric acid (*q.v.*). Benzenedisulphonic acid, made from oleum (fuming sulphuric acid) and benzene, yields by alkali fusion the important colour intermediate, resorcinol.

The sulphonic acids of naphthalene are manufactured on an extensive scale, for by alkali fusion naphthalene-α-sulphonic acid, made by low-temperature sulphonation, yields α-naphthol, whereas naphthalene-β-sulphonic acid, prepared at 140° C, when similarly treated, furnishes β-naphthol.

Anthraquinone, the oxidation product of anthracene (*q.v.*), when sulphonated with oleum at high temperatures yields anthraquinone-β-sulphonic acid, the sodium salt of which ("silver salt") is an important intermediate used in the manufacture of alizarin (*q.v.*) and the indanthrene vat colours. (*See* DYES, SYNTHETIC.) Sulphonation of anthraquinone is facilitated by a mercuric sulphate catalyst, and in this way anthraquinone-1:5- and -1:8-disulphonic acids are produced. These disulphonic acids are also used as intermediates in the dye industry. Sulphonation may be effected by chlorosulphonic acid whereby sulphonic chlorides are formed. (*See* SACCHARIN.)

In addition to direct sulphonation, the sulphonic group may be introduced into the aromatic nucleus through the diazo-reaction (*see* DIAZO-COMPOUNDS).

Sulphonic acids of aromatic hydrocarbons are very soluble in water and when obtained crystalline are extremely hygroscopic. With phosphorus pentachloride they yield sulphonic chlorides, which are reducible to thiophenols. On distillation with sodium cyanide or ferrocyanide the sodium arylsulphonates give rise to nitriles.

Sulphanilic acid, a sulphonic acid of aniline, is sparingly soluble in cold water and is to be regarded as an internal salt,

$$\overset{+}{N}H_3\cdot C_6H_4\cdot\overset{-}{S}O_3.$$

This compound and the similar naphthylamine sulphonic acids are important colour intermediates.

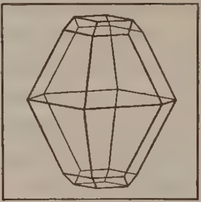
Aliphatic Sulphonic Acids are much less important than those of the aromatic series. They are obtained generally (i.) by the oxidation of mercaptans, alkyl disulphides, alkyl thiocyanates or alkyl sulphinic acids; (ii.) by the interaction of alkyl iodides and metallic sulphites; (iii.) by direct action of sulphur trioxide on hexane and its homologues (J. Worstall, 1898). They are either viscous liquids or crystalline solids, converted into sulphonic chlorides by phosphorus pentachloride and into alcohols and alkali sulphites by alkali fusion.

Hydroaromatic Sulphonic Acids.—Camphor yields a characteristic sulphonic acid on sulphonation with sulphuric acid in acetic anhydride. The optically active camphor sulphonic acids from dextro- and laevo-modifications of camphor have been very useful in the resolution of racemoid bases. (*See* STEREOCHEMISTRY.)

(G. T. M.)

SULPHUR, a non-metallic chemical element, also called "brimstone," has been known from remote times, and, owing to its inflammability, was regarded by the alchemists as the principle of combustion. Sulphur (symbol S, atomic number 16, atomic weight 32·064), is widely and abundantly distributed in nature, both in the free state and in combination. Various forms of free or native sulphur occur in volcanic areas, but they are all related to rhombic sulphur, the monoclinic form being unknown in a natural state. The crystals (*see* fig.) are of hardness 1–2, and sp.gr. 1·9–2·1; they are transparent or translucent; highly refractive with strong birefringence, and have a characteristic lustre. Although pure sulphur is yellow, impurities such as selenium or arsenic sulphide give it a reddish tint.

Volcanic sulphur usually occurs as a sublimate on the walls of vents, probably as the result of action between hydrogen sulphide and sulphur dioxide. Natural sulphureous waters, especially if hot, readily deposit sulphur owing to atmospheric oxidation of the sulphuretted hydrogen. Free sulphur may also result from the weathering of pyrites, as in pyritic shales or lignites or from the pyrites of Rio Tinto (Spain). Atmospheric oxidation may affect sulphur itself, producing sulphuric acid, which in the presence of lime produces gypsum, and outcrops of sulphur in Sicily are often covered with this. Important deposits of sulphur in the world occur in Sicily in Miocene marls and limestone, in Transcaucasia and in the Transcaspian steppes, in Japan, Chile, Peru and in many States of the U.S.A., especially in Louisiana. Sulphur is also found occasionally in Carrara marble in Calabria, and in carboniferous limestone in Galway.



RHOMBIC SULPHUR CRYSTAL, SHOWING PYRAMIDAL HABIT

In combination, the element occurs chiefly in sulphides and sulphates of metals. The former are of great importance and value, *e.g.*, copper pyrites, galena (lead), zinc blende, cinnabar (mercury). The sulphates include those of calcium (gypsum and anhydrite), barium (barytes), and magnesium (kieserite). Gaseous compounds occur in volcanic exhalations and in mineral waters. The element is also present in hair, wool, albumen (*q.v.*) and in certain vegetable oils, such as those of garlic and mustard.

Extraction.—As quarried or mined, free sulphur is always contaminated with clay, limestone, gypsum, etc., and its extraction depends on melting it and running it off from the earthy residue (liquation). In Sicily the method formerly employed was wasteful, but has been improved; a mass of the ore is placed in a kiln and is melted either by setting fire to a portion or by external heating; the molten sulphur is run off into moulds of damp wood, but still contains a certain proportion of impurities. Further purification is effected by distillation from large iron pots, the sulphur condensing in a stone chamber either as solid *flowers of sulphur* or as a liquid which is cast into sticks and sold as *roll sulphur*.

In Louisiana, the deposits are covered by quicksand and cannot be mined by ordinary methods. The Frasch process was specially devised for this purpose: four concentric pipes, of diameters 10, 6, 3 and 1 inch, are sunk in a bore hole, and superheated steam is forced down the 3-inch pipe to melt the sulphur. Compressed air is driven down the centre pipe and causes the mixture of water and molten sulphur to rise in the outer pipes; this mixture is run off into settling tanks and yields sulphur of 98% purity.

Sulphur is also obtained from pyrites either by distilling it in iron or fire-clay tubular retorts, whereby one-third of the sulphur is obtained in the distillate ($3FeS_2 = Fe_3S_4 + 2S$), or by a modification of the Sicilian process. Sulphur from pyrites, however, usually contains traces of arsenic.

Milk of sulphur is produced by boiling sulphur with a suspension of lime until it has dissolved—5 parts of sulphur require about 2 parts of quicklime—and the solution is clarified, diluted, and nearly neutralised by pure dilute hydrochloric acid; this decomposes the calcium polysulphides, giving a very fine, almost white powder, which is washed and carefully dried. If too much acid is added, the calcium thiosulphate, which is formed together with the polysulphides, is also decomposed, and this gives a yellow, coarser product.

Physical Properties.—Commercial sulphur melts at 113° C if quickly heated and boils at 444·53° C under atmospheric pressure. The orange-yellow vapour darkens with increase of temperature, being deep red at 500°, but above that it becomes lighter again and is straw-yellow at 650°. At 200° (under reduced pressure) the vapour density corresponds to S_8 molecules; at 500° to S_6, at about 1,000° to S_2 and at about 2,000° the molecules are completely dissociated to atoms. In carbon disulphide solution sulphur exists as S_8, as shown by boiling-point and freezing-point determinations. Sulphur is a bad conductor of electricity and becomes negatively electrified by friction. It is insoluble in water, it ignites in air at 363° and in oxygen at 280°, burning with a characteristic blue flame and forming sulphur dioxide, a gas with a choking smell, and traces of the trioxide. Sulphur also combines directly with most elements to form sulphides.

Allotropic Modifications.—Sulphur can assume a number of forms differing in external appearance, *e.g.*, crystal structure, and in physical properties, *e.g.*, density. Of these the two most important are rhombic (α, S_α, or S_I) and monoclinic (β, S_β, or S_{II}), since they provided the first instances of what E. Mitscherlich (1822) termed "polymorphism," but is now called "allotropy" (*q.v.*). Rhombic sulphur is readily obtained by allowing a solution of sulphur in carbon disulphide to crystallise. The monoclinic variety is formed as fine needles on the inside of the crust on molten sulphur which has been allowed to cool slightly. Both these varieties are soluble in carbon disulphide and sulphur chloride; above 96° S_α is more or less rapidly converted into S_β, whereas below 96° S_β changes gradually to S_α. If S_α is heated quickly it melts at 114° before it has had time to change into S_β, but if it is heated slowly the change is completed and the S_β formed then melts at 119°. The density of S_α is 2·07 and that of S_β 1·96. Under higher pressures the two forms can only co-exist at a definite temperature for any particular pressure (*i.e.*, the transition point is raised), and if the pressure is raised while the temperature is kept constant the rhombic form is produced, since it is the denser. This balanced state of affairs continues up to 151° and 1,288 atmospheres, above which the monoclinic form cannot exist at all.

The fact that, by rapid heating, the rhombic variety persists up to 114° (under ordinary pressure) without changing into the monoclinic is due to this change being slow and not instantaneous.

Although the foregoing account covers the more obvious phenomena, the relationships are, in fact, extremely complicated, and at least three varieties of sulphur (called S_λ, S_π, and S_μ) are involved. The first, S_λ, is almost certainly S_8, and constitutes the greater part of both the rhombic and monoclinic varieties, but the other two (possibly S_6, S_4, or S_2) form solid solutions with S_λ, and all three are involved in very complex equilibria in both the liquid and the solids. Owing to the slowness with which these equilibria are established, the physical conditions may be somewhat indefinite; thus pure S_λ is calculated to have an "ideal" freezing point of 119°, but the presence of S_π and S_μ depresses this to a varying extent (but never below 114°) according to the rate of cooling, *i.e.*, according to whether the time has sufficed for them to attain their equilibrium values.

Other forms differing in external appearance are the nacreous (or pearly) variety (S_{III}), formed when solutions of sodium thiosulphate and potassium bisulphate interact, or when hydrogen disulphide is shaken with alcohol or ether, and a tabular variety (S_{iv}), formed in the aerial oxidation of alcoholic solutions of ammonium polysulphides. Both these are monosymmetric but have different angles from S_{II}; they change rapidly to S_I at the ordinary temperature, or to S_{II} above 96°, but S_{III} may be melted at 107° if rapidly heated.

Engel's variety (S_ρ) is obtained by mixing sodium thiosulphate solution with hydrochloric acid, filtering, extracting the filtrate with chloroform, and evaporating the extract. It appears to be S_6, but its connection with the other forms has not been established. It is intermediate in colour between S_λ and S_π (*i.e.*, S_8 and S_4) and slowly changes into a mixture of these.

Apart from varieties possessing obvious external differences, more subtle differences have been detected. When sulphur melts the liquid is pale yellow, but on further heating it darkens, and at 160° C it rapidly becomes more viscous. At 180° the liquid is dark red and the viscosity attains a maximum. This behaviour has been traced to the existence of three different types of molecules in the liquid—S_λ, S_π and S_μ; if the molten liquid is poured into water, one obtains clear and elastic strings of *plastic* sulphur. From 5 to 20% of this (depending upon the temperature and time of heating of the liquid) is found to be insoluble in carbon disulphide and is S_μ and the rest is a mixture of S_λ and S_π. The material becomes opaque and brittle after a few days owing to the conversion of most of the S_μ and some of the S_π into crystalline S_λ or rhombic sulphur; the proportion of S_π and S_λ can be ascertained by taking advantage of the fact that at −80° C the latter becomes insoluble in carbon disulphide whereas the former is still soluble. The proportion of S_π in sulphur increases to about 6% at 200° from about 3·5% at 120°, and it has been shown to be tetratomic, *i.e.*, S_4. Owing to its insolubility, the molecular weight of S_μ has not been determined; it is the chief constituent of the so-called amorphous sulphur (S_γ) and of milk of sulphur, and because of its increasing production at higher temperatures it occurs in greater proportion in sulphur which has been rapidly condensed, as in flowers of sulphur.

Many of the above transformations are slow and afford instances of "dynamic" allotropy. (*See* ALLOTROPY.)

COMPOUNDS

Hydrogen sulphide or sulphuretted hydrogen results when hydrogen is passed over molten sulphur at 200°–350° C; at higher temperatures it begins to dissociate into its elements again; it is also formed when acids act on metallic sulphides, ferrous sulphide and dilute hydrochloric or sulphuric acid being most frequently used, but in this case the gas is contaminated with hydrogen. The purest hydrogen sulphide is obtained either by warming precipitated antimony sulphide with hydrochloric acid or by dropping water on to aluminium sulphide produced by a thermite process from sulphur and aluminium powder. It results from the putrefaction of organic substances containing sulphur or from the destructive distillation of coal; it is evolved when organic compounds (such as paraffin wax) are heated with sulphur.

Hydrogen sulphide, a colourless, poisonous gas having the odour of rotten eggs, is moderately soluble in water to give a very feebly acidic solution, which gradually deposits sulphur on exposure to the air; it is much more soluble in alcohol. It burns with a pale blue flame to give sulphur dioxide and water. The gas may be liquefied at 18° C by a pressure of 17 atmospheres, and the liquid boils at 61·8° under ordinary pressure, and solidifies at −83°. It is decomposed by the halogens or by sulphuric acid with the liberation of sulphur. It reacts with many metals to form sulphides, which are also produced by its action on aqueous solutions of metallic salts; the latter reaction is extensively utilised in chemical analysis. Hydrogen sulphide is also used as a reducing agent: in acid solution it reduces ferric to ferrous salts, chromates to chromium salts, and manganates to manganese salts; in alkaline solution it reduces many organic nitro-compounds to the corresponding amino-derivatives. It is rapidly attacked by oxidising agents, yielding primarily sulphur and water.

When metallic polysulphides are acted upon by hydrochloric acid they give a mixture of hydrogen polysulphides, and by fractional distillation under reduced pressure two of these have been separated as oils, viz., the *disulphide*, H_2S_2, b.p. 74°C, and the *trisulphide*, H_2S_3, b.p. 69°/2 mm. They are readily decomposed by the action of light or of water.

Halogen Compounds.—*Sulphur hexafluoride*, SF_6, formed by the action of fluorine on sulphur, is a tasteless, colourless and odourless gas, which may be condensed to a solid melting at −55° C; it is remarkably stable, being unaffected even by fused caustic alkalis, and is of considerable theoretical interest.

Sulphur chloride, S_2Cl_2, occurs as a by-product in the manufacture of carbon tetrachloride from carbon disulphide and chlorine, and may readily be prepared by passing chlorine over molten sulphur and condensing the issuing gas. It is an amber-coloured, fuming liquid with a very irritating smell; it boils at 139° and freezes at −80°. It is slowly decomposed by water to sulphur and a mixture of sulphur acids. Its chief use is in the vulcanisation of rubber, since it dissolves sulphur very readily.

Sulphur dichloride, SCl_2, had its entity definitely established by T. M. Lowry, L. P. McHatton, and G. G. Jones in 1927, before which it was frequently said to be a mixture of the mono- and tetra-chlorides. Chlorine reacts very slowly with the monochloride, but in the presence of a trace of iodine reaction becomes rapid, and by taking advantage of this discovery (among others), these authors were able to show that both SCl_2 and S_3Cl_4 exist; the former, however, becomes unstable just about its melting point (−83°) and gives SCl_4 and lower chlorides; S_3Cl_4 has a narrow range of existence but melts at −103°.

Sulphur tetrachloride, SCl_4, is formed by saturating S_2Cl_2 with chlorine at −22°; it is a yellowish-brown liquid, solidifying to a crystalline mass at −30° C, and dissociating rapidly above

−20°. It is violently decomposed by water: $SCl_4+3H_2O=H_2SO_3+4HCl$.

Sulphur bromide, S_2Br_2, is a dark red liquid boiling at 56° under 0·2 mm. pressure and decomposing at about 200°. Sulphur forms no definite compound with iodine.

Oxides.—*Sulphur dioxide*, SO_2, occurs in gaseous exhalations of volcanoes and in solution in some volcanic springs. It is formed when sulphur burns in air or oxygen, when metallic sulphides are roasted, and when sulphuric acid is reduced by being heated with carbon, sulphur, or certain metals:

$$C+H_2SO_4=2SO_2+CO_2+2H_2O;$$

$$S+2H_2SO_4=3SO_2+2H_2O;\ Cu+2H_2SO_4=SO_2+CuSO_4+2H_2O.$$

It is also a product of decomposition of many sulphur acids by dilute mineral acids. It is a colourless, incombustible gas with a suffocating odour; it dissolves readily in alcohol or water, the solution in the latter possessing acidic properties. The gas can be liquefied at −8° C and solidified at −73° C; the liquid is a good solvent for certain salts, giving definite compounds in some cases—*e.g.*, $KI,2SO_2$ and $KI,4SO_2$. It combines directly with chlorine (especially in the presence of camphor) to give sulphuryl chloride, and with many peroxides to give sulphates. In the presence of water it acts as a bleaching agent owing to its reducing properties, and these are also manifested in acid solution by the reduction of the manganates to manganese salts and of iodates or iodine to iodides: $2KIO_3+5SO_2+4H_2O=I_2+2KHSO_4+3H_2SO_4$, followed by $I_2+2H_2O+SO_2=H_2SO_4+2HI$. Owing to its reduction of chlorine, it is used as an "antichlor." It is prepared industrially for the manufacture of sulphuric acid (*q.v.*), for use as a bleaching agent and disinfectant, and for use in refrigerating machines.

The solution of sulphur dioxide in water is called sulphurous acid, but the acid (probably H_2SO_3) cannot be isolated because the solutions lose sulphur dioxide on concentration. A hydrate, $SO_2,7H_2O$ can be obtained on cooling, but it is unstable above 7°. The salts of the acid are termed bisulphites or sulphites according as one or two of the hydrogen atoms are replaced by metals. The sulphites of the alkali metals, *e.g.*, Na_2SO_3, are soluble in water and give an alkaline reaction; the other sulphites are more or less insoluble; the bisulphites are either neutral or feebly acidic in solution, and as solids they probably exist as *metabisulphites* ($Na_2S_2O_5+H_2O\rightleftharpoons 2NaHSO_3$). The sulphites are formed by the action of sulphur dioxide on oxides, hydroxides or carbonates, whereas excess of the gas produces the bisulphites. The acid is probably an equilibrium mixture of two tautomeric forms $O{:}S(OH)_2$ and $O_2S(OH)H$, and a study of the organic derivatives of the salts suggests that they are chiefly of the second (unsymmetrical) type.

Thionyl fluoride, SOF_2, is obtained by decomposing arsenic fluoride with thionyl chloride; it is readily decomposed by water into hydrofluoric and sulphurous acids. *Thionyl chloride*, $SOCl_2$, results from the action of phosphorus pentachloride on sodium sulphite, or of chlorine monoxide on sulphur at low temperatures; it is a colourless, highly refractive liquid, boiling at 78°, and fumes in moist air giving hydrochloric and sulphurous acids: $SOCl_2+2H_2O=H_2SO_3+2HCl$. Thionyl chloride is manufactured by adding sulphur trioxide to sulphur chloride at 75–80° C, sulphur is eliminated and the other volatile product is sulphur dioxide: $SO_3+S_2Cl_2=SOCl_2+SO_2+S$. The process is rendered continuous by passing in chlorine to reconvert the sulphur into chloride.

Sulphur trioxide is obtainable from the distillation of concentrated sulphuric acid with phosphoric oxide, but is chiefly prepared by the direct union of oxygen and sulphur dioxide in presence of a catalyst, such as platinised asbestos. (*See* SULPHURIC ACID.) It exists in two forms; the α-form results from the condensation of the vapour and melts at 17° and boils at 46°; the β-form either melts or undergoes transformation at a higher temperature (about 50°), and has an asbestos-like appearance (A. Smits, 1926, 1927). They are probably SO_3 and S_2O_6, respectively (G. Oddo, 1927). The trioxide combines violently with water to give sulphuric acid and with concentrated sulphuric acid to give pyrosulphuric acid. It is applied either directly or as the latter acid in the dye industry. It frequently chars organic matter.

Sulphuryl fluoride, SO_2F_2, formed by the direct union of the dioxide with fluorine, is an extremely stable colourless gas solidifying at −120°. *Sulphuryl chloride*, SO_2Cl_2, is obtained as described under sulphur dioxide, or by heating chlorosulphuric acid in the presence of a catalyst (*e.g.*, mercuric sulphate): $2SO_2Cl{\cdot}OH=SO_2Cl_2+H_2SO_4$; it is a colourless fuming liquid, boiling at 69° C and decomposing readily with water: $SO_2Cl_2+2H_2O=2HCl+H_2SO_4$.

Fluorosulphuric acid, $SO_2F{\cdot}OH$, from cooled sulphur trioxide and excess of hydrofluoric acid, or by distilling calcium fluoride with sulphuric acid, boils at 162° and is comparatively stable; it is slowly decomposed by water, an equilibrium being set up: $HFSO_3+H_2O\rightleftharpoons H_2SO_4+HF$. *Chlorosulphonic acid*, $SO_2Cl{\cdot}OH$, is formed by the direct union of hydrogen chloride and sulphur trioxide or by distilling sulphuric acid with phosphoryl chloride: $2H_2SO_4+POCl_3=HCl+HPO_3+2Cl{\cdot}SO_3H$; it is a colourless, fuming liquid, boiling at 155°, and is violently decomposed by water; it was used to provide smoke screens in naval warfare. *Pyrosulphuryl chloride*, $S_2O_5Cl_2$, is obtained by the action of sulphur trioxide on phosphoryl or sulphuryl chloride or on dry sodium chloride, or by distilling chlorosulphonic acid and phosphorus pentachloride; it is a colourless, oily, fuming liquid boiling at 153° and is readily decomposed by water:

$$S_2O_5Cl_2+3H_2O=2H_2SO_4+2HCl.$$

Sulphur sesquioxide, S_2O_3, formed as blue drops on adding dry flowers of sulphur to the cooled molten trioxide, sets to blue-green crystals and is rapidly decomposed by warmth. It is decomposed by water but not to hyposulphurous acid, H_2S_2O.

Persulphuric anhydride, S_2O_7, a thick, viscous liquid solidifying to long needles at 0° C, is formed by the action of the silent discharge on a mixture of oxygen and the trioxide, or by the action of ozone on the trioxide.

Sulphur Acids.—Apart from sulphurous acid (*see* above) and sulphuric acid (*q.v.*) many other acids are known.

Hyposulphurous or *hydrosulphurous acid*, $H_2S_2O_4$, has not been isolated, since its solutions are very unstable. The sodium salt is obtained (P. Schutzenberger, 1869) by dissolving zinc in a concentrated solution of sodium bisulphite: $Zn+4NaHSO_3=Na_2S_2O_4+ZnSO_3+Na_2SO_3+2H_2O$; the sulphites separate as a less soluble double salt and the hydrosulphite is crystallised from the solution. The pure zinc salt is obtained by the action of the metal on a solution of sulphur dioxide in absolute alcohol, and the sodium salt can be obtained by passing sulphur dioxide over sodium hydride. The "sodium hyposulphite" of photography is strictly a thiosulphate. Sulphoxylic acid, H_2SO_2, is unknown, but an important derivative, sodium formaldehyde-sulphoxylate (known as "rongalite"), is obtained from formaldehyde and sodium bisulphite: there are two products of the reaction, and fractional crystallisation from alcohol separates the formaldehyde-bisulphite compound, $CH_2O{\cdot}NaHSO_3$ from the formaldehyde-sulphoxylate, $NaHSO_2{\cdot}CH_2O{\cdot}2H_2O$. Both rongalite and sodium hydrosulphite are extensively employed as powerful reducing agents. The composition of the latter was for long a matter of dispute but was settled by C. Bernthsen in 1881. The mono-zinc salt of hydrosulphurous acid is used under the name "decrolin."

Permono- and *perdi-sulphuric acids*, H_2SO_5 and $H_2S_2O_8$, result from the electrolysis of solutions of sulphuric acid or bisulphates and by the action of hydrogen peroxide on concentrated sulphuric acid. They have been isolated in a state of purity by the action of the theoretical amounts of chlorosulphonic acid on hydrogen peroxide, the hydrogen chloride formed being pumped off under reduced pressure:

$$H_2O_2+HSO_3Cl=HCl+H_2SO_5;\ H_2O_2+2HSO_3Cl=2HCl+H_2S_2O_8.$$

The mono-acid melts at 45° and the di-acid at 65°. Potassium persulphate, $K_2S_2O_8$, was first obtained in 1891 by H. Marshall by electrolysing solutions of potassium bisulphate, and the existence of the permonosulphate was detected by Caro (1898) in solutions of the perdisulphate which had become partially hydrolysed: $K_2S_2O_8+H_2O=KHSO_5+KHSO_4$. In the electrolysis, it is necessary to secure overvoltage (*e.g.*, by use of a smooth platinum electrode), to have high anode potential and high current density, to cool the anode solution, and to separate the anode (by the use of a divided cell) so that the per-acids formed by anodic oxidation shall not be reduced at the cathode. Potassium and ammonium salts are more suitable than sodium salts, and ammonium persulphate, being less soluble than the potassium salt, is more easily crystallised. The yields of the per-acids depend largely on conditions: if sulphuric acid is used, that of sp.gr. 1·42 gives a maximum yield of the perdi-acid, and weaker or stronger solutions favour the permono-acid.

Solutions of both free acids slowly decompose to hydrogen peroxide and thence to oxygen on standing. Concentrated sulphuric acid "hydrolyses" the di-acid to the mono-acid: $H_2S_2O_8 + H_2O = H_2SO_5 + H_2SO_4$, but dilute acid is almost without effect. Caro's acid, on the other hand, is fairly stable in concentrated sulphuric acid and an equilibrium is set up, which shows that the acid may be formed from hydrogen peroxide and sulphuric acid: $H_2SO_5 + H_2O \rightleftharpoons H_2O_2 + H_2SO_4$. The constitutions of the acids are probably $HO{\cdot}SO_2{\cdot}O{\cdot}OH$ and $HO{\cdot}SO_2{\cdot}O{\cdot}O{\cdot}SO_2{\cdot}OH$. These explain certain differences: (1) Caro's acid is only monobasic, the peroxidic hydrogen atom in $-O{\cdot}OH$ not being acidic, whereas the sulphonic hydrogen atom in $SO_2{\cdot}OH$ is. (2) Caro's acid oxidises aniline to nitrosobenzene, $C_6H_5{\cdot}NH_2 \rightarrow C_6H_5{\cdot}NO$, in virtue of its $O{\cdot}OH$ group, whereas the perdi-acid does not—the action is unique. (3) Caro's acid oxidises solutions of iodides immediately, whereas acid solutions of persulphates act only slowly. Both types of acids oxidise ferrous salts but do not react with permanganates.

Thiosulphuric acid, $H_2S_2O_3$, is unstable in solution, but its salts are perfectly stable, the sodium salt, $Na_2S_2O_3,5H_2O$, being the well-known "hyposulphite" of photography; this is prepared by boiling sulphur with milk of lime, exposing the deep yellow solution of polysulphides to atmospheric oxidation, and converting the resulting calcium thiosulphate to the sodium salt by addition of sodium carbonate or sulphate. Thiosulphates are readily decomposed by mineral acids with liberation of sulphur and sulphur dioxide and formation of other sulphur acids, including trithionic acid. They form many double salts and give with ferric chloride a dark violet coloration which fades on standing. The acid is said to possess the structure $O_2S(SH)(OH)$, but in the absence of definite evidence it is better to formulate it as $\left[\begin{matrix} O & & O \\ & \overset{n}{S} & \\ O & & S \end{matrix}\right] H_2$.

The *thionic acids* are a group of general formula $H_2S_nO_6$, where n may be 2, 3, 4, 5, and possibly 6. *Dithionic acid,* $H_2S_2O_6$ is formed by passing sulphur dioxide into an aqueous suspension of freshly precipitated manganese dioxide or, better, ferric hydroxide; addition of barium hydroxide precipitates the barium salt, and if this is treated with dilute sulphuric acid, the resulting solution of dithionic acid can be concentrated to sp.gr. 1·35 but then decomposes (as do its salts when treated with hydrochloric acid) to sulphuric acid and sulphur dioxide. All the salts are more or less soluble in water.

Trithionic acid, $H_2S_3O_6$, may be obtained in the form of its salts by the action of sulphur dioxide on potassium thiosulphate solution, by warming silver potassium thiosulphate solution, or by adding iodine to a mixture of sodium thiosulphate and sulphite (Spring's reaction): $Na_2SO_3 + Na_2S_2O_3 + I_2 = Na_2S_3O_6 + 2NaI$. The salts and the solutions of the acid are unstable.

Tetrathionic acid, $H_2S_4O_6$, is obtained by the action of dilute sulphuric acid on the barium salt, obtained by digesting barium thiosulphate with iodine—compare the fundamental reaction of iodometric titrations: $2Na_2S_2O_3 + I_2 = Na_2S_4O_6 + 2NaI$. The free acid decomposes when its solutions are concentrated.

Wackenroder's Solution.—When hydrogen sulphide is repeatedly passed into a saturated aqueous solution of sulphur dioxide at 0° C, the resulting solution contains colloidal sulphur (also called $S\delta$, but $S_8{\cdot}H_2O$ according to Spring) and small quantities of all the thionic acids, especially pentathionic acid, $H_2S_5O_6$. The reactions involved are very complex and have been studied *inter alios* by H. Debus (1888), F. Foerster, F. Raschig, A. Kurtenacher, and H. Bassett and R. G. Durrant (1927), but in every case it has been found necessary to postulate the existence of one or more hypothetical compounds, such as SO, S_5O_5, $S_{10}O_{10}$, $H_2S_2O_2$, etc., for which there is only indirect evidence. The views of Bassett and Durrant may be summarised. (1) Sulphur dioxide reacts in the form of the hypothetical pyrosulphurous acid giving sulphoxylic acid and pyrosulphoxylic acid (both of these are hypothetical, and the latter is distinct from thiosulphuric acid): $H_2S + H_2S_2O_5 \rightarrow S(OH)_2 + HO{\cdot}S{\cdot}O{\cdot}S{\cdot}OH$. (2) Hydrolysis of pyrosulphoxylic acid gives more sulphoxylic acid: $H_2S_2O_3 + H_2O \rightarrow 2H_2SO_2$. (3) Sulphoxylic acid and hydrogen sulphide then react: $H_2SO_2 + H_2S \rightarrow 2S + 2H_2O$. (4) The finely divided sulphur thus formed is very reactive and rapidly gives thiosulphuric acid with sulphurous acid ($S + H_2SO_3 = H_2S_2O_3$) which, in the dilute feebly acidic solution, is sufficiently stable to have a temporary existence. (5) Thiosulphuric acid decomposes to give trithionic acid: $2H_2S_2O_3 \rightarrow H_2S + H_2S_3O_6$. (6) This acid reacts with (*a*) finely divided sulphur or (*b*) thiosulphuric acid to give tetra- and pentathionic acids: (*a*) $H_2S_3O_6 \rightarrow H_2S_4O_6 \rightarrow H_2S_5O_6$; (*b*) $H_2S_3O_6 + H_2S_2O_3 \rightarrow H_2S_4O_6 + H_2SO_3$ and $H_2S_4O_6 + H_2S_2O_3 = H_2S_5O_6 + H_2SO_3$. Trithionic acid is thus the first of the thionic acids to be formed, and pentathionic acid is a later product.

Pharmacology and Therapeutics.—The sulphur preparations mentioned in the British Pharmacopoeia are: (1) *Sulphur sublimatum,* flowers of sulphur, from which are made (*a*) *confectio sulphuris,* a mixture with potassium bitartrate, and (*b*) *unguentum sulphuris.* (2) *Sulphur praecititatum,* milk of sulphur, used with potassium bitartrate in the lozenge *trochiscus sulphuris.* (3) *Potassa sulphurata,* liver of sulphur, chiefly sulphides of potassium. (4) *Calx sulphurata,* sulphurated lime, mostly calcium sulphide, a greyish powder obtained when calcium sulphate and carbon are heated together. *Sulphuris iodidum* forms the basis of an ointment in the U.S.P.

Sulphur as an ointment is used in skin affections such as scabies (itch) or acne, but "sulphurated lime" is more efficient in the latter case and in the treatment of boils. Internally, it is a mild laxative, being used as milk of sulphur. Sulphur and sulphurous waters (as at Harrogate, Aix-la-Chapelle, and Aix-les-Bains) are effective for congested conditions of the liver and intestines, haemorrhoids, gout and gravel. Its ability to rid the lungs of mucus, is utilised in chronic bronchial affections. In chronic rheumatism sulphur waters are effectual both internally and as baths.

The sulphur dioxide produced by burning sulphur is a powerful disinfectant and is used for fumigating rooms which have been occupied by persons suffering from infectious diseases.

The use of sulphur dioxide or sulphites as a preservative in foods is to be deprecated and is illegal in many countries. Owing to the ancient French custom of fumigating wine-casks by burning sulphur in them, a small proportion of sulphur dioxide is allowable in wines, and in Great Britain 450 parts per million parts of wine has been fixed as a legal limit. (A. D. M.)

SULPHUR, SPECIAL APPLICATIONS OF. Sulphur is a convenient source of sulphur dioxide gas, which is the basis for the manufacture of sulphuric acid and sulphite pulp. In a number of industries sulphur plays an essential part and has no substitute. This is the case in the vulcanization of rubber, and for many agricultural and horticultural purposes, such as insecticides and fungicides, and for the making of lime-sulphur solutions. Among the properties of sulphur are fusibility, acid resistance, a number of physical forms, extremely low electrical conductivity and general chemical resistance. There are few solvents for sulphur and it is not acted upon by water, but for certain purposes its inflammability is detrimental.

As an Impregnant.—All forms of pulp and paper products can be impregnated with molten sulphur and the more absorbent types take up three or four times their dry weight. Pre-formed pulp and paper articles, when impregnated with sulphur become very strong, weather-resistant and converted into much denser and harder materials. Among the applications of such paper products are flat fibre boards so treated as to prevent warping and make them resistant to acid and other destructive agencies. Spool-heads, advertising signs and many other articles of paper, fibre or pulp can be hardened and weather-proofed by means of sulphur impregnation.

Practically all species of wood may be impregnated with molten sulphur under proper conditions, the more resistant species requiring the application of vacuum and pressure. The general procedure is very similar to that so widely used for the creosoting of wood, but the effect is quite different. With sulphur there is very little change in colour, but a marked increase in weight and a phenomenal hardening and strengthening effect. Pieces of soft wood with a high sulphur content appear almost as though petrified. It converts a soft wood into a very hard and durable product, comparing favourably with the heaviest and densest tropical woods. By the addition of various sulphur soluble dyes, attractive colours are imparted. Wood so treated is much less absorbent to moisture and withstands the action of acid and other destructive agencies. Tests made on wood structures in contact with the ground indicate that sulphur acts as a preservative even though not in itself particularly toxic. Its toxicity toward wood-rot fungi may be increased by the addition of certain substances that are recognized preservatives and which have been found to be miscible with molten sulphur. The applications for sulphur-treated wood are numerous and include floor blocks, especially where acids are used, fence posts, railway ties, etc. Stone and concrete are likewise subject to sulphur impregnation.

Textiles and fabrics may likewise be impregnated with sulphur and have the advantage of being readily formed or shaped before processing. Fabric coverings saturated with molten sulphur may be spirally wound on metal pipes or other objects in order to produce extremely dense, impervious coverings. These were under test in 1928 for the prevention of underground corrosion.

Sulphur Introfiers.—The term "introfier" has been applied to certain organic substances having a most peculiar effect on the penetrance of molten sulphur. They may be used to advantage in practically all the examples of sulphur impregnation heretofore described and are also valued in making certain sulphur compositions. Some of the substances which not only increase the rate but the ultimate limit of penetrance of molten sulphur are napthalene, its chlorinated and hydrogenated derivatives, anthracene, triphenyl phosphate and other compounds.

Other Special Uses.—In view of the fact that one of the problems of the steel industry is the removal of sulphur, it is interesting to note that it is deliberately added to steel for special purposes, notably for the making of screw stock. Likewise, in petroleum, refining sulphur-compounds present in many crude oils must be removed to make them fit for refining. But for some uses an oil containing sulphur is desirable. This is the case with metal-cutting oils, used largely by the metal-working industries for thread cutting, turret lathes and other machine work. Sulphur is incorporated with an animal or vegetable oil base and subsequently added in proper proportion to a petroleum oil.

Sulphur cements which are applied hot, consist of sulphur with various inert mineral fillers and are useful for anchoring metal in stone, such as bolts in engine foundations, iron railings and the securing of chains to granite blocks for buoys, setting electrical insulator pins, doorknobs and a great many other purposes. They are particularly useful for pointing up acid proof brick in order to protect lime mortar, cementing floor blocks in acid-pickling rooms, the pouring of pipe joints both water and acid, and for setting bushings in abrasive wheels.

Other uses for sulphur are the manufacture of sulphur colours, as a preservative for dried fruits and, in the form of tapers, for locating ammonia leaks and sulphuring wine casks. In colloidal form, sulphur is valuable as an intravenous injection for the treatment of certain diseases, and as a recognized curative agent in dermatology, especially for scabies, ringworm, acne, favus, prurigo and psoriasis. The boiling point of sulphur, 444·6° C is used in thermometry for scale determination, while molten sulphur is an excellent heating medium. Synthetic resins result from the interaction of sulphur or sulphur chloride with phenol, and it imparts the dark amber colour to glass bottles. Sulphur is used in making sheep and cattle dips, while it is admixed with the salt given to stock. It is also used for the stoving of wool, and the sulphuring of hops, silks, sponges, feathers and other commodities and is employed for making plaster cast moulds. Sulphur compounds are used for the so-called oxidation of silver, bronze and other metals, as well as for the bleaching of brooms, straw, wicker furniture and the tanning of leather.

Sulphur in its more complex phases, especially organic, is of industrial as well as biologic interest. Allyl isothiocyanate, a sulphur compound, is found in mustard oil and is responsible for the irritating action of the ordinary mustard plaster. An important derivative dichloroethyl sulphide, was brought into prominence during the World War as mustard gas. Sulphur may be responsible for the efficacy of certain organic compounds used as flotation oils in the recovery of valuable ores. This is notably the case with the various xanthates. Cellulose xanthate is one of the products in the process of manufacturing artificial silk, or viscose rayon. An albuminoid substance known as keratin occurs in practically all animal and human appendages such as hair, hoof, horn, fur, wool, feathers and nails, and since the keratins are very high in cystine, human hair containing about 14%, its importance is readily seen. Various complex organic sulphur compounds play an important part in the human body, and are vital to our welfare and probably to life itself. (W. H. K.)

SULPHURIC ACID, oil of vitriol, H_2SO_4, is commercially of the greatest importance. The urgency of the market demand for this acid is recognized as one of the most accurate and sensitive indications of the general state of the trade.

Pure sulphuric acid is an oily, colourless, heavy liquid (sp. gr. 1·85), freezing at 10·8° C and boiling with partial decomposition at 338° C. It is highly corrosive, charring many organic substances, largely owing to its great avidity for water. So much heat is evolved that on mixing with water it is unsafe to add water to the strong acid, the acid being always poured slowly into water with thorough stirring. When the vapour is heated to 450° C it is completely dissociated into water and sulphur trioxide, the latter decomposing into sulphur dioxide and oxygen on further heating. The hot concentrated acid is a weak oxidizing agent, converting carbon into carbon dioxide, sulphur into dioxide, and many metals, such as copper, into their sulphates with evolution of sulphur dioxide. The cold dilute acid dissolves certain of the more electropositive metals such as zinc and iron with evolution of hydrogen. Sulphuric acid is dibasic, giving rise to two series of salts, acid and normal. Most sulphates are readily soluble in water, the commonest exceptions being those of calcium, strontium, barium and lead. Its efficacy in many common chemical processes depends on its power of liberating other acids from their compounds, not because it is necessarily stronger (*see* CHEMICAL ACTION), but because it is less volatile. Its value in organic chemistry depends partly on its great affinity for water, whence its use in nitration processes (*see* DYES, SYNTHETIC; and EXPLOSIVES), and partly on its power of forming sulphonic acids with many aromatic compounds (*see* CARBOLIC ACID, INDIGO, and NAPHTHALENE).

Manufacture.—Sulphuric acid has been known for many centuries, having been originally prepared, probably by Arabian chemists, by condensing the fumes evolved on heating the naturally occurring sulphates of iron or alumina. A method of preparation by burning sulphur with saltpetre was described by Basil Valentine in the 15th century. Lead chambers for carrying out this reaction were introduced by Roebuck of Birmingham in 1746. It was first manufactured on a commercial scale in Bohemia and at Nordhausen in Germany by heating weathered pyritic shales, a method adopted from the practice of the early alchemists. This acid fumed strongly in the air, whence its old name of "fuming" or Nordhausen sulphuric acid. A great extension arose from Liebig's discovery in 1840 of a method of rendering the phosphorus content of mineral phosphates available in soluble form for plant growth by treatment with sulphuric acid, this process affording the greatest outlet for this acid. Subsequently, a more highly concentrated form of acid became essential to the manufacture of dyes and the refining of oil, and the "contact" process was developed to meet this requirement.

The original raw material was brimstone from Sicily, but by the middle of the 19th century this source had been largely replaced by iron pyrites which occurs abundantly in many countries, for example, in North Wales and County Wicklow, Ireland; but after the introduction of the wet process for copper extraction the pyrites most generally used in Great Britain and the eastern

States of America was the copper-containing variety found in immense quantities in South-Western Spain where it is mined by the Rio Tinto, Tharsis and other companies. In recent years, however, the enormous production of brimstone (*see* SULPHUR) in the United States by the "Frasch" process coupled with changed economic conditions in copper extraction has led to renewed use of brimstone. Spent oxide from the purification of coal gas and zinc blende or "concentrates" from the Australian lead-zinc ores are sulphur-containing materials which furnish sulphur dioxide in appropriate furnaces. Large quantities of acid are produced in America from the waste gases from copper smelters, and during the World War a promising process was developed in Germany whereby sulphur dioxide is produced from naturally-occurring calcium sulphate, gypsum or anhydrite by calcining with clay in a rotary kiln, yielding cement as a by-product. Brimstone and spent oxide contain free sulphur, whereas in pyrites and blende the sulphur is present as sulphides of iron and zinc respectively; nevertheless, the latter materials will burn in air without extraneous heat, although with blende it is necessary to use fuel in the finishing stages in order to assist in its complete desulphurization.

Whatever the nature of the raw material the resulting burner gas should preferably contain 7–8% (by volume) of sulphur dioxide with 9–9½% of oxygen, the remainder being inert nitrogen. Actually it is easy to get as much as 10 or 11% of sulphur dioxide in the gas obtained by burning brimstone and still leave an adequate excess of oxygen for the next stage. With blende it is difficult to maintain more than 6% of dioxide; in the case of this material and of pyrites some atmospheric oxygen combines with the zinc or iron originally associated with the sulphur, while in the case of spent oxide an appreciable amount is consumed by the carbonaceous matter. Burner gas from brimstone is the purest; that from pyrites always contains arsenic, lead, selenium and other impurities originally present in the ore; that from blende has only a small amount of arsenic but often contains a little fluorine; whilst that from spent oxide, though containing little more arsenic than the gas from brimstone, always includes in addition to harmless carbon dioxide a certain amount of tarry matter and ammonia which lead to a high consumption of nitrogen compounds in the next stage.

For the large-scale production of sulphuric acid from burner gas there are two processes: (1) the *contact process,* wherein oxidation is brought about directly by passing the burner gas over a suitable catalyst, and (2) the *chamber process,* in which oxidation is brought about by an intermediate reaction with oxides of nitrogen acting as oxygen carriers between air and sulphur dioxide. The disadvantages of the latter process are that it is impossible to produce high-strength acid directly, and also that unless pure brimstone is used the impurities (*e.g.,* arsenic) originally contained in the raw material are found in the finished acid. Further, except for certain modern modifications, the plant has the disadvantage of occupying a large ground space in proportion to output, but it has the great advantage of high efficiency, the yield regularly exceeding 98% of the sulphur in the burner gas; it is also controlled with very little labour. The contact process, on the other hand, will give directly acid of any required strength up to about 25% oleum. Moreover, in the preliminary purification of burner gas all harmful impurities are removed, so that a pure acid can be obtained directly from such material as arsenical pyrites or blende. The plant is, however, more costly, the labour and power charges heavier and the efficiency lower, so that whereas the Contact type of plant now holds the field almost exclusively for the manufacture of concentrated and fuming acid, the Chamber process can still compete in acid of no more than 80% strength, as required by most consuming trades except oil refining and the manufacture of dyestuffs and explosives.

Contact Process.—Although the reaction is very slow, sulphur dioxide is oxidized appreciably to trioxide by air at atmospheric temperature. At higher temperatures, however, the reaction proceeds more rapidly but is limited by the reverse change. For example, with a 7% burner gas the maximum yields, according to Haber, are 99%, 85%, and 60% at 435°, 550°, and 645° C respectively. Since the reaction is improved by the use of low temperatures, it is beneficial to employ some substance capable of increasing the velocity of the reaction without itself undergoing any change. Such a substance is called a catalyst. (*See* CATALYSIS.) It must be emphasized that a catalyst does not change the final equilibrium between the reacting substances at any given temperature: its function is purely that of an accelerator. For this reaction the various catalysts include metallic platinum and oxides of iron and vanadium, of which the first is much the most widely used. Platinum and vanadium operate effectively at 425–450° C, which is the optimum temperature. Iron oxide becomes effective only at 600° C, so that the maximum yield of SO_3 attainable is only about 70%.

Catalysts are peculiarly susceptible to "poisoning" by impurities commonly present in burner gas. Arsenic and halogens even in minute quantities render a platinum catalyst quite inactive, although the oxides of iron and vanadium are less sensitive. Consequently a preliminary purification of burner gases is essential.

There are many types of contact plant of which the best known are the Badische (using this term to describe processes which were developed in England by Squire and Messel as early as in Germany, while actually the Badische Gesellschaft itself now employs a modification of the process developed in the United States), Grillo, Tentelew and Mannheim. Excepting the Mannheim plant, which employs ferric oxide as preliminary, all these employ platinum as catalyst, and they differ only in the nature of the plant used for scrubbing and purifying the gases and in the carrier employed for the platinum; in the Grillo process the platinum is spread over the surface of calcined magnesium sulphate, whereas in the other processes it is carried on asbestos fibre. All types of contact plant (excepting the Mannheim, where the hot burner gas passes directly up rectangular shafts packed with oxide of iron) consist first of coolers followed by or combined with scrubbing towers in which the gases are washed with cold sulphuric acid, then another wash-tower, round which is circulated very weak sulphuric acid or an alkaline solution to remove traces of halogens (chlorine and fluorine). The washed gases pass through one or two filters which may be large rectangular boxes (as much as 30′ sq. x 12′ in depth) constructed of sheet lead packed with finely graded coke. The cold filtered gases are then dried by passing up another tower, again built of lead and lined with acid-resisting brick, through which pure 95% sulphuric acid is circulated. After filtering through graded coke to stop mechanically carried spray, the gases are passed through a Root's blower which creates a draught throughout the whole apparatus. Where brimstone is burned much of the foregoing plant may be omitted, but only after this complicated purification are the gases permitted to enter the contact chambers, which are cast-iron or steel vessels containing shelves or trays packed with platinised material. The heat generated by the reaction is utilized by tubular heat exchangers to heat the cold incoming gas, so that in a well-designed plant no extraneous heat whatever is required to maintain the correct temperature.

In the latest type of plant two catalyst chambers are used in series together with two heat-exchangers. A remarkable change takes place in the appearance of the gases after passage through the contact chambers; whereas the incoming gas is colourless and invisible with an unpleasant sulphurous smell, the product issues as a dense, white, intensely acid fume of trioxide, practically without odour. After cooling, this fume is always absorbed in 98% sulphuric acid, since it is only very slowly absorbed by water. A portion of this solution is continuously diluted with water and returned to the absorbers. The surplus may be sold as "fuming" acid or *oleum,* or it may be diluted with water to any required strength. The absorption is carried out in steel towers packed with quartz, over which 98% acid is circulated by centrifugal pumps, or alternatively the gases are actually bubbled through the acid in a series of steel vessels. Although lead is generally used in plant construction up to the stage of the contact chambers, nothing but steel or cast iron can be employed in the later stages for lead is very rapidly attacked either by sulphur trioxide or by fuming acid.

Chamber Process.—In this process the oxidation of sulphur dioxide to trioxide is brought about by means of oxides of nitrogen, and the name is still applied generally, although the reaction is frequently brought about in plants differing considerably from the rectangular lead chambers formerly in exclusive use. There has been considerable controversy over the nature of the reactions occurring in the chamber process. The simplest theory, that of Berzelius, suggests that nitric oxide, NO, is the essential "carrier" which takes up oxygen from the air to form nitrogen peroxide, NO_2. The latter then gives one of its atoms of oxygen to the sulphur dioxide, converting it into sulphur trioxide, which combines with water forming sulphuric acid. In yielding an atom of oxygen, nitrogen peroxide becomes again reduced to nitric oxide, which repeats the cycle of changes indefinitely except for losses which are inevitable under factory conditions. The foregoing interaction between nitrogen peroxide and sulphur dioxide only takes place in the presence of water. Nitrosyl sulphate, nitrosulphonic acid, or "chamber crystals," postulated by Lunge as an essential intermediate stage of the reaction, may appear under certain conditions in the later stages of the process when the supply of water to the chambers is insufficient.

A chamber plant of normal type includes burners to supply sulphur dioxide, with dust collecting chambers when necessary, followed as closely as possible (in order to avoid heat losses) by a *Glover tower,* which consists of a lead shell lined internally with vitrified brick and surmounted by two lead-lined cisterns. Internally the tower is packed with brick chequer work or flints supported on semi-circular arches. Down this tower are fed two qualities of acid—weak acid produced in the chambers at 60–70% strength which is concentrated by the heat of the burner gases (the steam driven off passing on to the chambers), and acid from the Gay Lussac tower at the other end of the process. The latter acid contains dissolved oxides of nitrogen which are expelled by the hot burner gas and returned to the leaden chambers, while the acid reaches the base of the Glover tower concentrated to about 80% H_2SO_4 and practically free from oxides of nitrogen. This acid is then cooled in water-jacketed lead coolers, a portion being returned to the Gay Lussac towers for re-absorption of the nitrogen oxides escaping from the chambers, while the remainder is available for sale.

From the Glover tower the gases pass into the lead chambers which are large rectangular boxes of sheet lead, generally about 25ft. wide, 20 to 30ft. high, and up to 140ft. in length, and are usually arranged consecutively in sets of at least three. The lead sheets are supported in a frame-work of timber or steel, and the leaden joints are made by "burning" or heating the lead at the junction with a blowpipe flame so that it just melts and then resolidifies. Lead of the very highest degree of purity, 99·99%, is to be preferred for this purpose. The chambers are generally erected on columns well above the ground so as to avoid unnecessary pumping of acid. Excepting in the first chamber, to which steam is largely supplied by the evaporation from the Glover tower, it is necessary to supply water to convert the sulphur trioxide produced into sulphuric acid which falls like a shower of rain to the floor of the chambers. This water was formerly supplied in the form of steam, but is now generally sprayed in a finely atomised form. The lead chambers afford sufficient time and space for the alternate cycles of oxidation and reduction to complete themselves until the whole of the sulphur dioxide has been converted into sulphuric acid, and they dissipate the heat evolved in the reaction.

By the time the residual gases leave the last chamber the whole of the sulphur dioxide should have been completely removed as sulphuric acid, whereas practically the whole of the nitrogen oxides should still be present unchanged. These are recovered by passing them up one or more *Gay Lussac towers,* which are similar to the Glover tower but of at least double the capacity, and of lighter lead since at this stage the acid is quite cold. The towers are lined with acid-resisting brick and packed either with coke, earthenware rings or narrow strips of glass with the alternate layers at right angles to one another. It is preferable to have at least two Gay Lussac towers with a fan between them controlling the draught of the whole process. These towers are fed from the Glover tower with cold strong sulphuric acid in which oxides of nitrogen are readily soluble. The nitrous vitriol leaving the first tower is returned to the Glover where its nitrogen oxides are returned to the cycle. To compensate for inevitable loss through incomplete absorption, quite apart from secondary reactions which may lead to destruction of a portion of the nitrogen oxides, it is necessary to replenish these oxides continuously. Formerly this was done by decomposing nitrate of soda with sulphuric acid in cast iron pots heated at the end of the pyrites burners. Alternatively nitric acid is trickled down the Glover tower or a mixture of ammonia gas and air is passed over a hot platinum gauze which catalyses the oxidation of ammonia to oxides of nitrogen. The amount of fresh nitre required should not be more than 2½–3% of the sulphur burned. Both in America and on the continent of Europe Glover and Gay Lussac towers have been constructed without any lead casing but simply of acid-resisting brick or volvic lava set in acid-resisting cement.

Attempts have been made to do away with chambers altogether, the oxidation of sulphur dioxide taking place largely in the liquid phase by means of the nitrous compounds dissolved in vitriol, as in the Opl plant where the reaction between burner gas and nitrous vitriol takes place in a series of towers, the later ones of which act as absorbers for the nitrogen oxides which are liberated in the earlier ones, the nitrous acid being returned to the first tower. Water is fed down the middle towers to maintain them at the requisite strength for the reaction. Other types of apparatus have been introduced in which, instead of the gas merely coming into contact with films of liquor flowing over tower packings, the acid is bubbled or passed through nitrous vitriol which is simultaneously agitated by revolving drums which fill the vessels with a continuously renewed spray or film of acid. Where non-arsenical acid is required from an acid produced from arsenical pyrites, the impurities are removed by treatment with sulphuretted hydrogen; this precipitates arsenious sulphide and most other impurities, which are then removed by filtration or by oil flotation methods.

Concentration.—The concentration of chamber acid is of small commercial importance, because strong acid can be produced more cheaply by the contact process, but concentration is still of value in connection with such manufactures as dyes and explosives where, after nitration with mixed nitric and sulphuric acids, a dilute sulphuric acid remains which must be recovered. An installation suitable for small outputs consists of a number of basins of silicon-iron or fused silica arranged in two or three rows in cascade fashion and heated from below, but where larger quantities of acid are being concentrated, plant of the Kessler or Gaillard type is employed. The *Kessler,* of which there are many modifications, consists of a producer-gas fired, over-heat pan, generally built of volvic lava, inside a heavy lead dish and provided with baffles in the roof so as to cause the fire gases which enter at one end to strike down on the layer of acid which flows in the opposite direction. At the other end of the pan is a small packed tower down which the incoming vitriol is fed on its way to the pan. The exit gases are passed through a fine coke-packed scrubber to remove acid mist. These fumes are usually removed by a Cottrell electrical precipitator, lead electrodes being used. The *Gaillard tower* consists of an empty tower of 6′ to 9′ internal diameter and 40′ to 50′ high, built of volvic lava or acid-resisting brick, into the top of which weak sulphuric acid is sprayed meeting the hot gases from a coke-fired producer. The exit gases from the Gaillard tower are usually passed up a scrubbing tower to remove acid vapour and are then put through a Cottrell precipitator. The Gaillard tower is suitable for dealing with dirty waste acids, but will not produce economically more than 93% vitriol, whereas the Kessler plant furnishes 95–96% vitriol.

Nomenclature.—The ordinary commercial grade of acid made from pyrites by the chamber process at 77–80% strength is known as common or brown oil of vitriol (B.O.V.); similar acid free from arsenic, either as the result of a de-arsenication process, or by preparation from a non-arsenical material such as brimstone, is called best brown oil of vitriol (B.B.O.V.). The stronger grade of 93–96% acid is known as rectified vitriol (R.O.V.). Acid of 100% strength, *i.e.,* exactly H_2SO_4, is called "monohydrate";

excess of sulphur trioxide readily dissolves in this, giving rise to still stronger acid known as "fuming" sulphuric acid or "oleum."

The grade of oleum is expressed by stating the percentage of free sulphur trioxide, SO_3, which it contains apart from that combined with water to form H_2SO_4; thus 20% oleum means acid containing 20 parts of SO_3 and 80 parts of H_2SO_4. The usual commercial grades of oleum are 20% and 60–65%, both of which are liquids at ordinary temperatures, while intermediate and higher strengths are solids. More dilute grades of acid are sold for use in electrical storage batteries; these are sold by specific gravity as measured by the hydrometer, the usual strength for batteries for wireless sets and motor cars being 1·215 to 1·250 or 28–33% of sulphuric acid.

Sulphuric acid is generally sold in glass carboys holding 10 gallons, which are protected by straw packing inside an iron frame work or steel drums, but chiefly in steel tank wagons. Acid should not be transported in steel, however, at less than 75% strength. For bulk transportation of weaker acid, lead-lined tanks are used.

Documents of the League of Nations International Economic Conference Geneva (1927) give the output of sulphuric acid in 1925 as follows:—

Metric tons @ 62·5% H_2SO_4

Germany	1,800,000	Denmark	175,000
Gt. Britain	1,300,000	Sweden	140,000
United States	6,300,000	Serbia	100,000
France	1,840,000	Czechoslovakia	210,000
Belgium	740,000	Hungary	80,000
Holland	150,000	Austria	70,000
Poland	320,000	Switzerland	50,000
Spain	230,000	Italy	1,075,000
		Total	14,580,000

The output in Germany in 1913 was 2,700,000 tons. The plant capacity is doubtless much greater than the above figures: in Great Britain, for example, it is above 2,000,000 tons per annum.

Bibliography.—W. Wyld, *Sulphuric Acid, Raw Materials* (1923); and *The Manufacture of Sulphuric Acid: Chamber Process* (1924); F. D. Miles, *The Manufacture of Sulphuric Acid: Contact Process* (1923); J. W. Parkes, *The Concentration of Sulphuric Acid* (1924); A. E. Wells & D. E. Fogg, *Manufacture of Sulphuric Acid in the United States* (1920). (C. S. I.)

SULPHUR SPRINGS, a city of Texas, U.S.A. Pop. (1920) 5,558 (21% negroes), estimated locally at 7,500 in 1928. Lignite is mined near by and natural gas is available.

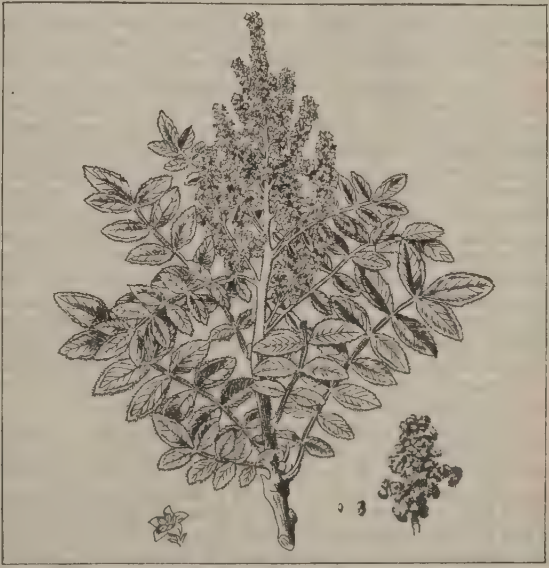
SULPICIA, the name of two Roman poetesses. The earlier lived in the reign of Augustus, and was a niece of Messalla, the patron of literature. Her verses, which were preserved with those of Tibullus and were for long attributed to him, are elegiac poems addressed to a lover called Cerinthus, possibly the Cornutus addressed by Tibullus in two of his *Elegies* (bk. ii., 2 and 3; *see* Schanz, *Gesch. d. röm. Litt.* § 284; F. Plessis, *La Poésie latine*, pp. 376–377 and references there given). The younger Sulpicia lived during the reign of Domitian. Martial (x. 35, 38), praises her wifely devotion, which was the subject of her poems. An extant poem (70 hexameters) discovered in 1493, and attributed to her, is probably 5th Century, or even later.

Editions by O. Jahn (with Juvenal and Persius, revised by F. Bücheler, 1893) and in E. Bährens, *De Sulpiciae quae vocatur satira* (1873); *see* also Teuffel, *Hist. of Roman Literature* (Eng. trans., 1900), p. 233, 6. There are English translations by L. Evans in Bohn's *Classical Library* (prose, with Juvenal and Persius) and by J. Grainger (verse, 1759).

SULPICIUS RUFUS, PUBLIUS (*c.* 121–88 B.C.), Roman orator and statesman, legate in 89 to Cn. Pompeius Strabo in the Social War, and in 88 tribune of the plebs. Soon afterwards Sulpicius, hitherto an aristocrat, declared in favour of Marius and the popular party. He was deeply in debt, and it seems that Marius had promised him financial assistance in the event of his being appointed to the command in the Mithridatic War. To secure the appointment for Marius, Sulpicius brought in a franchise bill by which the newly enfranchised Italian allies and freedmen would have swamped the old electors (*see* further Rome). The majority of the senate were strongly opposed to the proposals; a *justitium* (cessation of public business) was proclaimed by the consuls, but Marius and Sulpicius got up a riot, and the consuls, in fear of their lives, withdrew the *justitium.* The proposals of Sulpicius became law, and, with the assistance of the new voters, the command was bestowed upon Marius. Sulla, who was then at Nola, immediately marched upon Rome. Marius and Sulpicius, unable to resist him, fled from the city. Marius managed to escape to Africa, but Sulpicius was discovered in a villa at Laurentum and put to death; his head was sent to Sulla and exposed in the forum. Sulpicius appears to have been originally a moderate reformer, who by force of circumstances became one of the leaders of a democratic revolt. Although he had impeached the turbulent tribune C. Norbanus, and resisted the proposal to repeal judicial sentences by popular decree, he did not hesitate to incur the displeasure of the Julian family by opposing the candidature for the consulship of C. Julius Caesar who had never been praetor and was consequently ineligible. His franchise proposals, as far as the Italians were concerned, were a necessary measure of justice; but they had been carried by violence. Of Sulpicius as an orator, Cicero says (*Brutus,* 55): "He was by far the most dignified of all the orators I have heard, and, so to speak, the most tragic; his voice was loud, but at the same time sweet and clear; his gestures were full of grace; his language was rapid and voluble, but not redundant or diffuse; he tried to imitate Crassus, but lacked his charm." Sulpicius left no written speeches, those that bore his name being written by a P. Canutius (or Cannutius). He is one of the interlocutors in Cicero's *De oratore.*

See Appian, *Bell. civ.* i. 55–60; Plutarch, *Sulla and Marius;* Vell. Pat. ii. 18; Livy, *Epit.* 77; E. A. Ahrens, *Die drei Volkstribunen* (Leipzig, 1836); Mommsen, *Hist. of Rome,* bk. iv. ch. 7; Long, *Decline of the Roman Republic,* vol. ii. ch. 17.

SULTANPUR, a town of British India, on the river Gumti, midway between Benares and Lucknow. Pop. (1921), 8,846. The district has an area of 1,713 sq.m. and in 1921 the population was 1,003,912.



Sumach (Rhus coriaria): from left to right: flower, branch, seed, fruit, cluster of fruit

SUMACH or **SUMAC,** the name given to numerous shrubs and small trees of the botanical genus *Rhus* (family Anacardiaceae) which comprises about 150 species, natives chiefly of warm regions. They have a milky or resinous juice; simple or compound leaves; small flowers, with the parts in fours or sixes; and small, dry, one-seeded, often hairy, sometimes highly-coloured fruits, usually in dense clusters.

The name sumach is given also to the commercial preparation of the dried and ground leaves of the Sicilian or tanners' sumach

(*R. Coriaria*) of southern Europe, long used in making leather.

In North America the sumachs are represented by about 15 species. Several have poisonous foliage, as the poison-ivy (*q.v.*); the non-poisonous sumachs include some of the most attractive American shrubs. Among those found in the eastern States and Canada are the handsome staghorn sumach (*R. hirta*), sometimes 30 ft. high, and the smaller smooth sumach (*R. glabra*), sometimes 20 ft. high, both of which in autumn display highly coloured fruit and foliage. The dwarf or mountain sumach (*R. copallina*) is a small shrub in the North and a tree 30 ft. high in the South. Its leaves, as also those of the two preceding, were formerly much used in tanning. The aromatic sumach (*R. aromatica*), 3 ft. to 8 ft. high, with pleasant-scented foliage, occurs in the eastern States; its western counterpart, the skunk-bush (*R. trilobata*), with ill-scented foliage, is found from Illinois to Oregon and southward. The mahogany sumach (*R. integrifolia*), the laurel sumach (*R. laurina*), and the sugar-bush (*R. ovata*) are elegant shrubs, native to southern California.

The lacquer-tree (*R. vernicifera*), of Japan, yields Japan lacquer. The wax-tree (*R. succedanea*), also of Japan, furnishes wax used in candle-making. *R. javanica,* of eastern Asia, and *R. hirta* var. *dissecta,* a North American form, are planted for their ornamental foliage.

SUMATRA, lying between 5° 39′ N. and 5° 57′ S., so that the Equator divides it into two nearly equal parts, is the westernmost, and, after Borneo, the largest of the Great Sunda islands, of the Malay archipelago, and forms part of the Dutch East Indies. Its axis runs from south-east to north-west, Sunda strait to Malacca passage; it is 1,060 miles in length, and its greatest width is 248 miles. With its dependencies, Sumatra has an area of 180,380 sq.m. (alone, 167,480 sq.m.) and is nearly four times as large as Java, almost as large as Spain, and thirteen times the size of the Netherlands. The economic development of Sumatra, though it is far behind that of Java, is much further advanced than that of any other of the islands of the Dutch East Indies.

In relief, Sumatra consists of a high mountain chain which runs along the western coast, descending eastwards to a huge tract of flat, alluvial land, seamed with many large rivers and their scores of tributaries. Its great mountain chain is a link between the mountain system of Lower Burma, which is continued by way of Preparis and Great Coco islands, the Andaman islands, and the Nicobars, to Sumatra, and thence to Java, and on through the Lesser Sunda islands to the Moluccas. This (Sumatran) chain extends for a distance of over 1,000 m., and contains numerous volcanic peaks of heights from 5,000 to over 12,000 ft. The whole system is known as *Bukit Barisan,* or the Barisan mountains, and consists in general of two or more folded chains running parallel to each other, with a valley between, which is broken up into separate sections by the intrusion of volcanic massifs, and along this valley lies a string of mountain lakes, from south to north—Ranau, Korinchi, Singkaran, Maninjau and Toba. By far the largest of these is Lake Toba, which is 45 m. long, by 15 wide, with a depth of 450 metres, and which has a large island, Pulau Samosir.

The line of volcanoes commences with Krakatoa, in Sunda strait, then continuing southwards, Sinabung (7,930 ft.), in the centre of the island, in the Battak country, as also are Sibayak (7,075 ft.), and Pusuk Bukit (6,562 ft.); Berapi (5,875 ft.), Mandailing group; Pasaman (9,844 ft.), Talang (8,399 ft.), Merapi, (9,484 ft.), and Singalang-Tandikat (9,479 ft.), all in the Padang highlands; Korinchi, or the peak of Indrapura (12,484 ft.), in the Korinchi group; Kaba (6,528 ft.), in the Rejang group; and Dempo (10,326 ft.), in the Pasuma group. In all ninety volcanoes have been discovered, twelve of them now active.

Sumatra, like Java and Borneo, is formed largely of strata of the Tertiary period, although it contains also two schistose formations, one of which is anterior to the carboniferous period. The Tertiary series are more complete than in Java; the numerous volcanoes, so characteristic of the whole archipelago, are due to the quaternary period. The western mountain system is composed largely of Archaean rocks, with occasional longitudinal bands of Jurassic and Cretaceous rock. The whole ridge is metalliferous, and erosion of the ranges exposes their mineral contents. Gold and silver are known in close association, lead in association with silver, copper, and tin, antimony and cobalt, marine schists, yielding fossil fish and plants, give petroleum; there are iron deposits, and in the stratified rocks coal, in the Lampong and Padang highlands district of Eocene age, and in Bencoolen district of Miocene. The coal-fields exist in and not under the Tertiary strata, rendering their contents easier of access. The crystalline rocks (granites, basalts, and their allies), are of various geological ages, and they are exposed by denudation, or pushed through by intrusion. Intrusion causes change in some sedimentary rocks, sandstone changing into quartzite, limestone into marble, and clay, or shale, under pressure, into slates.

The river system of Sumatra is extensive and of great value to the country. Owing to the proximity of the mountains to the west coast, the rivers there run in valleys with a steep slope, have a very short lower course, and are unnavigable, except near the mouth in the case of a few. The eastern rivers run through alluvial plains, have extensive drainage areas (they are often impeded by silt), and form the principal, and often the only means of communication, and are of such value to the community, that many of the districts they water are named after the rivers. South of 3° N., there are extremely important rivers, the first, in order, being the Asahan, which drains the lake of Toba, and is navigable by steamers for a portion of its length, next the Panei (Bila and Barumun), with a very wide mouth, then the Rokan, over 120 m. long, and flowing into Malacca straits through a wide, muddy estuary, is navigable for 70 m. inland; the Kampar, a very long river, navigable for ocean steamers for 18 miles, the Indragiri, which is navigable for ocean steamers as far as Kulachenako, and for river steamers as far as Cheranti. The Jambi, which springs from the peak of Indrapura, is the most beautiful and largest of all the rivers of Sumatra, having a maximum navigability of just under 500 m.; the Musi is the only one which bears comparison with the Jambi. Ocean-going vessels can reach Palembang, 54 m. from its mouth, steam launches and motor boats navigate the river for 200 m., and small boats for 330 miles. Below Palembang the Musi splits up into a number of channels which spread out amidst a vast unhealthy swamp covering an area of some 4,600 m. These subsidiary channels slowly deposit their suspended quota of mud among the mangroves, thus gradually creating new land, and slowly the whole coast-line is advancing sea-wards and tending to fill up the Malacca straits and join Sumatra to the Malay peninsula. But this tendency may be counteracted by a sinking of the land.

On the coast, there are small semi-circular bays, but few large indentations, the principal being Koninginne bay, which, in Emmahaven, gives a good harbour, and Tapanuli bay (Sibolga). North of Tapanuli and south of Indrapura none of the indentations provides immunity from the south-west monsoon. The north coast has precipitous cliffs crowned with dense vegetation in some parts; in others sandy beaches, and well cultivated plains, whilst the bay of Oleh Leh gives shelter for shipping. The southern coast consists, mainly, of two large indentations, Lampong bay and Semangko bay, the eastern shore of the former being mountainous and little indented, whilst the western is much cut up; the centre of the bay has a good harbour (Teluk Betong). Semangko has a mountainous coast-line, with little indentation. The whole of the east coast is formed of morasses and sandbanks, which break up into innumerable islands, large and small, particularly about the central portion, and the coast-line is deeply indented in many places and very irregular. The indentations are not permanent, the coast is constantly advancing, and it is difficult to establish practicable ports or landing-places. Belawan, in the north, is the best harbour, and other harbours, also on the northern part of this coast, are Sigli, Lho Seumawe, Langsa, and Tanjong Balei. Sumatra has a chain of islands off the west coast which rise from the edge of the submarine platform and serve as a kind of outer barrier. They have an area of 5,769 sq.m., several are thickly populated and some are of considerable size, whilst many are of volcanic origin and most have rocky, reef-bound coasts, dangerous of approach.

Climate.—The climate of Sumatra resembles that of Java and is hot and extremely moist, but in most eastern coastal districts and often for many miles inland the heat is tempered by cooling land and sea breezes, the wind generally being north-east by day and south-west by night all the year round. The wind system of north Sumatra differs from that of the greater part of the Dutch East Indies, the north-east monsoon blowing from December to March, and the south-west monsoon from May to October. During the south-west monsoon the strong squalls from the north-west known as "Sumatras," accompanied by thunder, lightning, and rain, blow in the Malacca strait, and they have been known to occur during the north-east monsoon. On the west coast the influence of the north-east and south-west monsoons is felt as far south as 4° N.; between 4° N., and 2° N. there is a region of calms and light variable winds, which have a westerly tendency from March to November, when the north-west monsoon is blowing along the remainder of the western coast, *i.e.*, from 2° N. to 5° 57′ S., and an easterly tendency from May to September, the period of the south-east monsoon on the western coast. Southern Sumatra has the highest temperatures, and the mean annual temperature, for the lowlands, is about 80°. At Toba, in the Battak country (3,772 ft.), this is 69·6°, and higher altitudes show a corresponding reduction. On the whole, temperature in Sumatra is slightly higher than in Java. March, April and May are the hottest months; January and February the coolest, but the difference does not exceed 2°. The different wind distribution causes a variation of the seasons. Thus in north Sumatra October is the wettest month and February and March are the driest, whilst elsewhere the wettest months are December, January, and February, and from July to September is the dry period. Accordingly the rainfall varies considerably. The annual average rainfall for north Sumatra is 95·71, for east Sumatra 106·27, and for west Sumatra 122·32 inches. The west monsoon gives the heavier rainfall and the fall is accentuated in west Sumatra by the high mountains.

Fauna.—Notwithstanding the proximity of the island to Java the fauna of Sumatra shows a greater resemblance to that of Borneo than to that of Java, this being particularly noticeable as regards the fauna of the east coast of Sumatra, whilst that of the west coast and the islands adjacent is more allied to the Javan fauna. The orang-utan, common to Sumatra (in the north-east), and Borneo, is unknown in Java; the *siamang* (*Hylobates syndactylus*) is found in Sumatra only; there are ape species common to Borneo and Sumatra, also the elephant, tapir and Malayan bear, all of which are unknown in Java, though, on the other hand, Sumatra shares the tiger with Java, whilst it is unknown in Borneo. The one-horned rhinoceros of Java is unknown in Sumatra, which shares a two-horned variety with Borneo; the wild ox, or banteng (*Bos sundaicus*), known in Java, seems to be lacking in Sumatra, which has, however, a species of antelope, (*kambing-utan*), found only in the loneliest districts of the mountains. The Sumatran fauna also includes the apes *Hylobates agilis*, *Semnopithecus melalophus*, *Cercocebus cynomolgus* and *Macacus nemestrinus*, fox-nosed monkeys (*Tarsius*); the slow loris (*Nycticebus*); tupai (*Tupaja*); and the flying maki, or lemur (*Galeopithecus volans*); the flying fox, the kerbau, or buffalo (*Bos bubalus*), the Malayan deer (*Cervus muntjac*); wild dog; wild pig; Sumatran hare (*Lepus netscheri*); and civet cat. Species of birds exist in Sumatra which are unknown in Java—the great Argus pheasant, the fire-backed and ocellated pheasants, crested partridge, small Malacca parrot (*Psitticus incertus*), great helmeted hornbill (*Buceroturus galeatus*), pheasant ground cuckoo (*Carpococcyx radiatus*), rose-crested bee-eater (*Nyctiornis amicta*), and the great and green-crested gapers. Other Sumatran birds include the woodpecker, pigeon, and trogon. Insects, which also show a marked difference from those of Java, comprise the beautiful *Papilio memnon* butterfly, the *Papilio cöon*, and other species of this section, the *Kallima paralekta* (which attaches itself to and is able to imitate the leaf of a certain plant so closely as to secure itself from the attacks of enemies), flocks of Cyrestes, *Melantis suradeva*, a new species of *Amnosia*, *Eurhinia fulva*, one of the prettiest species of *Ecophoridae*, two specimens of the curious genus *Homopsyche*, and the moth *Pentacitritus transversa*. Lizards, large and small, frogs, tortoises and turtles abound, crocodiles frequent the mouths of rivers and are also found up-stream, there are many varieties of poisonous snakes, the rocks around the coast yield many kinds of shell-fish, and the sea, ponds, and rivers numerous sorts of edible fishes. The striking difference in species between the fauna of Sumatra and Java led A. R. Wallace to assert that the first severance of Sumatra from Java is very ancient; that since the epoch of the first (volcanic) disturbance several distinct elevations and depressions may have taken place, and the islands may have been more than once joined with each other or with the mainland (of Asia), and again separated, and that successive waves of immigration may thus have modified their animal productions and led to those anomalies in distribution which are so difficult to account for by any single operation of elevation or submergence.

Flora.—The flora of Sumatra bears a strong resemblance to that of India and the Malay peninsula in the northern part of the island, and to that of Java in the south, but it has also many varieties distinct from either, and not only different varieties, but different genera from those of Java. The pine (*Pinus Merkusii*), not found elsewhere in the East Indies, is found as far south as the Equator, and the distribution of vegetation does not appear to depend so closely on altitude as in Java. A striking feature of the vegetation is the flower of the huge Rafflesia, known from 20 to 24 inches in diameter. There are immense areas of savannah country, covered with coarse grasses, chiefly *alang-alang* and *glaga*, which stifle other forms of vegetation and give shelter to hordes of wild animals. These tracts occur as low as within 700 ft. of sea level. Myrtles, eucalyptus, bamboo, rhododendrons and moss-loving orchids are well known, palms abound, and orders strongly represented are Dipterocarps, Begonias, Nepenthes, Oxalidaceae, Melastomaceae, Myristicaceae, Chryobalanaceae, Connaraceae, Cyrtandraceae, Amyridaceae, Epacridaceae, Eriocaulaceae and Ternstromiaceae. There are zones of vegetation, differing with altitude, but the general tendency is for all forms to grow at a lower level than is the case in Java. The Sumatran forest begins at a height of from 300 to 400 feet, and it extends to all but the highest mountain peaks, this wealth of vegetation producing very beautiful mountain scenery. The forests contain the finest timber-producing woods in the archipelago; there is not only a great variety of trees, but they possess both stature and beauty. Deciduous trees such as the oak, chestnut, etc., grow on lower slopes than in Java, and apart from ebony, ironwood, camphor-wood, and sandalwood, there are also many species of resin and wild rubber-producing trees. The forestry service of Java has been extended within recent years to Sumatra, which is divided into five districts for this purpose, and all wasteful exploitation of timber is checked, where this is possible.

Population.—The following table gives the area and population of the several administrative divisions and of the island as a whole.

Division	Area	Population, 1927
	sq.km.	
Sumatra East Coast	93,500	1,183,283
Sumatra West Coast	50,723	1,598,262
Lampong Districts	28,268	239,985
Palembang	85,918	844,626
Bencoolen	25,886	271,373
Tapanuli	38,227	895,146
Achin and Dependencies	55,549	782,493
Jambi	44,452	179,691
Indragiri (the mainland territory of Riouw and Lingga Dependencies)	32,391 (with Riouw-Lingga)	224,145 (with Riouw-Lingga)
Total	454,914	6,219,004

The population includes 19,259 Europeans and Eurasians, and 229,775 foreign Asiatics, including Chinese. One-third of the

Europeans and four-fifths of the Chinese live in the East Coast Government. Sumatra has a very small urban population.

Arabs, Chinese and Indians of many races have long been settlers round the coast, where, also, there were once Hindu-Javanese colonies, and the mixture of blood which has resulted, and European contact, has given a much higher civilization than that which prevails in the interior, where the Hindu-Javanese influence was little felt in many regions, and even Islamic culture failed to penetrate, leaving the people in their ancient state of animistic barbarism. Many of the indigenous tribes of the interior are still in a state of development comparatively low, but simple education is spreading under advancing Dutch influence, barbarous customs are disappearing rapidly, lack of clothing is giving place to garments of Malayan style, a higher standard of living is beginning to assert itself, also improved methods of agriculture, and there are the beginnings of industry, whilst both Christianity and Islam are tending to replace the animism of savagery.

The whole of the indigenous population had, probably, a common Malayo-Polynesian origin, but to-day all the races may be classified as Malay, in a wide sense, the pre-Malay blood of the country having been absorbed thoroughly, whilst there is no race of true Negrito type. Of these Malayan divisions the Achinese (*q.v.*) inhabit the ancient kingdom of Achin in the north-western promontory and the whole of the north of the Gayo country.

Gayos.—The Gayos live in the northern central portion of the country, between the Achinese and the Battaks, with the Alas on their west, living mainly in the valley of the Simpang Kiri. The Gayos, numbering about 60,000, are essentially a highland and insular race, and form an ethnographical unit, all speaking one language. Akin to the Battaks, they are agricultural and pastoral, a friendly and honest race, living in well-built houses of wood, in small scattered villages, and are the equal in civilization of the Chams of Indo-China. Their chief crop is rice, maize, cotton and sugar-cane are grown, horses and cattle are reared, and forest products are collected, and there is an export trade to the coast in the latter, and in horses and cattle. Forest tracks, only, exist and transport is difficult, much being carried on the backs of the natives. Mohammedan by religion (with an animistic substratum), they are clever craftsmen in wood-carving and plaiting, and they make weapons. They are patriarchal.

Battak Groups.—The Battaks number 500,000, and inhabit the mountainous region about Lake Toba, the residency of Tapanuli, and a large part of the northern coast. They are divided into several groups, differing considerably in language and customs. Of Malay-Polynesian origin, the Battaks are nearly one-third Mohammedan, 80,000 are Christian, and the remainder Animist. Their old-time cannibalism, which was largely punitive and ritualistic, and slavery have disappeared. Their standard of culture is high; they possess a written language of their own, build compact and picturesque houses, with horned roofs (on piles, many families inhabiting one house), and have rice barns, and a communal hall, and the houses are beautifully decorated, the Battaks being clever craftsmen in wood, ivory and copper, whilst they understand iron smelting. They are good agriculturists, rice cultivation, wet and dry, being their chief occupation, though maize, coffee, fruit and vegetables are grown, and horses, cattle, buffaloes and pigs are reared, and they weave and dye cotton garments, make their own jewellery, also pottery, and there are amongst them keen traders and shop-keepers, teachers and even doctors. Society is patriarchal, marriage exogamic, women are in a subordinate position, but are treated kindly, and polygamy is practised. There are village councils, a nobility, land belongs to a family, or village, but tenure differs.

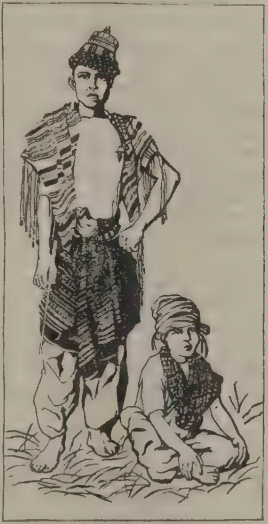
Menangkabau Malays.—South of the Battaks, in the Padang highlands and surrounding districts are found the Menangkabau Malays. At one time their ancient and powerful kingdom (which, legend says, rose on the ruins of a Hindu empire) covered the greater part of central Sumatra. They sent out emigrants to the Malay peninsula, and represented the highest form of Malayan civilization. Although converted to Islam, the Menangkabau Malays retained their ancient custom of the Matriarchate, *i.e.*, descent and inheritance in the female line, which is said to be preserved nowhere in a purer form than amongst these Malays. A wife remains after marriage with her kinsfolk on the mother's side, the husband, having no home of his own, only visits his wife, and resides in his mother's house. Names, privileges and property derive from the mother's side. The eldest man of the elder female line is termed *Mamak*, and he is the keeper of all the possessions of the family. Land is unalienable, and always comes back into the possession of the family or village. Marriage between members of the same tribe is not allowed. Houses, raised from the ground, are very ornate and picturesque, with horned ridge-poles and finely-carved wooden fronts, sometimes painted. Several families bearing the same patronymic live in the same house, and several houses, their rice-barns, a communal house, a mosque, school, an inn and market form a village. There are priests and nobles; the people live by trade, agriculture, hunting and fishing. Their language is one of the chief branches of Malay (with a few words of Sanskrit origin). At one time the Javanese script was used; now this is Arabic. Literature is legendary and poetical. Native chronicles derive the Menangkabau dynasty from Alexander the Great; and the Achinese princes derived their ancestry from a missionary of Islam.

Other Peoples.—South of the Menangkabaus, in the Indrapura region, live the Korinchis, a small community, partly Mohammedan, partly Animist, and east of these, in Jambi, Malays, using the term as denoting a seafaring race (Mohammedans), speaking Malay and having the usual Malay characteristics, not fond of work, prone to finery, devoted to sport and gaming, friendly and intelligent, and living in tribes. In Rejang-Lebong there are the Rejangs, a rather truculent people, who work in the gold and silver mines of their country, are Mohammedans, possess a script of Indian origin, and have Hindu antiquities scattered amongst them. In the south are the Lampongs, who were largely under Hindu influence and attained a high degree of civilization which they have retained. Pepper culture, for the European market, is the chief occupation, and many plantation owners are men of wealth, employing a great deal of outside labour. Among the primitive tribes, there are the Kubus of the Jambi mountains, who are nomadic and quite savage, almost dwarfs, and have frizzled hair denoting negritic blood. All are extremely shy and isolated peoples, but quite peaceable, nomadic or semi-nomadic, primitively clothed, living by fishing and hunting and rude agriculture. (For "island peoples" *see* NIAS, MENTAWEI, BATU, SIMALUR.) Enggano people are Animistic Malays, fishers and agriculturists.

Administrative Divisions and Towns.—The northern part of Sumatra is administered by the Government of Achin and Dependencies (*q.v.*), the capital of which is Kota Raja (*q.v.*), with Oleh-Leh as its port. Other ports are Sigli, Idi, Lho Seumawe (pop. 1,725), and Langsa, on the north-east coast, Meulaboh (pop. 1,732), and Singkel, on the west coast. Apart from Lhoinga on the north coast, Chalang, on the west coast, and Tapatuan, which have a *controleur*, Kuala Simpang near the southern boundary on the east coast, Meuredu, Bireuen and Kota Chane (Alas country), Blang Kejeren (Gajo country), Lokop and Takengun, a mountain station (4,000 ft.), in the interior, there are no towns worthy of mention. Exports in 1926 were 19,016,628 and imports 9,636,745 guilders. On the east coast, below Achin from 4 m. N. to the Equator, and extending inland to the central mountains and Lake Toba in the north, and to the western mountains in the south, is the Government of the East Coast of Sumatra, the largest administrative unit in the island, with its capital at Medan, and with its chief port Belawan (Deli) (*q.v.*).

A railway runs from Kuala Simpang, where it links up with the Achin coastal railway, to Tanjong Balei (pop. 7,970), the capital of the Sultanate of Assahan. It is the seat of the Sultan of Assahan, who has two palaces here, and, situated at the mouth of the Assahan river, is a port of call for vessels of the Royal Packet Navigation Company (which call also at Belawan, Bengkalis, Labuan Bili and Bagan Si-Api Api), with a trade in copra, rubber and gambier. The railway ends here, but a long motor road runs inland to Si Paré Paré. Other motor roads follow more or less the line of the coastal railway; they also connect other centres. South of these railways and roads there are no communications save riding-tracks and the rivers. Towns are: Bengkalis, on the island of that name (pop. 2,398), Pasir Pengarajan, and Gunung Sahilan, in the interior, Labuan Bili, on the coast, Siak Sri Indrapura, on the Siak, and Pakan Baru, 100 m. up the Siak, which is a port of call for vessels of the Royal Packet Navigation Company, and is connected by road with Gunung Sahilan. East Coast imports (1926) amounted to a total of 90,387,313 and exports were 277,453,450 guilders. Below Achin, on the west coast, opposite the East Coast Government, is Tapanuli (*q.v.*), a residency, its capital and chief port being Sibolga (pop. 5,822). Other ports are Barus and Natal, and all three are ports of call for Royal Packet Navigation Company steamers. Coffee, rubber and nutmegs are grown. Imports (1926) 5,072,923 and exports 14,899,537 guilders.

South of Tapanuli the residency of the West Coast of Sumatra has its border. With the exception of a few alluvial plains along the coast it is very mountainous, comprising the beautiful region of the Padang highlands (*q.v.*), with large lakes, Maninjau and Singarak, and many high mountains. Coffee, nutmegs, ground-nuts, coco-nuts (copra is a chief export) and cinchona are grown, apart from the usual native crops. There are coal-fields by the sides of the Ombilin river, near Sawah Lunto. Gold and silver are mined. The capital and chief port is Padang (*q.v.*) (pop. 41,238), and other ports are Ayerbangis and Priaman. Royal Packet Navigation Company vessels call at all these ports and ocean steamers at Padang. Priaman is connected by rail with Padang, and from it the railway extends to Sungai Limau along the coast. A coastal highway from Padang passes southward along the coast through Painan and Balai Salasa to Indrapura. Another road goes inland to Solok (pop. 1,965), Sawah Lunto (pop. 14,353), headquarters of the coal-mining district, Sijunjun-Jung and Sungai Dareh near the eastern boundary. A railway line from Padang runs inland to Padang Panjang (pop. 6,842) and 2,365 ft. above sea-level, where there is a small hotel and an industrial school for native girls and a good centre for mountain scenery. From there it branches northwards to Fort de Kock (pop. 12,624) (assistant resident), with hotels, an interesting old Dutch fortress, and the chief excursion centre for the Padang highlands. A good motor road connects with Sibolga, in Tapanuli, and thence to Lake Toba and across the island to Arnhemia. The railway extends inland to Pajokumbu (assistant resident) (pop. 5,121) (1,680 ft., a.s.), another excursion centre, which has a quaint native market, is a tobacco-growing centre and has a small hotel. In 1926 West Coast imports amounted to 22,563,046 and exports to 27,259,775 guilders.


BY COURTESY OF ROYAL PACKET NAVIGATION CO.

A YOUNG NATIVE MAN AND SLAVE

The residency of Bencoolen extends along the coast from the West Coast Government. Coffee, cloves, coco-nuts, tea and rubber are grown, and Bencoolen has gold and silver deposits in the Rejang-Lebong district. Coal occurs, but is not worked. The capital is Bencoolen (pop. 7,867), which is also the chief port. Royal Packet Navigation Company steamers call here and at Kru and Bintuhan. Bencoolen was the headquarters of the British administration in Sumatra, and the old Fort Marlborough still stands. Imports into Bencoolen for 1926 were 2,602,727 guilders and exports were 3,140,814 guilders.

East of the West Coast residency lie the residencies of—first Indragili, the mainland portion of the residency of Riouw-Lingga, the capital of which is Rengat (assistant resident), and which had, in 1926, imports valued at 6,991,360 guilders and exports 17,248,462 guilders; then Jambi (*q.v.*), the capital and port of which is Jambi (pop. 16,164) (imports [1926] 11,324,513 and exports 26,293,699 guilders); and then Palembang (*q.v.*), with capital and port the town of the same name (pop. 62,438), (imports [1926] 41,775,831 and exports 89,827,248 guilders). The whole of the south-eastern extremity of Sumatra is occupied by the residency of the Lampongs (*q.v.*), capital and port Teluk Betong (pop. 14,980), and which is a great pepper-growing centre. Imports (1926) were 1,173,722 and exports 15,492,735 guilders.

Agriculture.—Agriculture is divided into two classes, native and European. Native agriculture is occupied chiefly with rice cultivation, rice being the main food staple. Both *sawah*, wet, and *ladang*, dry, methods are used. Government helps cultivation with irrigation and agricultural advice. Sumatra does not grow sufficient rice to feed its population and has to import rice from British India, Saigon and Siam. Another food crop is maize (grown by the Battaks as a primary crop). Coffee, tobacco, pepper, cotton, kapok, cloves, nutmegs, coco-nuts, gambier, ground-nuts and betel-nuts are grown for export, generally being sold to Chinese middlemen. Of very recent years there has been a great expansion of native-grown rubber. Cattle-, pig- and horse-breeding is carried on in a primitive fashion (the Battak-bred horse is small; the Padang breed is larger), fishing is a common occupation (there is a considerable dried fish export trade, mostly in Chinese hands), whilst shells, trepang and prawn-spawn are exported, and such forest products as wild rubber, *jelutong*, rattan and resins are collected for export, while ebony, sandalwood and ironwood are cut for sale.

European agriculture is estate cultivation, the chief products being rubber and tobacco. Rubber is grown chiefly on the East Coast, with imported labour—Javanese, Chinese, Indian, etc. At the end of 1926 there were 238,563 hectares of rubber planted in Sumatra. The total crop for 1925, including native-grown rubber, was 133,660 tons. The tobacco centre is on the East Coast. Sumatra tobacco is a thin silky-looking leaf, of excellent colour and quality. It fetches a high price in Holland. In 1926, 19,008 hectares were under cultivation and the crop was 20,049 tons of estate leaf tobacco. Coffee produced in 1926 was 36,313 tons. Tea is also an important crop. In 1926 there were 15,802 hectares planted and production was 8,558 tons. Tea-growing is a young industry but the quality is so high that it bids fair to prosper. The intensive cultivation of the oil palm during the past seven years has been remarkable. The cultivated area is 28,642 hectares and the production for 1926 was 9,483,990 kg. of oil and 1,627,230 kg. of kernels. As against 36% of fatty acids in African palm oil, Sumatra oil contains only 12%. Cinchona (quinine) is produced on the West Coast. The planted area is 2,181 hectares, and production, in 1926, was 1,326 tons. A rapidly extending cultivation of agave fibres surpasses the production of the much older Java plantations. Production in 1926, from large estates on the East Coast, was 22,000 tons. Extensive areas are being planted with manila hemp, until now grown exclusively in the Philippine islands. Two East Coast estates in 1926 produced 2,800 tons of gambier. Coca (cocaine) is grown on the East Coast.

Native rubber production in 1925 was 53,000 tons. Pepper production in 1926 was about 23,000 tons and copra production, chiefly native, 33,366 tons. Padang shipped 14,607 buffalo hides and 8,879 cow hides also 1,317 tons of damar, 100 tons of gum benzoin and 1,000 tons of rattan, whilst Palembang shipped (1926), 3,633 tons of rattan and 1,053 tons of gum benzoin. Tanning barks to the extent of 18,800 tons were shipped from Sumatra East Coast, and 4,900 tons of areca nuts, also 2,339 tons of areca nuts from Palembang. Shipments of areca nuts from Acheen (quantities unascertainable) were much larger. The total imports and exports for Sumatra in 1926 were, respectively, 191,528,180 guilders and 490,227,730 guilders. Exports from Belawan were 189,463,289 guilders, from Palembang 89,287,248 guilders and from Padang 27,289,775 guilders.

Industries.—Coal is mined at Ombilin, near Sawah Lunto, in the Padang highlands (mining started in 1892), at Bukit Asem, 12 km. south-west of Muaro Enim, in Palembang, at Pulu Punggung, Darmo, Buluran and Laje, in Palembang, and at Bukit Durian (West Coast). Ombilin and Bukit Asem are operated by the Government and are modern-equipped. Production in 1925 was, Ombilin, 543,745 tons and Bukit Asem 245,638 tons. Petroleum is secured in Achin, East Coast, Palembang and Jambi. Crude petroleum production in 1925 was—Palembang 441,588 tons, East Coast 79,579 tons, Achin 74,670 tons and Jambi 13,274 tons. The oil produces benzene, kerosene and lubricating oil. Gold and silver are mined on the West Coast and in Bencoolen. Government-owned mines in 1925 produced gold worth 550,281 guilders, and silver worth 1,608,198 guilders, the Rejang-Lebong mine, gold 2,117,244 guilders and silver 460,076 guilders, the Simau mine, gold 2,334,507 and silver 910,952 guilders, the Aequator mine, gold 926,456 guilders and silver 983,641 guilders, and the Kinandam mine, gold 187,220 and silver 449,516 guilders. Lead, sulphur, naphtha, alum and saltpetre are found, also lignite and magnetite. A tank for palm oil has been completed at the port of Belawan, from which the oil will be pumped to steamers.

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HISTORY

Some authorities suggest that Sumatra, not Ceylon, may have been the Taprobane of Pliny. The island was the first to receive the Hindu emigrants whose descendants by the 7th century had made it the seat of a powerful Hindu Kingdom. In the 13th century the Arabs invaded Achin and Mohammedanism took firm hold of some of the most important states. On ancient inscriptions discovered in the Padang highlands, the island was called "the first Java"; Marco Polo called it "Java Minor." It became known to Europeans as Sumatra through Ludovico de Varthema, an Italian, in 1505. The Portuguese established a trading post about 1509 and were driven out by the Dutch at the end of the century. For the next three centuries the Dutch were engaged in costly efforts to establish supremacy in Achin: a thirty years' war, started in 1873, is estimated to have cost 250,000 lives and £50,000,000 sterling. In 1602, the English first visited Achin, when Sir John Lancaster was well received, and eleven years later, to the annoyance of Dutch and Portuguese, were given permission to start a factory. Elsewhere Dutch sovereignty was gradually extended—in 1664 over Indra-pura; in 1666 over Padang; in 1620 they secured a modest concession in Palembang; the Sultans repeatedly sought to throw off the yoke; twice—in 1654 and 1819—the Dutch were actually driven out, and not till after a serious revolt in 1851 had been suppressed was their tenure secure. In Jambi the efforts of the Sultans to escape the consequences of concessions were equally persistent. Throughout the 18th century Dutch and British maintained a constant rivalry in Sumatran waters. Benkulen, where the English acquired a footing in 1685, was among the sources of irritation to the Dutch, and was handed over to them in 1824 in exchange for Malacca. In Deli, in Menangkabau—whose princes claimed descent from Sultan Iskander (Alexander the Great)—and elsewhere, the Dutch established their authority in the teeth of repeated insurgence and generally as the result of the quarrels of native rulers who invoked their help and had to pay the price. Politically Sumatra is not as far advanced as Java, but is under the Governor General of the Netherlands East Indies, and enjoys the same representative rights in the Volksraad. (C. H.; E. S.)

SUMBA (Dutch *Soemba*), also known as Sandalwood, one of the Lesser Sunda islands, Dutch East Indies; area 4,600 sq.m. Sumba forms part of the residency of Timor. The island is dominated by heights of from 2,200 to over 3,000 ft. Several bays on the north coast give good anchorage, the best being that of Waingapu. The rivers, mostly unnavigable, are of importance for agriculture. A fertile soil and a fairly good rainfall (average 63·7 in. annually) help to produce good forests, grazing ground and food crops. The forests yield sandalwood (giving rise to the old name for the island), dye-woods, wax and wild cinnamon. On the grazing grounds are bred some of the finest horses in Netherlands India—the sandalwood breed—and fine cattle (Ongole), both figuring largely as exports, whilst rice is raised on *sawahs* and *ladangs*, and maize, coffee, tobacco, coco-nuts, vegetables and fruit are grown; copra being exported. The population is 124,401, consisting, apart from the indigenous Sumbanese, of people from Flores, Savu and Rotti. The Sumbanese are a Malayo-Papuan people of good physique. Except in the interior, where clothing is far more primitive, the *sarong* and *baju* are generally worn by women, and sometimes by men. Both sexes are fond of ornaments. They cultivate the soil, fish, mostly in rivers, not being a sea-loving race, collect forest products, edible birds' nests and turtles, make fishing-nets and plait baskets. There are workers in copper and iron, whilst the women weave, spin and dye, and make pottery. The natives are largely pagan (there are some Mohammedan), and make offerings on stone altars. A particular breed of horses is held sacred. The Sumbanese enjoy feasts, music and dancing. Marriage is by dowry and polygamy is fairly common amongst the upper classes. There is no written form of the Sumbanese language, which is allied to that of Savu. Sumba has numerous megalithic monuments. The assistant resident lives in Waingapu (pop. 1,622), and vessels of the Royal Packet Navigation Company call.

The sandalwood of Sumba attracted attention to the island in the 17th century, when Sumba appears to have been a tributary of the state of Bima, in Sumbawa. Later Sumba became independent of Sumbawa, and treaties were concluded in 1756 with the Dutch. Between 1856 and 1874, new treaties were made, but there have been frequent difficulties with the natives, due to piracy and slave raids. The trouble continued and in 1901 the Dutch were compelled to land troops. Most of the chiefs of the tribes are now bound by the "short declaration," but there were disturbances in Sumba (Lamboja), necessitating a Dutch armed force as recently as 1914. (E. E. L.)

SUMBAWA (Dutch SOEMBAWA), one of the Lesser Sunda Islands, Dutch East Indies, between Lombok and Flores, and separated from the former by Alas Strait and from the latter by Sapeh Strait and the island of Komodo. Sumbawa with neighbouring islands, has an area of 5,240 sq.m. From 30 to 100 m. north of Sumbawa there are the Tenga and Sabalana Islands, small low banks, surrounded by reefs. Mountain chains traverse the centre of each of the peninsulas. There are only a few stretches of alluvial land along the coast: off the southern shore great depths of water are soon reached in the Indian Ocean. The mountains, some volcanic, are highest in the north. Mt. Tamboro is still 9,042 ft. high, though it was very severely damaged in the eruption of 1815. No other volcanoes appear to be active. The average annual rainfall (Bima), is 93 in. Agriculture is carried on, rice being raised on *sawahs* and *ladangs*, whilst maize, cotton, coffee, tobacco, coco-nuts, onions, and other vegetables, and fruit, are grown. Horse and cattle breeding are important industries. The forests yield teak and dye-woods, sapan wood the chief.

The population of Sumbawa is 246,179. The natives of the western peninsula (Sumbawa) are of Malayan stock and allied to the Sassaks of Lombok, and those of the eastern peninsula (Bima, Sanggar and Dompo), are Malayo-Papuan.

Sumbawa is part of the residency of Timor and dependencies, and is governed by an assistant resident, who resides at Bima. Vessels of the Royal Packet Navigation Company call at Bima, Sumbawa, and Taliwang, affording regular communication with Macassar, the other Sunda Islands, and Java ports. Sumbawa consisted originally of six States, all owing allegiance to either Gowa or Macassar in Celebes—Bima, Dompo, Sanggar, Tambora, Papikat and Sumbawa: after a rebellion in Tambora in 1815 that State and Papikat ceased to exist. In 1701 the Dutch arbitrated between Sumbawa and other States in the island engaged in civil war, and in 1765 the Dutch made a separate agreement with Sumbawa, revised in 1875 and again in 1905, under which it has a certain measure of self-government. A contract made with Bima in 1857 and again in 1886, on the lines of that made with Sumbawa, was revised in 1905. It allows the State some self-governing powers. Sanggar was subject to the sultan of Ternate originally, then to the Sultan of Macassar, and after the Bongay Contract of 1667 it became a fief of the Dutch. A treaty made in 1858, and revised in 1905, defines its right of self-government. Dompo gave up allegiance to Macassar after the Bongay Contract, was a party to the Sumbawa treaty with the Dutch of 1765, and has had its self-governing powers fixed by subsequent treaties. (E. E. L.)

SUMBUL or **SUMBAL,** also called Musk Root, a drug occasionally employed in European medical practice. It consists of the root of *Ferula sumbul*, Hook., a tall Umbelliferous plant found in the north of Bokhara, its range apparently extending beyond the Amur. The action and uses of the drug are the same as those of asafetida (*q.v.*).

SUMERIAN LANGUAGE. The language now called Sumerian was revealed about the middle of the 19th century to Sir Henry Rawlinson and other scholars when examining the baked clay tablets which had formed the library of Ashurbanipal, king of Assyria. These had recently been discovered by Layard in the ruins of Nineveh and brought to the British Museum. When the cuneiform script in which they were written was deciphered, it was found that certain of them contained works composed in a language entirely different from the Semitic tongue of the Assyrians, but sometimes provided with interlinear translations into Assyrian; other tablets were dictionaries in which the words of this strange language were assigned their Assyrian equivalents.

It was many years before the study of Sumerian was firmly established, although its meaning could be so confidently interpreted from the Assyrian translations. This was due both to the impossibility of discovering cognate languages, and to the factitious obstacle of a paradox which was subsequently maintained, chiefly by Joseph Halévy, that Sumerian was no true language at all, but a purely artificial system of secret writing invented for mystification of the vulgar by the Assyrian priests. The second of these hindrances was ultimately removed by the discovery of monuments inscribed in this language, which evidently belonged to a time before the Semitic tongue was written in Mesopotamia; the problem of finding a cognate language remains.

Its Speakers and Script.—The area covered by this ancient speech was probably never very extensive. It is, at any rate, found only upon the monuments from the country lying between the Euphrates and Tigris, extending somewhat to the east of the latter, and from about the latitude of Baghdad to the head of the Persian gulf, which has receded since ancient times. Its main centre was apparently the region of Nippur, the seat of the chief Sumerian cult. To the north, in the country later called Akkad, a Semitic language prevailed from very early times. Of the race or original home of the Sumerians nothing can be confidently asserted, for they appear settled in this territory from the earliest intelligence we have of them, and their own tradition of a fabulous antiquity gives no hint of another home. In this habitation they invented (for there is no evidence of borrowing) the pictorial script which became by a long process of evolution the cuneiform signs, later adapted by the Semites for the writing of their own language. The year 3500 B.C. may be taken as a round date for the beginning of this script, the development of which can now be somewhat exactly observed, from definite pictures into the purely conventional groups of wedges with which it ended in about the last century before Christ. Very early the stage was reached at which signs were used not only to express the idea which they represented as pictures, but also for the mere sound of the corresponding word in a context which did not involve the actual idea at all; thus the sign *ka* is the picture of a mouth, but it is also used to write a certain grammatical ending -*ka* which has nothing to do with the idea of "mouth." The Sumerian writing, then, is a mixture of pictorial and phonetic elements, the roots being generally written with a sign which in itself expresses the required idea, accompanied by other signs used simply to supply the grammatical modifications. Two difficulties are caused by the polyphony of signs, and the existence of homonyms; one picture (*e.g.* the "foot") having been used to express two connected but different ideas (*e.g.* the "foot" itself, and "to go"), two phonetic values, or more, became attached to the sign. On the other hand the language possessed many words, of different meanings, which chanced to be of similar sound, (*e.g.*, the word *sig* was both "low" and "to strike"). In modern works these homonyms are usually distinguished by diacritical marks. Certain of the signs are also used as determinatives, *i.e.*, they are placed before or after words to assign them to a particular class of natural things, such as man, bird, fish, wood and several more.

Outline of Grammar.—The roots of the language are generally monosyllables though a few longer words are found. These roots are not subject to internal change, since grammatical distinctions are made by grouping a number of elements together around the root, not by causing the root to assume different forms. In the case of roots having the form consonant-vowel-consonant the final consonant is often dropped when a consonant immediately follows. In itself the root expresses a bare idea only; thus *dug* means "good," and can appear not only as an adjective but (with the appropriate modifying elements) as a noun "goodness," or a verb "to be good." Nouns are mostly formed by adding prefixes, sometimes the vowels *a* or *u*, but more often *nam* or *nig* which form abstracts; thus, from *dug*, the noun "goodness" would be *nam-dug*. Sumerian has no gender, which is disregarded in places where it is indifferent and expressed where necessary either by prefixing the determinatives for "male" and "female" or by the use of entirely different words, such as *adda* "father" and *ama* "mother." Plural of nouns is not always indicated, but can be formed when required either by repeating the root (*kur* "land," *kur-kur-ra* "lands"), or by the addition of suffixes -*ene* (used of persons), -*mesh* or *hi-a*. There is no special form of the dual, though the number two can be written if essential. The relation in which the noun stands to the rest of the sentence is shown by a rather elaborate set of suffixes, which may be treated either as postpositions or case endings. Of these -*a* generally expresses the accusative, -*e* the nominative, -*da* is "with," -*ta* "from," -*ra* and -*shu* "to," -*gim* "like," while the genitive is denoted by a suffix -*ak*, which has the peculiarity of doubling itself to correspond with the number of genitives to be expressed, though this doubling is often concealed by the omission of a final consonant. Finally, the noun always stands at the head of a complex of modifying elements, with which it combines to form a kind of composite unity.

A peculiarity of the verbs is that, besides the simple roots, there are also compounds formed by the prefixing of a noun, the whole making one idea (*e.g.*, *de* "to pour" and *gu-de* "to pour out a voice, to speak"). Between the nominal and the verbal part of the compound root are placed such of the accompanying elements as normally precede the root. These accompanying elements may be classified into three kinds (*a*) subject prefixes, (*b*) conjugating elements and (*c*) infixes. The first merely indicate the subject, not expressing in themselves either number or person, and the force of the individual prefixes is still insufficiently clear. Distinction of tense, number, person, mood and voice is effected by the conjugating elements, but the resources of the language for these purposes are not highly developed, and it is clear that some of the grammatical tablets compiled by Semitic scribes for their own use lent to the Sumerian verb a number of artificial refinements which are not observed in the native texts. Extensive use is made of participial constructions, and there is a special form for the optative, and a corresponding prohibitive particle. The infixes, which convey the direct or indirect object, as well as certain adverbial relations, are included in the verbal forms as the result of a strong tendency for the predicate to gather into itself parts representing all the other members of the sentence. The order of elements in the verb-complex follows a strict rule. The numeral system was sexagesimal and decimal.

The native grammarians knew of five different "tongues" in Sumerian. These are assumed to have been dialects, but in fact nothing is known of them except the *eme-sal* "broad (?)-tongue," in which a number of religious texts are composed. This is differentiated from the ordinary form chiefly by a weakening of certain consonants, particularly of *g* into *m*, and by a preference for phonetic writing. Sumerian ceased to be spoken before 1500 B.C., but was long used as a learned language.

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SUMER IS ICUMEN IN, famous 13th century English rota or round which occupies a unique place in the history of music as standing so entirely alone in respect of the advanced character of its writing, as well as of its musical beauty, among the compositions of its period. As Father Anselm Hughes has put the matter in Grove's *Dictionary of Music*, this astonishing composition is pre-eminent in six respects, for (1) it is the oldest known canon; (2) it is the oldest known harmonised music which is frequently performed and enjoyed by singers and listeners to-day; (3) it is the oldest known 6-part composition; (4) it is one of the oldest known specimens of the use of what is now the major mode; (5) it is the oldest known specimen of ground-bass; (6) it is the oldest known manuscript in which both secular and sacred words are written to the music. The generally accepted belief is that it was composed somewhere about the year 1240, and it is ascribed to one John of Fornsete, who wrote the ms., which came from Reading Abbey. *See* article MUSIC, section 3, where the music is reproduced.

SUMMANUS, properly an epithet (= "highest") of Jupiter (q.v.); afterwards god of the nocturnal heavens, thunderstorms at night being attributed to him, those by day to Jupiter. Summanus had a temple at Rome near the Circus Maximus, dedicated at the time of the invasion of Italy by Pyrrhus, king of Epirus (278). Here sacrifice was offered every year to Summanus on June 20, together with cakes called *summanalia* baked in the form of a wheel.

See G. Wissowa, *Religion und Kultus der Römer*, p. 122 (1912); W. W. Fowler, *The Roman Festivals*, p. 160 (1899).

SUMMARY JURISDICTION. (1) **Meaning:** The phrase is now understood in English law as referring to jurisdiction, exercised by justices of the peace, which may result in a summary conviction or order. Blackstone divides the proceedings in courts of criminal jurisdiction into two kinds: summary and regular: and by regular he means such as involve trial by jury, the only mode of trial known to the Common law except in the case of contempt of court. In these regular proceedings there is only a preliminary hearing before justices, followed by either a dismissal or committal for trial by jury at Quarter Sessions or Assizes.

(2) **History.**—Being unknown to the Common law, this jurisdiction is entirely the creation of statutes. A brief sketch is to be found in Stephen's *History of the Criminal Law*, vol. 1. ch. 4, of the growth of the criminal jurisdiction. Speaking generally this growth has shown itself in two distinct forms: (a) The conferring of exclusive jurisdiction in a vast number of minor offences, mainly involving the infliction of pecuniary penalties, under such headings as Army, Game, Highway, Licensing, Motor Cars, Merchant Shipping, Post Office, Public Health, Revenue and Vagrancy. These offences have been created and are being created by Acts of Parliament or by by-laws of county councils or other local authorities made under statutory authority, or by orders of Departments. (b) The providing in indictable cases of a mode of trial, alternative to trial by jury and dependent for its adoption on the consent of the tribunal, of the accused and in some instances of the prosecution. These cases are referred to as indictable cases triable summarily.

In addition to summary criminal jurisdiction, justices have been endowed by many statutes with a summary civil jurisdiction of increasing scope and importance.

(3) **General Legislation.**—A court of summary jurisdiction is defined by the Interpretation Act 1889 as "Any justice or justices of the peace or other magistrate by whatever name called, to whom jurisdiction is given by or who is authorised to act under the Summary Jurisdiction Acts and whether acting under the S. J. Acts or any of them, or under any other Act or by virtue of his commission or under the Common Law." This does not apply to justices sitting as the licensing authority nor to the preliminary hearing by justices of indictable offences.

In the Interpretation Act "The Summary Jurisdiction Acts" means the S. J. Act 1848 and the S. J. Act 1879 and any Act past or future amending those Acts or either of them: thereby including amongst others, the Criminal Justice Administration Act 1914 and the Criminal Justice Act 1925. (*See* S.J. Act 1848 s. 35; S.J. Act 1879 s. 54 and C.J.A. Act 1914 s. 32 [i.].) These Acts prescribe the constitution of the courts and the procedure to be followed up to, during and following the hearing, in such civil cases as are not otherwise specially provided for, in purely summary criminal cases and in indictable cases triable summarily, and further specify what indictable offences are triable summarily, and the maximum punishment which can be inflicted on conviction. Rules made under these Acts of 1915 and 1926 deal with such matters as the register, accounts, payments and bail.

(4) **Constitution of the Courts.**—A court consisting of not more than one justice has a jurisdiction limited to receiving an information or complaint, issuing a summons or warrant (S.J. Act 1848 s. 1), adjourning the hearing to the next practicable sitting of a Petty Sessional Court, and where authorised by the statute creating the offence, trying the case and imposing a punishment of not more than 14 days imprisonment or a fine of not more than 20/–(S.J. Act 1879 s. 20).

A Petty Sessional Court is defined by the Interpretation Act 1889 as "A court of summary jurisdiction consisting of two or more justices when sitting in a Petty Sessional Court, and shall include the Lord Mayor of the City of London and any Alderman of that city, and any metropolitan or borough police magistrate or other stipendiary magistrate, sitting in a court-house or place at which he is authorised by law to do alone any act authorised to be done by more than one Justice of the Peace." It is by this court that summary jurisdiction must ordinarily be exercised (S.J. Act 1879 s. 20 [9 and 10]).

The position in London (excluding the city) is peculiar. Under the Metropolitan Police Courts Act 1839, a number of stipendiary magistrates (commonly known as police magistrates) are appointed and sit at 14 police courts. The jurisdiction of the justices for the county of London was not expressly taken away, and in theory they possess a concurrent jurisdiction, but inasmuch as by S. 42 of the Act of 1839 court fees in respect of proceedings elsewhere than in the police courts were prohibited, a practical obstacle was interposed which has prevented the jurisdiction being exercised except to a very limited extent. It is not suggested that thereby any public mischief has ensued. Outside London, some 17 stipendiary magistrates are appointed under various statutes for various cities and boroughs.

Offences under the Conspiracy and Protection of Property Act 1875 are to be prosecuted before, and jurisdiction under the Law of Distress Amendment Act 1908 is to be exercised by, a stipendiary magistrate where there is one.

(5) **Subject Matter of Criminal Jurisdiction.**—(a) *Summary Cases:* It has been already stated that *inclusive* summary jurisdiction has been conferred in numerous criminal cases both by or under special statutory authority: this statement requires qualification.

(i.) When the offence is punishable by imprisonment for more than three months the person charged may claim to be tried by jury: to this there are at least two exceptions: a male person who knowingly lives wholly or in part on the earnings of prostitution or who in a public place persistently solicits or importunes for immoral purposes. Punishment: 6 months' hard labour, without right to trial by jury (Criminal Law Amendment Act 1912 S. 7 [2]).

(ii.) A like claim to the trial by jury may be asserted under the Explosives Act 1875 S. 92, and the Conspiracy and Protection of Property Act 1875 S. 9.

(iii.) Some offences are triable either summarily or by indictment, *e.g.*, assault, some forms of public indecency, cruelty to children and the offences mentioned above under C.L.A. Act 1912.

(b) *Indictable Cases Triable Summarily:* Where an adult is charged with one of the offences specified in the second schedule to the Criminal Justice Act 1925 and the court thinks it is expedient and the accused consents, the court may try the case summarily, unless the case affects the property or affairs of His Majesty or of a public body, or unless the Public Prosecutor is prosecuting, in which cases the consent of the prosecutor is also necessary. (C.J. Act 1925 S. 24.)

This statute greatly increases the number of indictable offences triable summarily, and confers wider, though more elastic, powers of punishment than any previous statute. The power to fine, which is particularly appropriate in some cases of dishonesty is not possessed by courts of Quarter Sessions or Assize when dealing with felonies.

(6) **Criminal Procedure.**—(a) *Procuring the Attendance of the Accused:* Where the offence is originally indictable, the accused is brought before the court either on arrest without warrant or upon warrant or summons under the Indictable Offences Act 1848, and the charge cannot proceed in his absence.

In summary cases, unless there has been an arrest by a constable under statutory powers, information is laid before a justice as to the offence, whereupon either a summons or a warrant may be issued. For a summons the information may be oral and unsworn; for a warrant it must be in writing and upon oath. The information must be laid within six months from the commission of the offence unless a different time is limited by some particular statute (S.J. Act 1848 S. 11) or unless the offence is a continuing one.

A warrant is not ordinarily granted in the first instance, except for a serious offence; but if the summons is disobeyed, a warrant may be issued upon proof of service.

(b) *The Hearing:* The hearing must take place in open court, and parties may appear by counsel or solicitor. If the accused does not appear and the court determines to proceed, the case must be proved in the ordinary way as if he had appeared. If the informant does not appear the case is dismissed, unless the court thinks proper to adjourn the hearing and to remand the accused either in custody (which would be very unusual) or on recognizance with or without surety. If the accused appears, he is asked to plead; if he pleads guilty, the court proceeds to judgment. If the accused pleads not guilty, the prosecutor opens his case and his witnesses are sworn, examined, cross-examined and re-examined.

A police officer of whatever rank has no right *ex officio,* and should not be permitted to act as advocate or to take any part in the proceedings at all; that is, unless he is the actual informant: even in the latter event, whatever his actual right under the S.J. Act 1848, his activities should be confined, so far as possible, to those of a witness. The attendance of a witness may be enforced either by a Crown office *subpoena* or by a summons or warrant of a justice.

If there is a variance between the evidence and the information, and the party charged is prejudiced thereby, an adjournment on terms should be granted. At the close of the evidence for the prosecution, if the court is of opinion that there is a case to answer, the defendant may open his case and call his witnesses, subject to this: that if the defendant be the only witness on his side as to fact, he must be called immediately after the close of the evidence for the prosecution.

(c) *The Judgment:* The judgment follows the opinion of the majority of justices present at the hearing, and the chairman has no second or casting-vote. In the case of an equality of votes, unless a justice withdraws his vote, the case should be adjourned for a rehearing before another court, when, if the same result ensues, the case should be dismissed. If the court decides to dismiss the information either upon the non-appearance of the informant or as being of opinion that the charge is not proved, it makes an order to that effect and may award costs to the defendant: but costs do not follow the event so frequently as in civil cases. If the charge is without foundation and the defendant is in no way to blame, there seems no reason why he should bear any part of the costs of the defence, whether the prosecution is by the police or by a private person, but a variety of considerations, generally unstated, influence the courts in this matter, and it cannot be pretended that there is any general or settled practice. If the defendant has pleaded guilty or the court is of opinion that the charge is proved, the court may either:

(i.) Postpone judgment (either for consideration or to avoid inflicting sentence of imprisonment) and remand the defendant either in custody up to 8 days, in an appropriate case, or for that or a longer period, on recognizance, with or without sureties, or

(ii.) Convict the defendant, and commit him to the Assizes or Quarter Sessions in order that a sentence of detention in a Borstal institution may be passed, or

(iii.) Convict and sentence the defendant. The maximum term of imprisonment and the maximum fine which can be inflicted are in general fixed by the statute or bye law creating the offence: an order for costs can be included in the conviction. Whatever the provisions of the statute, or bye law, the imprisonment may be either with or without hard labour, and the court may reduce the term as it thinks fit or substitute for imprisonment (where no power to fine existed) a fine not exceeding £25 and not involving, on default, a longer term of imprisonment than that prescribed by the Act or bye law: and where a fine is prescribed, the court may, if it is imposed as in respect of a first offence, reduce the prescribed amount, or

(iv.) Without proceeding to conviction, where the court is of opinion that having regard to a variety of circumstances (*see* Probation of Offenders Act 1907 S. 1) make an order dismissing the information or charge, or discharge the defendant conditionally on his entering into a recognizance, with or without sureties, to be of good behaviour and to appear for conviction and sentence at any time within not more than 3 years.

(d) *Execution and Enforcement of Payment of Fines and Costs:* Fines and costs, ascertained by conviction, are enforced by warrant of distress and, in default of distress, imprisonment on a scale set out in S. 5 of the S.J. Act 1879. The court may issue a warrant of commitment in the first instance if the defendant has sufficient means to pay or if he does not ask for time to pay or has no fixed estate within the jurisdiction or for other special reasons. (*See* further C.J. Act 1914 S. 25.) Where no fine has been inflicted but costs have been ordered to be paid either by the defendant or, upon dismissal, by the informant, recovery is by distress under S.J. Act 1848 S. 18 and C.J. Act 1914 S. 25. There are exempt from distress: the wearing apparel of the defendant and his family, and, to the extent of £5, the tools and implements of his trade. Provision is made in C.J. and S.J. Acts and rules for payment by instalments.

(e) *Appeal:* (i.) *To Quarter Sessions:* There is a general right of appeal against a conviction (including an order under S. 1 of the Probation of Offenders Act 1907) where the person aggrieved did not plead guilty (C.J. Act 1914 S. 37 [1]: C.J. [Amendment] Act 1926 S. 1), and against sentence after a plea of guilty (C.J. Act 1928 S. 25). There is no right of appeal against a dismissal, unless specially given by some statute. The procedure is regulated by the S.J. Act 1879 to which reference should be made to master the technicalities which are numerous.

(ii.) *To the High Court by a Case Stated on a Point of Law:* Such an application may be made by either party under the S.J. Acts 1857 and 1879. A recognizance, similar to that required on appeal to Quarter Sessions, is necessary. Generally speaking, the parties agree upon the form of the case: failing agreement the court settles the case.

(iii.) The court of King's Bench has further powers, on certain limited grounds, to restrain or control the exercise of a refusal to refuse to exercise jurisdiction by writ of *certiorari mandamus* and *prohibition.*

(7) **Civil Procedure.**—(a) As before stated, justices have been authorised by many statutes to make orders for the payment of money or otherwise: and some of the statutes contain special provisions as to the procedure to be observed. Mention is made of those most in use. Bastardy is specially dealt with under the Bastardy Acts 1872 and 1923 and the Affiliation Orders Act 1918.

Disputes between employers and workmen and employers and apprentices are provided for by the Employers and Workmen Act 1875.

A special code, applicable to certain differences between husbands and wives, is contained in the S.J. (Married Women) Act 1895 as amended by the Married Women (Maintenance) Act 1920 and the S.J. (Separation and Maintenance) Act 1925 and S. 5 of the Licensing Act 1902.

A limited jurisdiction in ejectment is conferred on justices by the Small Tenements Recovery Act 1838, at present qualified by a variety of Rent Restriction Acts.

In the absence of provision to the contrary in the Act conferring jurisdiction, the procedure is governed by such parts of the S.J. Acts and rules as deal with orders and the recovery of civil debts. A summons is issued on complaint and not on information; and no warrant can be issued to compel attendance. On the hearing the civil laws of evidence apply. To enforce an order for the payment of a civil debt or costs, in default of distress, a judgment summons, of which personal or substituted service is necessary, must be obtained. If on the hearing of this summons it is proved that the defendant has or had, since the date of the order, means to pay, he may be committed for any term not exceeding 6 weeks. (S.J. Act 1879 S. 35). Default in complying with an order other than for payment of money may be visited by an order to pay a sum (to be enforced as a civil debt) up to £1 a day during default, not exceeding £20 in the aggregate, or for imprisonment, until compliance, for a period not exceeding two months.

(b) *Appeal:* There is no general right of appeal to Quarter Sessions: in Bastardy, however, either party may so appeal, and various other statutes conferring civil jurisdiction include this right. For instance the Pawnbrokers Act 1872 (on refusal of a certificate) and the Money-Lenders Act 1927. In matrimonial cases a special form of appeal lies to the High Court, Probate, Divorce and Admiralty Division.

The S.J. Acts 1857 and 1879 as to appeal by stated case apply to civil determinations in like manner as they do to criminal determinations, and the powers of the High Court as to writs of *certiorari, mandamus* and *prohibition* can also be invoked.

(8) **General Observations.**—The public advantage of the courts is not confined to the work done in open court. The stipendiary magistrates, in London especially, act as friendly advisers of the poor, who flock to the courts for counsel and assistance. Many difficulties are solved, quarrels composed, and redress secured by extra-judicial methods.

It must be confessed, however, that occasionally the need is felt for some further provision for the defence of the needy and ignorant persons in these courts. Societies for the protection of women and children play their part, the magistrate does what he can and even has been known to instruct a solicitor for the defence at the expense of the poor box. Yet still there is a gap to be filled, and it seems probable that, sooner or later, some scheme, however closely limited and guarded, will have to be devised to prevent possible injustice. (H. W. W. Wil.)

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THE UNITED STATES

Summary jurisdiction in the United States, as in England, is the creation of statutes. The American colonists were familiar with the institution of summary jurisdiction as developed in Stuart England and adapted it to the exigencies of their new life. Reasons such as their distrusts of bureaucratic tyranny, the lack of trained lawyers, the limited need for criminal legislation, made for a reduction in the extent of summary jurisdiction. That a vigorous and extensive jurisdiction over minor offences was exercised is, however, clear. (*See* Frankfurter and Corcoran, Petty Federal Offenses and the Constitutional Guaranty of Trial by Jury, 39 Harvard L. Rev. 917, 1926.) Some of the colonies gave general summary jurisdiction of all offences where the maximum punishment was a moderate fine and a moderate term of imprisonment. Special legislation conferred summary jurisdiction for petty offences such as swearing, gambling, illegal selling of liquor, profiteering, etc. The extent of this jurisdiction as being "a veritable social control in the daily lives of the people" is demonstrated by the fact that prior to the American Revolution the number of offences punished in the first instance by a single magistrate in Massachusetts amounted to 170, a figure equally illustrative of the extent to which summary jurisdiction prevailed in the other colonies.

Prior to the Revolution much antagonism was aroused by the Crown's denial of the right to trial by jury in a number of cases where traditionally such trial was had. This grievance of the colonists loomed large in the Declaration of Independence of 1776 and was responsible for the inclusion of provisions in the United States and State constitutions guaranteeing the right to trial by jury. The relationship of these constitutional provisions to the recognized summary jurisdiction of the magistrates has proved a controversial issue in American law. It is quite clear, however, that their effect was not to introduce jury trial in all cases but that, whatever restrictions they placed upon the statutory extensions of summary jurisdiction, they left the existing ambit of that jurisdiction, in the main, untouched. The history of that jurisdiction has controlled the courts in determining the scope of the constitutional provisions for trial by jury. Thus, the constitutional provision has been interpreted by various courts as not to deny the power of the legislature to confer summary jurisdiction upon magistrates in a variety of petty offences such as assault and battery, disorderly conduct, petty larceny, violations of game, food inspection, liquor, vagrancy, Sabbath-breaking and highway laws. The test of what offences can be entrusted to the summary jurisdiction of single magistrates has been framed by the New Jersey court of errors and appeals in Katz *v.* Eldridge, 97 N.J.L. 123, 151. (1922), as follows: "The offence must be a petty and trivial violation of regulations established under the police power of the State in order that the offender may be summarily tried, convicted, and punished without indictment by a grand jury and without trial by a petit jury. It must, of course, be assumed that the punishment for such a petty and trivial offence will also be comparatively petty and trivial, otherwise it would violate another provision of the State constitution which prohibits cruel and unusual punishments."

The constitutional problem arising from the guarantee of jury trials is present to a less degree in the grant of summary jurisdiction in civil cases. In some States the constitutional provision is expressly limited to criminal cases. In those where it includes civil causes its interpretation has followed the historical manner given to the provision applicable to criminal jurisdiction. To increase summary jurisdiction without infringing upon the constitutional right to jury trial, statutes commonly provide that unless such trial is expressly demanded by the defendant at a certain stage of the proceedings the magistrate is empowered to proceed as if the case fell within his summary jurisdiction.

The extent to which magistrates exercise summary jurisdiction varies with the statutes of each State. In criminal matters it is exercised only in the broad class of petty offences. The furthest extent to which this classification has been enlarged concerned the breach of a State liquor law where the penalty prescribed amounted to a fine of $500 and six months' imprisonment. No summary jurisdiction has as yet been conferred upon the judicial officials of the Federal Government. Federal crimes are limited in character and of such a grave nature as would traditionally call for the benefit of a jury trial. The recent prohibition amendment to the United States Constitution and the legislation thereunder punishing the manufacture, sale and transportation of intoxicating liquor has, however, thrust upon Federal courts a large amount of trivial criminal business and brought to the forefront the desirability of establishing some system for Federal summary jurisdiction. In civil matters magistrates exercise a large summary jurisdiction. The abatement of nuisances, the collection of taxes, the enforcement of liens, actions upon official bonds, *quo warranto* proceedings, the enforcement of awards, bastardy proceedings, are examples of classes of cases commonly entrusted to single magistrates. In ordinary civil actions upon contracts, promissory notes, torts and the like, summary jurisdiction is conferred provided that the claim does not exceed a certain pecuniary limit. Actions involving title to real property are generally excluded from grants of summary jurisdiction.

The procedure in summary jurisdiction matters is more informal than otherwise. Matters of form are largely dispensed with and great liberality with respect to the proceedings is exercised. Actions are commenced by summons which contains a short statement of the cause of action. No formal pleadings are necessary and in many cases the pleadings are oral, the magistrate's entry showing their substance. Defences are also pleaded orally. Many States, however, require the plaintiff to set out his cause of action in a bill of particulars and require the defendant to file a formal answer. The admission of evidence is governed by general common law principles though less exactness in their application is required. Judgments may be sued upon or executed in the same fashion as other judgments of superior courts. Dockets are required to be kept, upon which a record of the proceedings must be entered. Review of the proceedings is generally accorded by statute by appeal or writ of error within certain limitations as to the amount involved. The review is limited to those issues which were presented to the single magistrate and to the jurisdiction of that magistrate. Provisional remedies of arrest and attachment are also generally conceded to magistrates invested with summary jurisdiction.

(J. M. La.)

SUMMER SCHOOLS. Courses of instruction given at educational centres during the summer vacation. These specialized courses are largely attended by those wishing to increase their knowledge of special subjects, *e.g.*, teaching, music, drama, handwork, etc. Among the earliest summer schools must be mentioned the one carried on at Naas in Sweden and attended by teachers who desired to learn Sloyd as a step to handwork.

GREAT BRITAIN

The progress of handwork in English schools soon led to the establishment of summer courses under the direction of the Educational Handwork Association. In a less specialized field, the University Extension Movement had established summer meetings held alternatively at Oxford and Cambridge. These were attended by many teachers, although designed primarily to meet the needs of students in University Extension classes. The Science and Art Department, now merged in the Board of Education, provided holiday courses for selected teachers in various branches of science; and certain French universities organized summer classes in French language and literature which attracted teachers of modern languages.

Development.—The movement developed rapidly, and the provision of summer schools and vacation courses became extremely liberal, although it did not cover the whole ground. The courses offered present great variety alike in their curriculum, direction, and organization. Some are specialized in character, as, for example, a course dealing with the teaching of Latin; while others aim at supplying teachers in secondary and elementary schools with general information concerning new developments in school organization and method. The Board of Education continues to provide courses for selected teachers who receive a grant and attend lectures and demonstrations in such subjects as rural education, modern languages, science, geography and history. Music also receives considerable attention.

Features of Summer Courses.—A well-arranged course provides opportunities for social intercourse and for free discussion. Some of the most successful courses are held in university towns, where the students live for a time in a college and enjoy the amenities of the playing fields and the river. A very popular course, which is held in London under private auspices, aims at giving to teachers from the provinces and from abroad an intimate knowledge of the chief attractions of London and of hearing addresses from eminent men and women.

Courses for Teachers.—It is now generally accepted that teachers should be encouraged in every possible way to refresh their minds and revivify their work by attending schools and classes, whether in the summer or at some other time. Probably the most complete example of such classes in term time is that of classes arranged by the London County Council, which extend from single lectures or sets of lectures to courses of a year or more, leading to the acquisition of a university certificate, diploma or other degree, such as the geography and history courses at University College, London, and the certificate and diploma course at the French Institute. There is a growing feeling, however, that for many teachers the best refreshment is a complete holiday, and some of the courses arranged are therefore held outside the holiday period, the teachers being granted leave of absence. This plan is held to be justified on the ground that the work of the teacher gains in efficiency and therefore brings a return in public service. In England the practice of giving a "Sabbatical year" has not been widely adopted, although in some universities certain professors or lecturers have been granted leave of absence for a term or more to enable them to pursue definite lines of research. It is increasingly held, however, that some arrangement should be made by which teachers may have the opportunity of bringing their studies up to date. The report of the departmental committee on the training of teachers recommended that teachers of experience should be granted leave of absence in order that they might attend university courses on education, and thereby equip themselves for posts of responsibility in the educational service. (F. Ro.)

THE UNITED STATES

In the United States since the '70s, and more especially since about 1905, there has been a widespread offering of instruction by universities and colleges during the summer months. The universities have been desirous of aiding their students who wish to qualify for degrees as rapidly as possible and especially by continuing during the summer regular study "for credit," and enabling teachers to attend the summer sessions for additional training. Furthermore, quite apart from any question of academic recognition for summer work, there is a nation-wide interest in intellectual improvement. (*See* Adult Education.)

The interest in study as a recreation rather than for credit was satisfied by the earliest programme of summer study, and in 1869 at Harvard university a course in geology was arranged by Dean Shaler. Similar field work in his own subject was offered by Prof. Louis Agassiz of Harvard university in a zoological laboratory established on Penikese island in Buzzards Bay, Mass., in 1873. Provision for lectures on special subjects was made in other places. In 1878 at Martha's Vineyard the first six weeks' course in education for public school teachers was offered. In 1880, Prof. C. O. Whitman established the Marine Biological Laboratory at Woods Hole as a centre for researchers in biology.

Another early form of summer study which has greatly influenced the growth of summer schools was the Chautauqua summer assembly (*see* Lyceums and Chautauquas) which began with a ten-day session in 1874, enlisting the co-operation of many notable scholars and educators. One of these, William Rainey Harper, who conducted courses in Hebrew and in Old Testament literature, became president of the University of Chicago in 1891. Moved by the success of his Chautauqua experience he provided for a university calendar which included four quarters of which the summer one was like each of the others, an integral part of the university year. Shortly thereafter other universities provided for summer sessions, many of them offering courses which could be counted toward the baccalaureate degree: 1893, University of Nebraska; 1894, University of Michigan; 1896, University of Illinois; 1897, Clark university, Cornell university, Ohio university; 1899, University of California; 1900, Columbia university.

In 1911, the U.S. Bureau of Education reported the existence of 497 summer schools of which 280 granted credit toward degrees. This list, however, included normal schools and other teacher-training institutions. Of 397 institutions which reported to the American Council on Education in 1926, 254 had summer sessions.

A few institutions, because the summer school is an integral part of the university calendar, offer courses in all departments. In 1926 at the University of Wisconsin 149 departments offered 438 courses; at Iowa State college 51 departments offered courses. The number of courses offered is even more significant than the number of departments; certain departments—notably English and Education—increasing their courses through the addition of temporary instructors from other institutions and even enlisting editors, school superintendents and other experts to conduct courses in their special fields. In 1925 Columbia offered 854 courses; Iowa 600; Wisconsin 438; West Virginia 365; Louisiana State 378; Kansas State Agricultural college 372; Massachusetts Institute of Technology 335; University of Indiana 319. Nine others offered more than 200 courses each, and 31 offered more than 100 courses each.

The length of the summer session varies. Institutions organizing their calendar on the four-quarter system usually offer a summer quarter between 11 and 12 weeks in length. The session at Columbia is six weeks in length. Harvard university offers a five weeks' session.

Enrolment in summer sessions reported for 1925 shows Columbia to be by far the largest with 31,756 students in its 854 courses during six weeks of the summer of 1925. The University of Chicago during its regular summer quarter in 1925 enrolled 6,577 students. In 1926 during a similar period of two six-week terms the University of Minnesota enrolled 6,566. The University of Wisconsin in 1925 in its two terms, one of nine and one of five weeks, enrolled 5,015. The University of California in 1926 enrolled 4,976. Pennsylvania State college, the University of Iowa, the University of Texas, the University of Michigan and the College of the City of New York enrolled more than 3,000 each.

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(D. A. R.)

SUMMER TIME: *see* Daylight Saving.

SUMMIT, a village of Cook county, Illinois, U.S.A., on the Illinois and Michigan canal, 11 m. S.W. of the Chicago "loop." It is served by the Chicago and Alton and electric railways. Pop. 4,019 in 1920 (38% foreign-born white) and the local school census indicated over 8,000 in 1928.

SUMMIT, a city of Union county, New Jersey, U.S.A., 21 m. W. of New York city, on the crest of a ridge called Second mountain; served by the Lackawanna and the Rahway Valley railways. Pop. (1920) 10,174 (21% foreign-born white and 5% negroes). It is a residential suburb, with two private schools and little manufacturing. Summit was incorporated as a township in 1869 and was chartered as a city in 1899.

SUMMIT HILL, an anthracite-mining borough of Carbon county, Pennsylvania, U.S.A., served by the Lehigh and New England railroad, and in summer by a switch-back railway connecting it with Mauch Chunk, 9 m. N.E. Pop. (1920) 5,499 (21% foreign-born white). It has a famous burning mine, which has been on fire since 1832. The Mauch Chunk Switch-Back railway, now used for tourist traffic, was built in 1827 by the Lehigh Coal and Navigation Company for transporting coal, and boasts that it is the oldest railroad in the United States.

SUMMONS: *see* Practice and Procedure.

SUMNER, CHARLES (1811–1874), American statesman, was born in Boston, Mass., on Jan. 6, 1811. He graduated in 1830 at Harvard college, and in 1834 at the Harvard law school. At the age of 23 he was admitted to the bar. The three years (1837–40) spent in Europe were years of fruitful study and experience.

In his 30th year Sumner returned to Boston, to settle down to the practice of law. But gradually he devoted less of his time to practice and more to lecturing in the Harvard law school.

Sumner co-operated effectively with Horace Mann for the improvement of the system of public education in Massachusetts. Prison reform and peace were other causes to which he gave support. He took an active part in the organizing of the Free Soil Party, in revolt at the Whigs' nomination of a slave-holding Southerner for the presidency; and in 1848 was defeated as a candidate for the National House of Representatives. In 1851 control of the Massachusetts legislature was secured by the Democrats in coalition with the Free Soilers, but the Democrats refused to vote for Sumner, the Free Soilers' choice for U.S. senator, and urged the selection of some less radical candidate. A deadlock of more than three months ensued, finally resulting in the election (April 24) of Sumner by a majority of a single vote.

In the closing hours of his first session, in spite of strenuous efforts to prevent it, Sumner delivered (Aug. 26, 1852) a speech, "Freedom national; Slavery sectional," which marked a new era in American history. The conventions of both the great parties had just affirmed the finality of every provision of the compromise of 1850. In 1856, at the very time when "border ruffians" were drawing their lines closer about the town of Lawrence, Kan., Sumner in the Senate (May 19–20) laid bare the "Crime against Kansas." He denounced the Kansas-Nebraska bill as in every respect a swindle, and held its authors, Stephen A. Douglas and Andrew P. Butler, up to the scorn of the world. Two days later Preston S. Brooks (1819–57), a Congressman from South Carolina, confronted Sumner in the Senate chamber, denounced his speech as a libel upon his State and upon Butler, his relative, and struck Sumner till he fell unconscious to the floor. This assault cost Sumner three years of heroic struggle to regain his health—years during which Massachusetts re-elected him, in the belief that in the Senate chamber his vacant chair was the most eloquent pleader for free speech and resistance to slavery.

After the withdrawal of the Southern senators, Sumner was made chairman of the committee on foreign relations (March 8, 1861), a position for which he was pre-eminently fitted by his years of intimate acquaintance with European politics and statesmen. While the war was in progress his letters from Cobden and Bright, from Gladstone and the duke of Argyll, at Lincoln's request were read by Sumner to the Cabinet, and formed a chief source of light as to political thought in England. In the turmoil over the "Trent Affair," it was Sumner's word that convinced Lincoln that Mason and Slidell must be given up, and that reconciled the public to that inevitable step.

Throughout the war Sumner had constituted himself the special champion of the negro, being the most vigorous advocate of emancipation, of enlisting the blacks in the Union army, and of the establishment of the Freedmen's bureau. The credit or the blame for imposing equal suffrage rights for negroes upon the Southern States as a condition of reconstruction must rest with him.

In the impeachment proceedings against Johnson, Sumner was one of the President's most implacable assailants. Sumner's opposition to Grant's pet scheme for the annexation of San Domingo (1870), brought upon him the President's bitter resentment. Sumner had always prized highly his popularity in England, but he unhesitatingly sacrificed it in taking his stand as to the adjustment of claims against England for breaches of neutrality.

Under pressure from the President, on the ground that Sumner was no longer on speaking terms with the secretary of State, he was deposed on March 10, 1871, from the chairmanship of the committee on foreign relations. Whether the chief cause of this humiliation was Grant's vindictiveness at Sumner's opposition to his San Domingo project or a genuine fear that the impossible demands which he insisted should be made upon England, would wreck the prospect of an adjustment with that country, cannot be determined. Sumner's last years were further saddened by the misconstruction put upon one of his most magnanimous acts. In 1872 he introduced in the Senate a resolution providing that the names of battles with fellow-citizens should not be placed on the regimental colours of the United States. The Massachusetts legislature denounced this battle-flag resolution as "an insult to the loyal soldiery of the nation" and as "meeting the unqualified condemnation of the people of the Commonwealth." For more than a year all efforts—headed by the poet Whittier—to rescind that censure were without avail, but early in 1874 it was annulled. On March 10 against the advice of his physician, Sumner went to the Senate—it was the day on which his colleague was to present the rescinding resolution. That night he was stricken with an acute attack of *angina pectoris,* and on the following day he died.

"The slave of principles, I call no party master," was the proud avowal with which Sumner began his service in the Senate. His was the first clear programme proposed in Congress for the reform of the civil service. It was his dauntless courage in denouncing compromise, in demanding the repeal of the Fugitive Slave Act, and in insisting upon emancipation, that made him a great propelling force in the struggle that put an end to slavery.

See Sumner's *Works* (Boston, 1870–83), and Edward L. Pierce's *Memoir and Letters of Charles Sumner* (Boston, 1877–93). Briefer biographies have been written by Anna L. Dawes (New York, 1892); Moorfield Storey (Boston, 1900); and George H. Haynes (Philadelphia, 1909). *See* also *Charles Sumner, His Complete Works* with an introduction by G. F. Hoar (Boston, 1910); W. G. Slotwell, *Life of Charles Sumner* (1910); A. N. Gimke, *Charles Sumner Centenary.*

SUMNER, EDWIN VOSE (1797–1863), American soldier, was born at Boston (Mass.), and entered the U.S. Army in 1819. He took part in the Black Hawk war and served many years on the frontier. For distinguished action in the Mexican war, he received the brevet rank of colonel. From 1851–53 he served as military governor of New Mexico. At the outbreak of the Civil War (1861) Sumner had just been promoted to the rank of brigadier-general, and was sent to relieve Sidney Johnston in command of the department of the Pacific. The following year, he was recalled to command the 1st Corps of the Army of the Potomac. At the battle of Fredericksburg he commanded the right grand division under Burnside. Upon Hooker's appointment to chief command of the eastern army, Sumner was assigned to command the department of Missouri, and died suddenly, on March 21, 1863, while on his way thither.

SUMNER, WILLIAM GRAHAM (1840–1910), American economist, was born, of English parentage, in Paterson (N.J.), on Oct. 30, 1840. He was brought up in Hartford (Conn.), graduated at Yale college in 1863, studied French and Hebrew in Geneva in 1863–64 and divinity and history at Göttingen in 1864–66, and in 1866–69 was a tutor at Yale.

He was ordained a priest of the Protestant Episcopal Church in 1869, was assistant rector of Calvary Church, New York city, and in 1870–72 was rector of the Church of the Redeemer, Morristown (N.J.). From 1872 to 1909, when he became professor emeritus, he was professor of political and social science at Yale. In 1909 he was president of the American Sociological Society. He died at Englewood (N.J.), on April 12, 1910.

SUMPTUARY LAWS, those laws intended to limit or regulate the private expenditure of the citizens of a community. They have existed both in ancient and in modern States. In Greece, it was amongst the Dorian races, whose temper was austere and rigid, that they most prevailed. All the inhabitants of Laconia were forbidden to attend drinking entertainments, nor could a Lacedaemonian possess a house or furniture which was the work of more elaborate implements than the axe and saw.

At Rome the system of sumptuary edicts and enactments was largely developed, whilst the objects of such legislation were concurrently sought to be attained through the exercise of the censorial power. The code of the Twelve Tables (*q.v.*) has provisions limiting the expenditure on funerals. The most important sumptuary laws of the Roman commonwealth were the following:—

(1) The Oppian law, 215 B.C., provided that no woman should possess more than ½ oz. of gold, or wear a dress of different colours, or ride in a carriage in the city or within a mile of it except on occasions of public religious ceremonies. This law, which had been partly dictated by the financial necessities of the conflict with Hannibal, was repealed 20 years later, against the advice of Cato. (2) The Orchian law, 187 B.C., limited the number of guests at entertainments. (3) The Fannian law, 161 B.C., limited the sums to be spent on entertainments; it provided amongst other things that no fowl should be served but a single hen, and that not fattened. (4) The Didian law, 143 B.C., extended to the whole of Italy the provisions of the Fannian law, and made the guests as well as the givers of entertainments at which the law was violated liable to the penalties. After a considerable interval, Sulla anew directed legislation against the luxury of the table and also limited the cost of funerals and of sepulchral monuments. Julius Caesar, in the capacity of *praefectus moribus,* after the African war re-enacted some of the sumptuary laws which had fallen into neglect. Suetonius tells us that Caesar had officers stationed in the market-places to seize such provisions as were forbidden by law, and sent lictors and soldiers to feasts to remove all illegal eatables (*Jul.* 43). Augustus fixed anew the expense to be incurred in entertainments. Tiberius also sought to check inordinate expense on banquets.

In modern times the first important sumptuary legislation was: in Italy that of Frederick II.; in Aragon that of James I. in 1234; in France that of Philip IV.; in England that of Edward II. and Edward III. In 1294 Philip IV. of France made provisions as to the dress and the table expenditures of the several orders of men in his kingdom. Charles V. forbade the use of long-pointed shoes, a fashion against which popes and councils had protested in vain. Under later kings the use of gold and silver embroidery, silk stuffs and fine linen wares was restricted. In England we hear much from the writers of the 14th century of the extravagance of dress at that period. In the reign of Edward II. a proclamation had been issued against the "outrageous and excessive multitude of meats and dishes which the great men of the kingdom had used, and still used, in their castles." In the year 1336 Edward III. attempted also to legislate against luxurious living, and in 1363, at the same time when costumes were regulated, it was enacted that the servants of gentlemen, merchants and artificers should have only one meal of flesh or fish in the day, and that their other food should consist of milk, butter and cheese. An act of 1444 had regulated the clothing, when it formed part of the wages, of servants employed in husbandry; a bailiff or overseer was to have an allowance of 5s. a year for his clothing, a hind or principal servant 4s., and an ordinary servant 3s. 4d.—sums equivalent respectively to 50s., 40s. and 33s. 4d. of modern money. Another statute was passed in the year 1462 (3 Edw. IV. c. 5) for the regulation of the dress of persons of all ranks. Similar acts to those above mentioned were passed in Scotland also. In 1433 (*temp.* James I.), by an act of a parliament which sat at Perth, the manner of living of all orders in Scotland was prescribed, and in particular the use of pies and baked meats, which had been only lately introduced into the country, was forbidden to all under the rank of baron. In 1457 (*temp.* James II.) an act was passed against "sumptuous cleithing." The Scottish sumptuary law of 1621 was the last of the kind in Great Britain.

Bibliography.—The *loci classici* on Roman sumptuary laws are Gellius, *Noctes atticae,* ii. 24, and Macrobius, *Saturn.* iii. 17. For Great Britain *see* Henry of Huntingdon, *Historia Anglorum* ("Rolls Series," ed. T. Arnold, 1879); W. Denton, *England in the Fifteenth Century* (1888); W. J. Ashley, *Introduction to English Economic History and Theory* (1893); W. Cunningham, *Growth of English Industry and Commerce in Modern Times* (1921) and *Growth of English Industry and Commerce during the Middle Ages* (1922).

SUMTER, THOMAS (1734–1832), American soldier, was born in Hanover county, Va., on July 14, 1736. He served in the French and Indian War, and was present at Braddock's defeat in 1755. Later he removed to South Carolina. After the fall of Charleston in 1780, when his State was ravaged by the British, he escaped to North Carolina, where he took the field as brig.-general at the head of a body of light horse and soon became one of the most active and able leaders of the South. His vigilance and bravery earned for him the sobriquet of "Gamecock." After successes over the British at Catawba and at Hanging Rock (Lancaster county), he was surprised and defeated by the British general, Tarleton, at Fishing Creek (Chester county). Raising a new force, he defeated Mayor Wemys at Fishdam (Union county) and repulsed Tarleton's attack at Blackstock (Union county) in Nov. 1780. At the time of his death at South Mount, S.C., on June 1, 1832, he was the last surviving general officer of the War of Independence.

See Edward McCrady, *The History of South Carolina in the Revolution* (1901–02); H. A. M. Smith, "General Thomas Sumter" in *Magazine of History* (vol. 8, 1908, and vol. 9, 1909).

SUMTER, a city of South Carolina, U.S.A., the county seat of Sumter county; 45 m. E.S.E., of Columbia, on Federal highway 76. It is served by the Atlantic Coast Line, the Seaboard Air Line and the Southern railways. Pop. 9,508 in 1920 (41% negroes); estimated locally at about 11,000 in 1928. Sumter was founded in 1800, named for General Thomas Sumter, and chartered as a city in 1887. It was the first city to adopt (1912) the commission-manager form of government.

SUMY, a town of the Ukrainian S.S.R., in 50° 56′ N., 34° 47′ E., on the Isel river, a tributary of the Psiol, and on the railway. It is a grain and beet-collecting centre and has an elevator. Its industries include the making of agricultural machinery, sugar refining, woollen, cloth and leather manufacture, and saw-milling. Pop. (1926) 39,782.

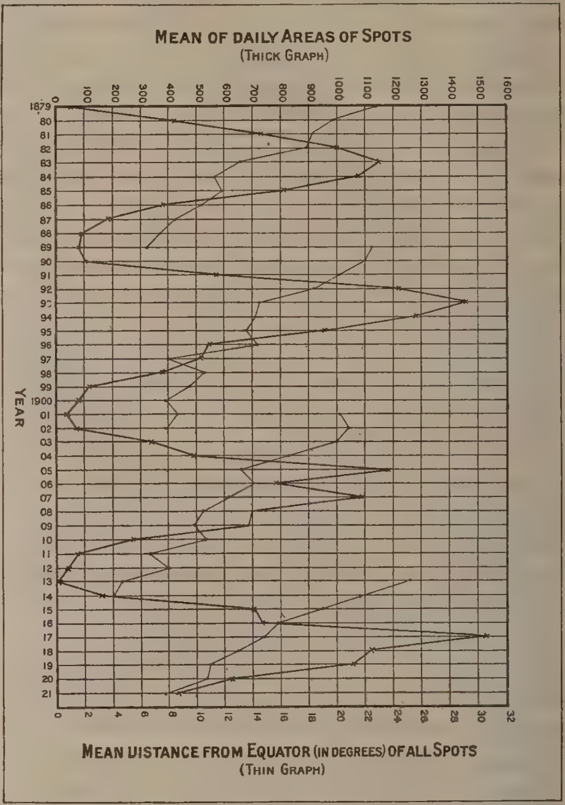
SUN. The sun is apparently the largest and brightest, and actually almost the smallest and faintest, of naked-eye stars. The illusion, of course, arises from its comparative nearness—the next nearest star is, in fact, nearly 300,000 times as far away.

TELESCOPIC INVESTIGATION

General Characteristics.—The sun presents to the telescopic view a dazzling white circular disc, with a sharp edge, whose diameter subtends an angle of about half a degree. Slight but systematic variations of the angular diameter reveal the fact that the distance from the earth to the sun is not constant, and that the earth's orbit is an ellipse with the sun at one of the foci. Several methods have been employed to measure the various distances of the sun from the earth; it will suffice to describe one of them. Early in the 17th century Johann Kepler, by the method of trial and error, discovered rules from which an accurate plan of the solar system could be drawn, although the scale could not be given. It then became necessary only to measure at some instant the distance between any two of the bodies represented in the plan in order to fix the scale for the whole. A minor planet named Eros at certain times in its career comes within 14 million miles of the earth, and if its direction be then measured simultaneously from two places at a known distance apart on the earth the distance of the planet can be calculated from the angle between the directions. A scale is thus obtained from which the distance of the sun from the earth at any time follows immediately. The mean value throughout the year (from which the actual distance never departs much) is found to be about 92,900,000 miles. This is generally expressed by saying that the *solar parallax* is 8″.80 (*i.e.*, 8·80 seconds of arc), the solar parallax being the angle the earth's equatorial radius subtends at the distance of the sun.

The sun's linear diameter follows at once from this measurement and the observed angular diameter. It is approximately 864,000 miles—far transcending the powers of imagination, but small as stellar diameters go; the sun is, in fact, a *dwarf* star. Its mass is calculated from the force with which, according to Newton's law of gravitation, it attracts the earth, whose mass is separately determined (*see* EARTH). The result—2×10^{33}gms., *i.e.*, 2×10^{27} tons, or 332,000 times the mass of the earth—is about the average for stellar masses. Mass and diameter are sufficient data for the estimation of the mean density of the sun, viz.—1·41 times that of water. This figure, of course, affords no information about the density in any particular region or the rate of variation of density from the surface inwards.

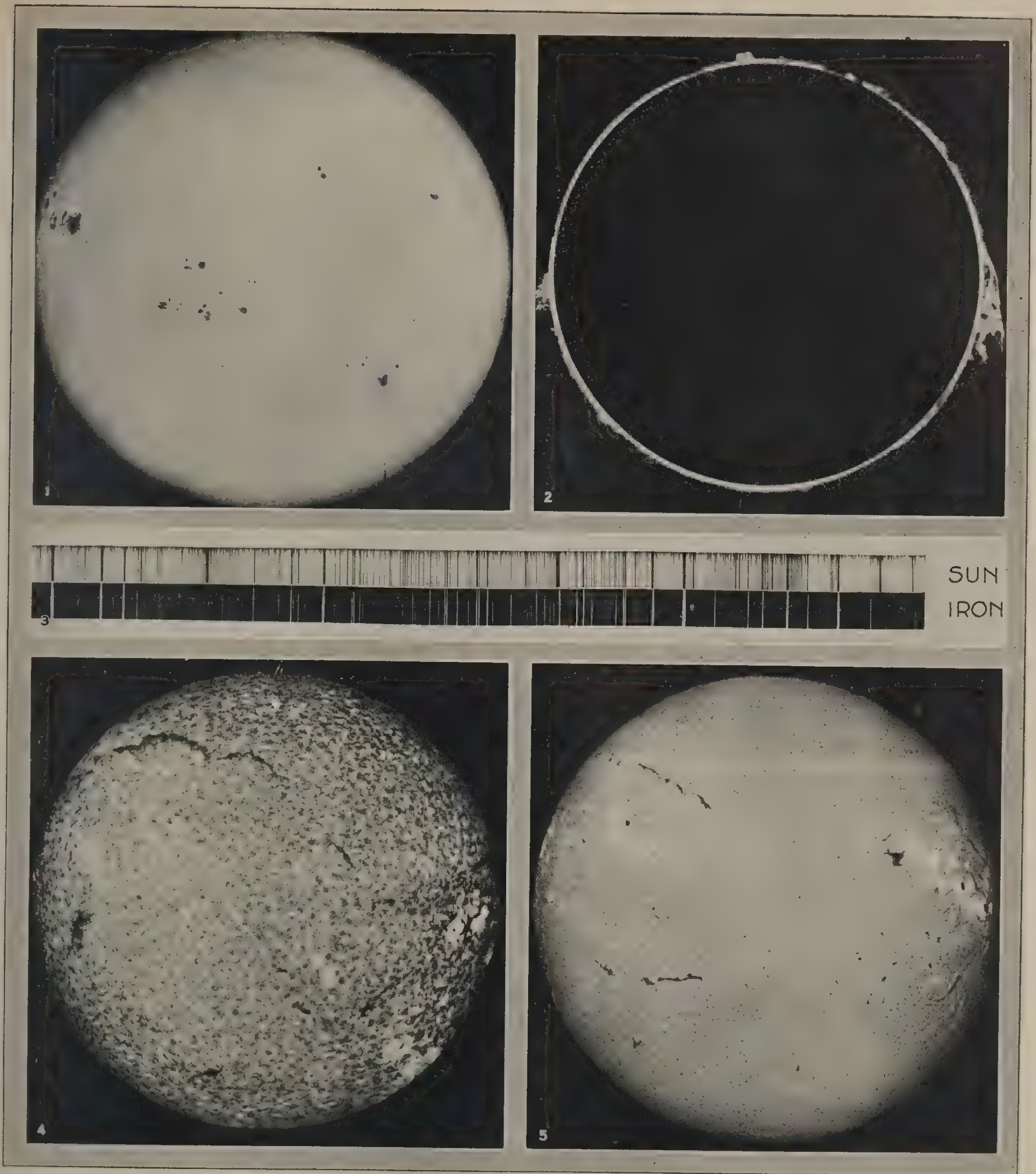
Close examination of the night sky over a prolonged period shows that around the constellation *Hercules* the stars appear, on the whole, to be getting farther apart, whereas, in the opposite direction, they appear to be gathering together. This is interpreted as an indication that the sun, with its attendant satellites, is moving towards a point in the former region.



GRAPH SHOWING SUNSPOT FREQUENCY AND LATITUDE

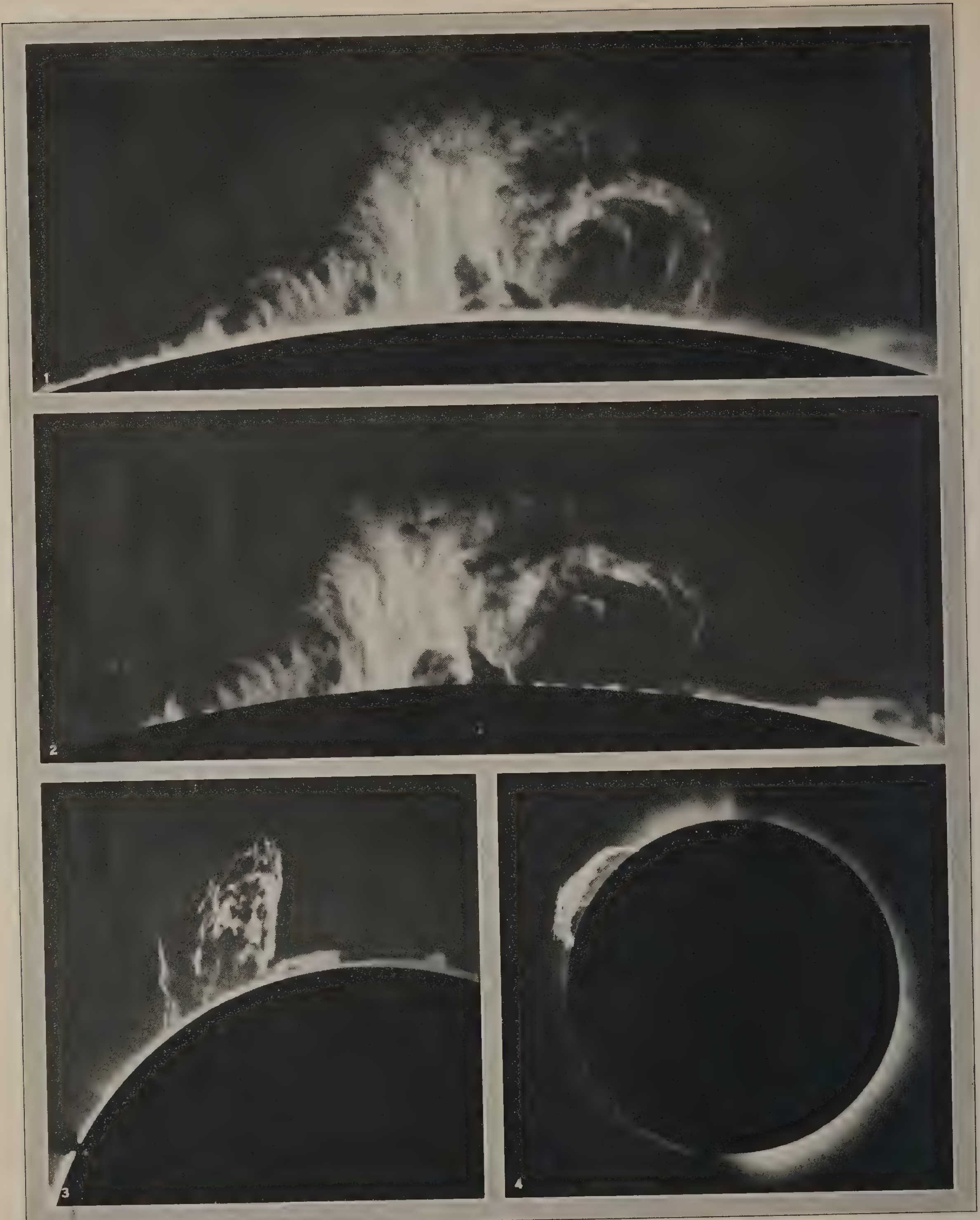
The scale on the left indicates the spotted area with a unit of one-millionth of the Sun's visible hemisphere. During a complete cycle—i.e., from one minimum to the next—the solar latitude at which the spots break out changes in the manner indicated by the thin lines. As the cycle progresses there is a fairly steady approach to the equator, which, however, is never quite reached

Surface Features.—These general characteristics must now be supplemented by more intimate knowledge. When the surface of the sun is carefully examined it is found to present a grained structure; the appearance has been likened to that of rice grains and even willow leaves. The brightness of the disc in other respects also is not uniform; the region near the circumference, or *limb*, is appreciably less bright than the centre of the disc—a fact which appears most obviously in photographs. More striking violations of uniformity are caused by *sunspots*, which are frequently visible, sometimes even to the unaided eye. A sunspot generally consists of a central, apparently black, *umbra*, surrounded by a less dark *penumbra* (*see* Plate). It should be said at once that each of these regions is in reality exceedingly bright, and appears dark only by contrast with the still brighter solar disc. Spots often cluster together in groups, but perhaps even more significant is their characteristic of associating in pairs. They move steadily across the face of the sun in such a manner as to leave no doubt that the motion is due to a rotation of the sun about an axis. The sun, therefore, like the earth, is approximately a sphere, and its bright visible surface is accordingly known as the *photosphere*. A remarkable feature of the sun's rotation is that it does not take place at the same rate in all latitudes; *i.e.*, the sun does not rotate as a rigid body; the nearer to the equator the faster is the rotation. Sunspots very rarely appear outside two zones of the photosphere, bounded by circles



PHOTOGRAPHIC STUDIES OF THE SUN

1. The photosphere of the sun, showing an unusually large number of spots, faculae, and darkening at the limb (Rutherfurd)
2. Photograph taken in calcium light, the image of the photosphere having been artificially covered. Shows Chromosphere and Prominences (Evershed)
3. Comparison of solar spectrum with laboratory spectrum of iron (violet region). Presence of iron in the atmosphere of the sun is indicated by coincidence in positions of lines (Imperial College)
4. Spectroheliogram (photograph of sun made by monochromatic light) showing distribution of high-level calcium in the solar atmosphere (Deslandres)
5. Spectroheliogram showing distribution of hydrogen in the solar atmosphere (Deslandres)



BY COURTESY OF (1, 2) YERKES OBSERVATORY, (3) J. EVERSHED, (4) THE ASTRONOMER ROYAL

STUDIES OF SOLAR PROMINENCES

1. Solar prominence observed at Yerkes Observatory, Wisconsin, on October 10, 1910. 2. Another observation of the same prominence made on the same day, also at Yerkes Observatory. 3. Prominences of the sun observed May 26, 1916, at Srinagar, Kashmir, India. 4. The inner corona and prominence photographed at a total solar eclipse, May 29, 1919, observed at Sobral, Brazil. The red flame rose from a height of 130,000 miles to more than 500,000 miles above the surface of the sun in less than seven hours

of latitude about 5° and 40° N. and S. respectively. Within each of these regions R. C. Carrington found, as the result of a large number of observations, that the mean rotation period was 25·38 days, while near the equator the period was only 24·5 days.

Individual sunspots appear spasmodically, remain visible for periods varying from a few days to several months, and then disappear. This apparently capricious behaviour, however, contributes to a striking regularity which is revealed only when large numbers of spots and a great length of time are considered. Samuel Heinrich Schwabe, in 1843, found that if the number of spots appearing per year (or the total area covered by them) were plotted against time, as in the diagram, a markedly periodic relation was shown, the number reaching a maximum approximately every 11⅓ years. It was afterwards discovered that a similar regularity characterized the location of the spots. At a time of minimum those of a new cycle began to appear in the higher latitudes, both north and south, of their appointed belts, and as the cycle progressed the place of outbreak gradually moved towards the equator. The dotted lines in the figure illustrate this.

Sunspots are often accompanied by exceptionally bright areas on the photosphere, known as *faculae*. They are most easily seen near the limb, where the brightness of the photospheric background is diminished.

On the comparatively rare occasions on which the sun is observed in eclipse, red flames are seen apparently rising from various points on the circumference of the dark moon. They belong in reality to the sun, and are known as *prominences*. They are not seen through the telescope alone in full daylight, because the intense photospheric light, diffused by our atmosphere as by a screen of ground glass, acts as a veil through which prominences and stars alike are invisible as individual objects although their radiation contributes to the sum total of the light of day. Prominences assume various shapes and sizes, sometimes reaching heights of hundreds of thousands of miles. On such occasions they can easily be seen by the naked eye during eclipses.

The most striking solar eclipse phenomenon, however, is the *corona*, a pearly white halo enveloping the sun and extending in more or less definite rays or streamers to a distance of several of its radii. The brilliance of the corona diminishes fairly rapidly with distance from the sun's limb, and although its total brightness is not far short of that of full moon, it is still less able than the prominences to maintain the individuality of its appearance in full daylight. No two aspects of the corona seen at different eclipses are identical, but here again the apparent arbitrariness is subject to conformity with a rather vague but unquestionable relation with the sunspot period. At sunspot maximum the corona appears to extend from the sun's limb to roughly the same distance all around. At sunspot minimum, on the other hand, the poles of the sun are marked by comparatively small tufts of light, while from the equatorial regions long streamers shoot out to great distances. There is also a not fully determined relation between the corona and prominences of certain types.

SPECTROSCOPIC INVESTIGATION

General Considerations.—The spectroscope is an instrument by means of which a beam of light is analysed into its constituent colours, or *wave-lengths*. The analysed radiation of a substance is called its *spectrum*, and the instrument is constructed to show each colour radiated as a thin vertical line; hence the term *spectrum line* is often used to denote a particular colour. When, in the laboratory, a substance is vaporised and made luminous, the light it emits, when analysed by the spectroscope, appears as a collection of isolated lines and is characteristic of the substance. On the other hand, a glowing solid, liquid, or gas under great pressure or of great depth, such as is found in the stars, radiates light of all wave-lengths (within rather ill-defined limits), appearing in the spectroscope as a continuous band of colour ranging from red to violet in the order of the colours of the rainbow. This is known as a *continuous* spectrum. Again, when a beam of light which, if analysed, would form a continuous spectrum, is allowed to pass through a less brightly glowing vapour which, acting alone, would give a line spectrum, and is then received by the spectroscope, the spectrum formed consists of a continuous background on which *dark* lines appear exactly in the positions of the bright lines which the interposed vapour would give by itself. This is called an *absorption* spectrum. The glowing vapour absorbs, from the light passing through it, precisely those colours which it can itself emit. Absorption lines are not absolutely dark. They contain the light emitted by the glowing vapour.

The Solar Spectrum.—The spectrum of the sun is an absorption spectrum. This gives us immediately a piece of knowledge which the telescope was powerless to reveal; namely, that the sun has an *atmosphere* of glowing vapours surrounding the brilliant photosphere. Further, it enables us to ascertain the elements which make up this atmosphere by simply comparing the positions or wave-lengths, of the absorption lines with those of the emission lines produced by known substances in the laboratory. In this manner the presence in the solar atmosphere of 66 elements known on the earth (including a few doubtful identifications) has been established. The remaining elements are mainly the heaviest ones, which might be expected to sink to the interior of the sun.

The existence of the solar atmosphere is revealed in another way during times of total eclipse. When the moon has just covered the last remnant of photosphere, the crescent of the atmosphere which still remains exposed for a few seconds gives a bright line spectrum, for the glowing vapours there have no bright photosphere behind them. On account of its evanescence, this spectrum is known as the *flash*, and it is, of course, essentially identical with the *Fraunhofer*, or absorption, spectrum in the positions of its lines. Careful observation at such times enables the heights reached by the various substances to be determined. It is found that the majority are confined to the lowest atmospheric layer, not more than 500 miles high, known as the *reversing layer*. Hydrogen, helium, and calcium charged with positive electricity (*ionised* calcium), however, reach much greater heights, extending up to 8,000 or 9,000 miles, and form a relatively thick upper stratum of the atmosphere, which is known as the *chromosphere* on account of the red colour imparted to it by the glowing hydrogen. Prominences are eruptions of hydrogen.

The portion of the solar atmosphere just outside the sun's limb might be expected to give a bright line spectrum in full daylight. It does not do so, however, because of the diffused photospheric light in the earth's atmosphere which masks the bright radiations. Pierre Jules César Janssen and Joseph Norman Lockyer, in 1868, independently succeeded in partially overcoming this difficulty. If the dispersion of the spectroscope (*i.e.*, its power of separating the colours) is increased, the intensity of the continuous spectrum at any one point is diminished, while the lines in a bright line spectrum are merely drawn farther apart without loss of brightness. Janssen and Lockyer found it possible so to weaken the diffused daylight that the bright lines of the chromosphere and prominences became visible.

When the spectroscope is directed towards the corona, it is found that a great deal of the coronal light yields the ordinary Fraunhofer spectrum and is therefore reflected sunlight. But there is also light which must originate in the corona itself, for it gives a spectrum of which part is continuous and part is composed of bright lines which have not yet been matched terrestrially. The name *coronium* has been given to a hypothetical element which has been held to radiate the lines, but it is now generally believed that coronium is a familiar element in disguise. Elements have a habit of changing their spectra when certain changes are made in the conditions of their radiation.

Spectra and Physical Conditions.—This change of spectrum with change of physical conditions is one of the most important phenomena of spectroscopy. We shall at this stage consider three of its aspects without inquiring into their theoretical foundations. They are, respectively, the effect on a line spectrum of temperature, a magnetic field, and motion of the source of light.

When a luminous compound body is gradually raised in temperature, changes of spectrum of two kinds take place successively. First, the spectrum of the compound gives place to the lines of the constituent elements as the compound becomes dissociated by heat; secondly, the earliest elementary lines to appear slowly fade out, while new lines come into view and are gradually strengthened. Spectrum lines may therefore be roughly classified into "high temperature" lines and "low temperature" lines. These observations have an important application when the spectra of the photosphere and a sunspot are compared. The spectrum of the spot contains evidence of compounds of which only the separated elements contribute to the photospheric spectrum, and, furthermore, the spot spectrum shows a strengthening of "low temperature" and weakening of "high temperature" lines when compared with the spectrum of the photosphere. The obvious conclusion is that the vapours over a sunspot have a lower temperature than the rest of the solar atmosphere.

A source of light placed in a magnetic field (*i.e.*, a region such as the neighbourhood of the poles of a magnet, in which a freely suspended compass needle is constrained to lie in a definite direction) has each of its spectrum lines split into a number of component lines, lying side by side. Unless the field is a very strong one, the components are too close together to be seen as distinct individuals and the lines merely appear to be broadened. By means of special appliances, however, the existence of the separate components can be detected. In 1908 George Ellery Hale, using such appliances, found that the lines in the spectrum of a sunspot were of just the composite character that would result from the existence of a magnetic field in the spot in a direction perpendicular to the sun's surface.

Further observation showed that all sunspots are magnets, some presenting a north, and others a south pole to the surrounding space. In each pair of spots, the leader and the follower in the journey round the sun's axis had opposite polarities. Indeed, many apparently single spots were found by this magnetic criterion to have invisible companions. Moreover, there was a reversal of polarity in the southern solar hemisphere as compared with the northern; thus, if the leader of a pair were a N-pole in the northern hemisphere, it would be a S-pole in the southern hemisphere, and vice versa and, with few exceptions, this order would characterise all spots from one minimum to the next of a sunspot sphere, and vice versa, and, with few exceptions, this order would be reversed, so that the approximate period of a *complete* set of sunspot phenomena turned out to be, not 11 but 22 years.

More refined investigations of the same kind have shown that the sun as a whole is a magnet, just as the earth is. Its field, however, is much weaker than that of a spot, being only 50 gausses at its strongest observable region (the base of the reversing layer) as compared with about 4,000 gausses in large spots. (The maximum value of the earth's field is roughly 0·5 gauss.)

The third of the effects mentioned above—that of motion of the source of light, or *Doppler effect*, as it is called—has had many and various applications. When the distance between an observer and a source of light is decreasing the wave-length of every line emitted is lessened by an amount proportional to the wave-length itself and to the rate of approach. When the distance is increasing the wave-length is augmented in a similar manner. This shows itself by a displacement of the spectrum lines compared with their normal positions, and the amount and direction of the displacement indicate the velocity of approach or recession.

This effect has been used to measure the speed of the sun's motion among the stars. The displacement of spectrum lines, when properly analysed, shows that the solar system is moving at a speed of about 12 miles per second among the stars.

Another application of the Doppler effect to the sun is the verification of the speed of rotation by observing the rates of approach of the east limb and recession of the west limb. The values obtained agree very well with those indicated by the spots, and the observations can be extended beyond the belts to which the spots are confined. The same spectra can be used for a further purpose; namely, to determine what lines in the solar spectrum are produced by absorption in the *earth's* atmosphere. Our atmosphere, though not luminous, is able, in great thickness, to absorb certain lines (known as *telluric* lines) proper to its constituents, which are mixed with the true solar lines in the ordinary Fraunhofer spectrum. Such lines, however, occupy identical positions in the spectra of the two limbs and are therefore readily distinguished from the displaced solar lines.

One of the most difficult and important applications of the Doppler effect is to the detection of atmospheric currents in the sun itself. Solar storms not infrequently occur, of incomparably greater fury than the hurricanes and tornadoes of the earth, and the violent motions of the solar gases are revealed by distortions and displacements of the spectrum lines. Eruptive prominences are often the results of such storms. But there are more systematic movements also which have been brought to light in the same way, and of these perhaps the most interesting are the movements occurring near sunspots. The researches of John Evershed and Charles Edward St. John have shown that in the lower atmospheric levels gases move upwards and outwards from a spot, while in the higher levels the movements are inwards and downwards, as if a spot were a sort of whirlpool into which the high level gases are drawn. Indeed, there is definite evidence of high level circulatory movements round the axes of spots, which point strongly to the same conclusion.

SPECTROHELIOGRAPHIC INVESTIGATION

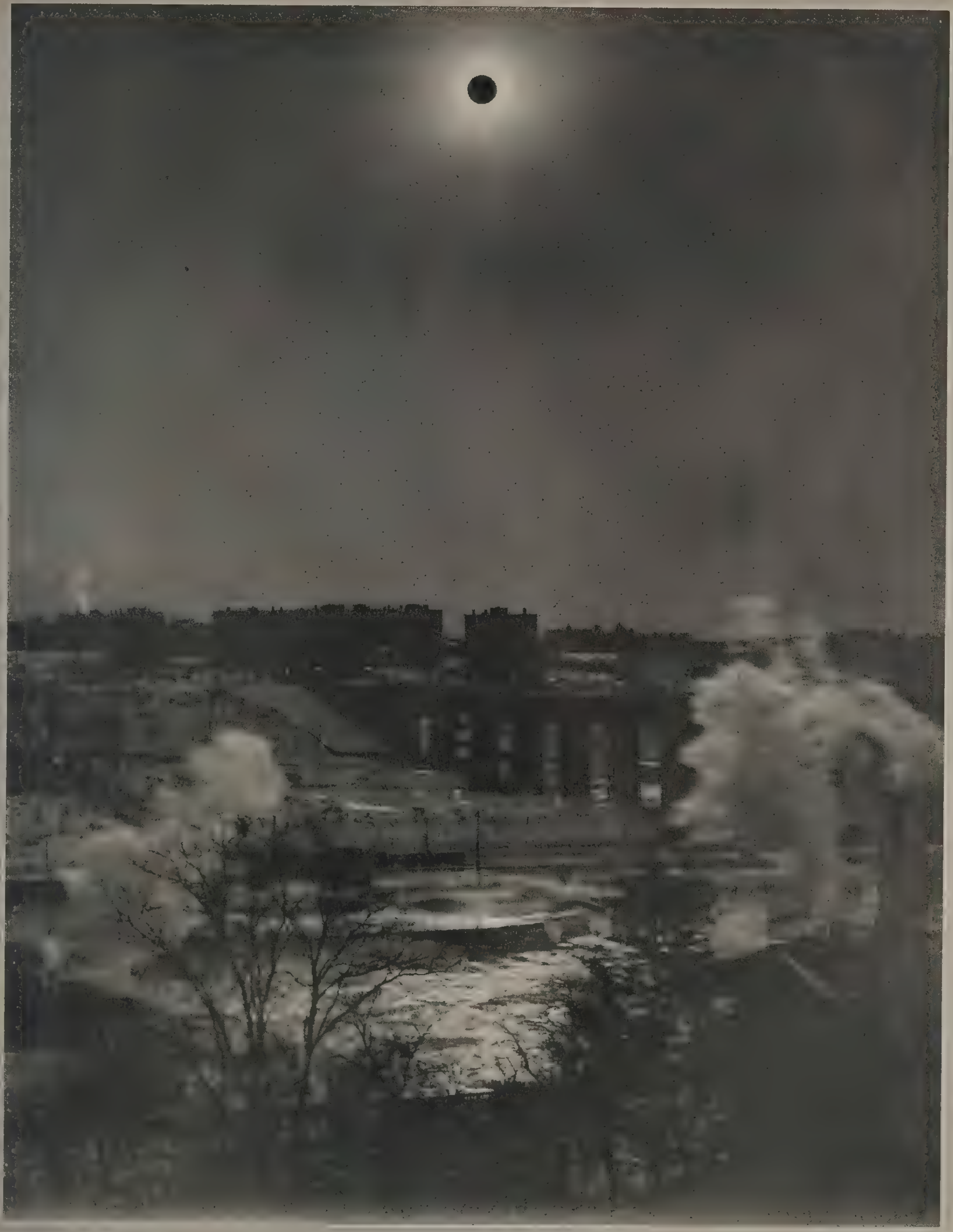
It has been said that the absorption lines in the solar spectrum contain light emitted by the glowing atmospheric gases; it is the *photospheric* light that is absorbed. The spectroheliograph is an instrument which gathers the light in a particular spectrum line and builds up a picture of the solar atmosphere in the light of that line, showing thereby how the substance producing the line is distributed in the solar atmosphere. The construction of the instrument is explained in the article SPECTROHELIOGRAPH. Some of the results which it produces are shown in Plate I., figs. 4 and 5.

It is clear that the evidence of the spectroscope and spectroheliograph points the way to a fairly complete knowledge of solar meteorology, from which it appears that the structure of the solar atmosphere is anything but uniform. Atoms congregate in clouds, or *flocculi*, particularly in the regions of sunspots, where they form the faculae observed through the telescope. Different substances are differently distributed, and the distribution of each substance is in a state of continual flux. The restless turmoil of the solar atmosphere stands in striking contrast to the comparative quietude and regularity of our own air. Yet even in the sun the motions are not wholly chaotic. On the large scale there is a consistency which points to a fundamental equilibrium. There is a fairly well defined limit to the ascent of each substance above the photosphere; we never find sodium so high as hydrogen, for example. Spectroheliograms are markedly characteristic in appearance for each substance; the coarse mottled structure of the calcium clouds is immediately distinguishable from the finer-grained layers of hydrogen, inconstant as each of them may be in detail. Once more there is a foundation of law and order to the superficial irresponsibility.

BOLOMETRIC INVESTIGATION

The Sun's Total Radiation.—One of the most important characteristics of the sun is its practice of radiating energy. Of the $3{\cdot}79\times10^{33}$ ergs which it discharges every second in the form of light, heat, and other ethereal vibrations, its attendant planets and their satellites receive about one part in 120 million, so that the significance of the process is cosmic rather than human. This enormous quantity of energy is sent forth regularly and ceaselessly, and goes no one knows whither or to what end. In seeking further knowledge of this fundamental process the first step to be taken is the measurement of the precise rate of radiation, for which purpose use has been made of various instruments bearing the generic name, *bolometer*.

Owing to natural limitations we can measure only the radiation received by a small area of the earth's surface, but, knowing the dimensions of the solar system, we can readily deduce the total amount. The general method is to convert the sun's radiation into heat, which can be accurately measured—making an allowance, which must be estimated from separate investigation, for absorption by the earth's atmosphere. The result is usually ex-



PHOTOGRAPH, D. FRANKLIN YEREX

TOTAL ECLIPSE OF THE SUN

The sun in total eclipse at 9 a.m. January 24, 1925, showing the long streamers of the Corona. From a photograph made from High Bridge Park, New York City, overlooking the Harlem River. Although the sun itself is hidden by the moon the Corona gives sufficient light for photographing the landscape

pressed as the *solar constant*, which is defined as the amount of energy which would fall perpendicularly per square centimetre per minute on a surface placed just outside the earth's atmosphere. The value of this constant, according to Charles Greeley Abbot, is about 1·94 calories (81 million ergs), but it is subject to slight variations which are related to the sunspot periodicity and possibly to other factors also. The rate of radiation appears to increase with the prevalence of sunspots, but further observations are required to determine the relation precisely.

The question of the source and maintenance of this ceaseless efflux of energy will be dealt with in a later section of this article. For the present we will limit ourselves to the consideration of the immediate use which can be made of the measurements in the light of ascertained physical principles. It is known that surfaces in a certain condition—known as that of a *perfect radiator* or *black body*—when they radiate energy, do so at a rate strictly proportional to the fourth power of their absolute temperature. There are strong theoretical reasons for believing that the sun radiates as a black body, and its absolute temperature is therefore calculable. Now the sun cannot be uniform in temperature throughout, so that it is necessary to consider what region has the temperature so determined. Since the greatest part of the radiation is in the form of visible light, this region must be the photosphere, and the photosphere is a relatively thin superficial layer at the base of the atmosphere. Thus the temperature measured from the total radiation is that of the outside of the sun. It is called the *effective* temperature, and has a value of 5,750 absolute centigrade degrees.

The Sun's Analysed Radiation.—The bolometer also provides the data for another method of estimating the sun's effective temperature. The radiation from a black body is distributed among the various wave-lengths in its continuous spectrum in a manner definitely related to the temperature of the body. Thus, if the bolometer be passed along the solar spectrum, and the amount of energy at each point in the continuous background thereby measured, the distribution of energy throughout the spectrum may be determined and the absolute temperature deduced. (Allowance must again be made for absorption by the earth's atmosphere, which is not uniform for all wave-lengths.) There are two partially independent methods of analysing the observations to obtain the temperature, which yield the respective values, 6,150° and 5,800°–6,300°. If the sun behaved exactly as a perfect radiator, these determinations would agree with one another and with the result obtained from the undissected radiation. The slight departures from agreement show that the sun is not quite in this condition, but is sufficiently near to it to enable us to say with confidence that the temperature near its surface is about 6,000°.

CONSTITUTION OF THE SUN

Modern View of the Sun's Constitution.—The chief facts concerning the sun which have so far been brought to light are now before us, and the question arises: What idea of the sun do they lead us to form? Following the independent investigations of Arthur Stanley Eddington and James Hopwood Jeans, we think of a vast concourse of broken fragments of atoms in violent movement, held together by gravitational attraction. An atom, it should be remarked, is now pictured as a sort of miniature solar system, in which a number of *electrons*, or units of negative electricity, revolve round a positive *nucleus*. The net amount of positive electricity in the nucleus is, in the normal atom, exactly equal to the sum of the negative charges constituting the revolving electrons, and one element is distinguished from another by the amount of this charge. Thus, the hydrogen atom consists of a nucleus with one unit of positive charge and a single satellite electron; the helium nucleus has two units of positive charge and two satellite electrons; and so on, up to uranium, the heaviest known element, which has 92 units of charge in the nucleus and 92 revolving electrons. By certain methods some of the electrons can be detached, one by one, from their orbits and set free. The remainder of the atom is then said to be *ionised*. Atoms can thus be singly, doubly, and, in general, multiply ionised; according to the number of electrons which are so detached. In such states, however, they are unstable and recapture electrons to make up their deficiency at the earliest opportunity.

Positive nuclei and electrons, then, are the material units of which the sun is believed to be composed. Whether the nuclei are entirely of the kinds existing on the earth, or whether in the interior of the sun there are also heavier ones, is a question on which opinions differ; the direct evidence of the spectroscope, of course, reveals the composition of the sun's atmosphere only. Since the sun is radiating energy, conditions of stability require that it shall get hotter towards the centre, so that the effective temperature of 6,000° represents approximately the *minimum* solar temperature. Now from laboratory experiments and deductions therefrom, we know that high temperature is one of the agencies through which atoms are ionised: the interior of the sun must therefore be pictured as a swarming crowd of electrons and ionised atoms, the degree of ionisation of the atoms and the speed of their motions increasing as the centre is approached. Near the centre, in fact, the nuclei are almost, if not quite, stripped bare of their satellite electrons.

In the ceaseless and inconceivably rapid motions electrons are captured by nuclei and set free again millions of times per second. Both the cause and effect of this process is radiation. Every time an electron is captured the energy of its former motion is liberated as a unit beam, or *quantum*, of radiation; every time a quantum falls on an atom tuned to receive it a satellite electron absorbs its energy and flies into momentary freedom. Ionised atoms, electrons, and radiation thus take part in a process of continual interchange, rapid beyond conception and without pause or diminution of intensity. But there is an important difference in the behaviour of the atoms and electrons on one hand and the radiation on the other. The headlong careering of the former is kept within a limited range by the gravitational consolidation of the whole mass, while electrostatic forces preserve a constant proportion between the number of nuclei and the number of electrons in each region. Radiation, however, is not so controlled. It works its way from the centre, where it is most intense, out to the surface and thence to space at the observed rate of $3{\cdot}79 \times 10^{33}$ ergs per second. The sun loses radiation at this enormous rate, and has been doing so for countless millions of years, while the electrons and atomic nuclei remain chained within its boundaries. How is it possible for the process of interchange to be maintained?

There appears to be only one answer to this question. Electrons and nuclei must in some measure cancel one another, producing fresh radiation by their complete or partial annihilation. Such a process is theoretically possible. It has never been known to occur on the earth, and the only evidence that it occurs in the sun and stars is that otherwise we cannot explain the prodigal generation of radiant energy which those bodies manifest. What conditions give rise to a process which terrestrial circumstances do not countenance is at present an unanswered question.

The picture of the sun which we have so far drawn will fit almost any star, and indeed will be found with greater elaboration of detail in the article STAR. We proceed to particularise for our own luminary. The temperature at the centre of the sun has been estimated at 30 or 60 million degrees, according to the view taken of the conditions of stability and generation of energy. The density at the centre is at least 20 times the mean density. The rate of radiation corresponds to a loss of mass of more than 4,000,000 tons per second—an enormous loss, but one which the sun will be able to sustain, if no sudden change occurs, for millions of years to come.

Application to Detailed Features.—Such, in outline, is the idea which is now held of the sun's constitution. The concepts out of which it is formed are atomic nuclei, electrons, and radiation. If it were complete, the existence of sunspots, prominences and the corona, the sun's rotation, equatorial acceleration and magnetic field, and the phenomena of the atmosphere would follow as inevitable consequences. They do not do so because we have either not yet specified sufficient fundamental concepts or failed to realise the full potentialities of those we have specified. Yet some progress has been made, especially in the consideration of the atmosphere, where, thanks largely to Megh Nad Saha, Ralph

Howard Fowler, Edward Arthur Milne, and Henry Norris Russell, ideas consistent with those applied to the interior have shown how the more prominent of the observed phenomena arise. The atom of each element requires a certain amount of energy to detach each of its electrons successively, and the conditions favouring detachment, or ionisation, are high temperature and low pressure. Thus the spectrum lines of sodium are produced only up to a certain height because, in the lower pressures above that height, all the atoms of sodium are ionised, in which state they produce different spectrum lines lying outside the range of wave-length which the transparency of our atmosphere allows us to observe. The precise connection between the degree of ionisation and the physical conditions has been formulated, and this enables the temperature and pressure in the sun's atmosphere to be estimated from the observed heights reached by the various elements. It appears that the pressure in the sun's atmosphere is very low—less than one thousandth of that of the earth's atmosphere—while the temperature is not far below that of the photosphere. When the selective pressure of radiation also is taken into account the relatively great heights reached by the chromospheric gases become intelligible, and in the hands of Milne a consistent theory of the chromosphere is in process of construction (*see* Chromosphere).

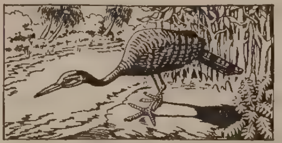
Although there is at present no sign of an explanation of sunspots along the lines of the general solar theory, the work of Hale has greatly clarified our ideas of the nature of those objects. Hale pictures a vortex motion just below the photosphere, in which the revolution of electrified particles produces a magnetic field. Photospheric matter is projected upwards along the axis of the vortex, becoming cool by sudden expansion and so appearing darker than the rest of the photosphere. This forms the umbra of a spot, and the outspreading and circulation of the material in the atmosphere constitutes the penumbra. Vilhelm Firman Koren Bjerknes has supplemented this view by assuming that during each 11-year cycle there exist, immediately beneath the photosphere, two vortex rings, one in each hemisphere, each lying along a circle of latitude. When, at a certain point, a ring rises up to the photosphere and is intersected by it the two sections of the ring form spots, which thus occur in pairs and appear to have opposite rotations and therefore opposite magnetic polarities. Periodic movements of the rings in latitude, occurring as part of a definite system of circulating currents of solar matter slightly below the photospheric level, account for the observed latitudinal migration of the spots. This conception is very attractive, but can be regarded at present only as a very plausible hypothesis. It remains to be shown how such rings have developed in a sun having the constitution described above.

Bibliography.—The latest authoritative book devoted exclusively to the sun is *Eclipses of the Sun* by S. A. Mitchell (1925); this deals comprehensively with solar observation and theory in a non-technical way. The chapter on "The Constitution of the Sun," by C. E. St. John, in the biography of Sir Norman Lockyer (1928) contains a valuable *résumé* of modern ideas. For general accounts *see* chapters in *Astronomy*, by H. N. Russell, R. S. Dugan, and J. Q. Stewart (1927); F. J. M. Stratton, *Astronomical Physics* (1925) and H. Dingle, *Modern Astrophysics* (1927). (H. D.)

SUN-BIRD, the name of a group of small birds forming the passerine family *Nectariniidae.* They inhabit the Ethiopian, Indian and Australian regions. One species occurs in Baluchistan, which is perhaps outside of the Indian region, but the fact of its being found there may be a reason for including that country within the region. They are considered to have their nearest allies in the *Meliphagidae* (*see* Honey-Eater). Some of them are popularly called "humming-birds" by Anglo-Indians and colonists, but with that group the sun-birds have nothing to do. The most wonderful combination of the brightest colours—scarlet, purple, blue, green and yellow—is often seen in one and the same bird. One group, however, is dull in hue. Graceful in form and active in motion, sun-birds flit from flower to flower, feeding on small insects and nectar; but this is usually done while perched and rarely on the wing as is the habit of humming-birds. The extensible tongue is converted into an almost tubular organ. The nests of the sun-birds, domed with a penthouse porch, and suspended from the end of a bough or leaf, are neatly built.

The Nectariniidae form the subject of a *Monograph* by G. E. Shelley.

SUN-BITTERN (*Eurypyga helias*), a South American bird the size of a small curlew. The plumage is variegated with black, brown, buff, grey, and white; the bill is slender and straight, the legs long. It frequents the banks of rivers and feeds on fish and insects. When alarmed, and also in courtship it displays its wings and tail in a striking way. It inhabits Guiana and Brazil. There is a large species, *E. major,* in Colombia and Central America. Its only ally is the kagu (*Rhinchetus jubatus*) of New Caledonia, a larger bird, with a pendant crest; this has the same habit of display when excited.


THE SUN BITTERN

SUNBURY, a city of Pennsylvania, U.S.A., the county seat of Northumberland county; 40 m. (in an air line) N. of Harrisburg, at the confluence of the west and the north branches of the Susquehanna river; served by the Pennsylvania, the Lackawanna and the Reading railways. Pop. (1920) 15,721 (98% native white); 1928 estimate, 17,000. Sunbury takes the place of the old Indian village Shamokin, long the principal one in the province, where a Moravian mission was maintained from 1747 to 1755. Because of the strategic importance of the spot Ft. Augusta was erected here by the provincial government in 1756, and it was a refuge to many fugitives from the Wyoming Massacre. Sunbury was surveyed in 1772 and was incorporated as a borough in 1797.

SUNBURY-ON-THAMES, an urban district in the Spelthorne parliamentary division of Middlesex, England, 17 m. S.W. of St. Paul's Cathedral, London, on a branch of the S. railway. Pop. (1921) 5,350. It is a favourite riverside resort and has grown considerably as a residential district. There are pumping works and filtration beds for the water-supply of London. To the north-east is Kempton park, the manor-house of which was a royal residence early in the 14th century. The park is famous for its race-meetings, the principal fixture being the Jubilee Handicap, established in 1887. The manor was granted by Edward the Confessor to Westminster Abbey, and passed in the 13th century to the see of London and in the 16th to the Crown; but was not so held later than 1603.

SUN CHUANG-FANG (1885–), one of the group of men who rose to prominence and obtained a brief tenure of power in China during the years of strife which succeeded the death of Yuan Shi-kai. He was born in Lingcheng in the Province of Shantung and received military training at the Peiyang College and in Japan. In 1921 he obtained command of a Division under Wu Pei-fu, and two years later was appointed military governor of Chekiang. During 1924 and 1925 he extended his authority over Kiangsu, and, after defeating the Northern troops, announced the consolidation of five provinces, Kiangsu, Chekiang, Anhwei, Kiangsi and Fukien, into an independent State under himself as governor-general. He made gestures of good-will towards the foreign enclaves within his jurisdiction, and, expressing shame for the insanitary condition of his cities, pleaded for foreign co-operation. Early in 1927 he was swept aside in the advance of the Southern Army, and, in spite of resistance rendered by reinforcements from Shantung, he found himself a fugitive and his five provinces in Nationalist hands. He fought on tenaciously at Hsuchowfu with the remnants of his army, but without success.

SUN COPYING or Photo Copying, the name given that branch of photographic contact printing which is carried out without the aid of a camera-made negative. (*See* Blue Print.)

SUN CURE: *see* Heliotherapy.

SUNDA ISLANDS, the collective name of the islands from the Malay Peninsula to the Moluccas, including the Great Sunda Islands—*i.e.,* Sumatra, Java, Borneo, Celebes, Banka and Billiton, and the Lesser Sunda Islands, Bali, Lombok, Sumbawa, Flores, Sumba and Timor, etc.

Sunda Strait is the channel separating Sumatra from Java and uniting the Indian Ocean with the Java Sea. Its narrowest part, between the south-eastern extremity of Sumatra and the town of Anjer in Java, is 14 m. wide. In the middle is the low-lying well-wooded island of Dwars-in-den-Weg ("right in the way"), otherwise Middle Island or Sungian, which divides the strait into two channels each about 4 m. wide. In 1883 Sunda Strait was the scene of the eruption of Krakatoa (*q.v.*), a volcanic island farther west in the strait.

SUNDARBANS or **SUNDERBUNDS,** a tract of country in Bengal, India, forming the seaward fringe of the Gangetic delta. It extends for about 170 m. along the sea face of the Bay of Bengal, from the estuary of the Hooghly on the west to that of the Meghna on the east, and runs inland for a distance of 60 to 80 miles. It is intersected from north to south by large tidal rivers or estuaries, which are connected by numerous interlacing channels. The whole tract is a network of estuaries, rivers and creeks, which enclose a large number of flat, marshy islands. Many are covered with forest and a dense undergrowth standing in soft mud, half in and half out of the water. The area under forest is about 3,000 sq. miles. The characteristic tree is the *sundri* (*Heritiera littoralis*), from which the name of the tract has probably been derived. Along the sea face the forest is composed of mangrove, which in some places are separated from the sea by a line of sand dunes. Cultivation is confined to the north, where over 2,000 sq.m. have been settled, but the population is very sparse. South of the area of cultivation, the Sundarbans are practically uninhabited. The chief wild animals are tigers, of which many are man-eaters, leopards, deer and wild pig; crocodile infest the estuaries.

SUNDAY, the Lord's day in the Christian world, the first day of the week, and the day set apart for divine worship in Christendom, in memory of the Resurrection. Early apostolic writings bear witness to the sanctity of the day dedicated to the duties laid down in the fourth commandment, the equivalent in the Christian religion of the Jewish Sabbath (Saturday). Eventually the Roman emperor Constantine enjoined Sunday rest from labour, except agricultural, by constitutions, the first of which was decreed in A.D. 321, and most of which are contained in the code of Justinian.

English Laws.—In the 7th century A.D. the laws of Wihtred, king of Kent, provided that if a servant, contrary to his lord's command, did servile work between sunset on Saturday evening and sunset on Sunday evening, he should pay a fine to his lord; they forbade a servant to make a journey of his own on horseback on Sunday under penalty of a fine or the lash, and a freeman to work during the forbidden time, under certain penalties including the payment of half the fine to the informer, who also was entitled to the profits of the Sabbath-breaker's labour. On the other hand, Ina, king of Wessex, in the same century ordained that if a slave worked on Sunday by his lord's command he should become free, and the lord be liable to a fine of 30 shillings.

By a series of statutes, many of which are still the law of the country, it is illegal to work or to take part in certain forms of pastime on a Sunday, which in English law is reckoned from midnight to midnight. The first such prohibition in a statute is in 28 Edw. III. c. 14 (repealed) by which in 1354 the sale of wool at the staple was forbidden on a Sunday. Prior to the Reformation Sunday was regarded as a suitable time for national sports, and there were, for instance, a statute in Richard II.'s reign and another in Henry IV.'s reign, which enjoined the practice of archery on that day (*see* SPORTS, BOOK OF). Both Acts were subsequently repealed. Although the church had sufficient temporal power to visit Sabbath-breakers with its displeasure, Sunday observance was not ordained by statute until the reign of Edward VI. by the Act of Uniformity of 1551. By I. Eliz. c. 2 (1558) everyone had to go to church on a Sunday or be liable not only to the censures of the church but to a fine of twelvepence. The penalty was not formally repealed until 1846 (9 and 10 Vict. c. 59). It is still the law of England that members of the Church of England are required to attend divine service on Sunday, and though in practice this law has not been enforced for generations, obedience to the law has been upheld by the High Court in the analogous case of Ascension Day as against a later Act relating to compulsory education attendance (*Marshall and Bell* v. *Graham,* 1907, 2 K.B. 112).

By the Sunday Observance Act 1677 tradesmen, artificers, labourers "or other person whatsoever" are forbidden to carry on their ordinary businesses under penalty of a fine of 5s or two hours in the stocks in default. Acts have been passed to obviate some of the inconveniences in modern life caused by the 1677 Act, which however did permit the sale of milk before 9 A.M. and after 4 P.M., and of victuals in cook shops and fried fish shops (*Bullen* v. *Ward,* 1905, 14 L.J.K.B., 916). Other statutes followed but are all repealed. Still law are the Acts of 1762 (2 Geo. III. c. 15 s. 7), allowing fish carriages to travel on Sunday in London and Westminster; 1827 (8 Geo. IV. c. 75), repealing s. 2 of the Act of 1677 as far as regards Thames boatmen. The Bread Acts of 1822 (3 Geo. IV. c. 106) allow bakers in London, and of 1836 (6 and 7 Will. IV. c. 37) allow bakers out of London, to carry on their trade up to 1.30 P.M. Since an Act of 1871 (34 and 35 Vict. *c.* 87) no prosecution for penalties under the Act of 1677 can be instituted except with the consent in writing of the chief officer of a police district or the consent of two justices or a stipendiary magistrate. (*Thorpe* v. *Priestnall,* 1897, 1, Q.B. 19.)

Since 1871.—The result of the Act of 1871 has been in substance to make the Lord's Day Acts a dead letter as to Sunday trading, and during the present century prosecutions have been extremely rare. In London Sunday markets are usual in all the poorer districts, and shopkeepers and hawkers are allowed freely to ply their trades for the sale of eatables, temperance drinks and tobacco. The Factory and Workshop Act (1901) forbids the employment of women, young persons or children on Sunday in a factory or workshop (s. 34).

Fishing is permissible on a Sunday, except that one may only fish for salmon with rod and line (Salmon Fishery Act 1861). By the Game Act 1831, it is a crime to take or kill game on a Sunday, but the prohibition does not apply to rabbits. The law with regard to Sunday entertainments and performances is based upon the Sunday Observance Act 1781 (21 Geo. III. c. 49) by which heavy pecuniary penalties were imposed upon anyone who promoted any public entertainment or debate to which people were admitted only by payment. As much as a £200 fine could be inflicted upon the keeper of the house or room used, but in 1875 the Remission of Penalties Act was passed to enable the Crown to remit penalties for offences against the Act of 1781.

Sunday is a *dies non* for the sitting of the courts or meetings of public bodies, though parliament has at times sat on a Sunday in national emergencies, and Saturday sittings of the House of Commons have been extended into the small hours of the Sabbath. Process may not be served nor persons arrested except in cases of treason, felony, or breach of the peace (1677 Act), but a justice may issue an arrest or search warrant.

Contracts on a Sunday.—Though at common law a contract made on a Sunday is valid, the technical restrictions imposed by statute on Sunday labour, especially those contained in the Sunday Observance Act 1677, render most contracts made and completed on that day void or voidable (*Smith* v. *Sparrow,* 1827, 4 Bing. 84). But any contract in respect of labour, business, or work not done in the course of a man's ordinary calling is binding. A cheque drawn on a Sunday is binding on the drawer; in an action on a bill of exchange drawn on a Sunday the drawer was given judgment against the acceptor (*Begbie* v. *Levy,* 1830, 1 C. and J. 180). The position in regard to these matters has been clearly laid down by the Bills of Exchange Act.

Computation of Time.—Where any limit or period of time fixed in the High Court exceeds seven days the Sundays included in it (except in divorce proceedings) are counted in computing the time, provided that if the last day fall on a Sunday, the period must be computed so as to cover the next following working day. But where the period fixed is less than six days Sunday is not counted, so that five days from a Saturday would commence on the following Monday and end on the Friday.

In Scotland and the British dominions generally the laws as to Sunday have followed more or less the same course as in England, except that native customs have been interfered with as little as possible and particular Acts have been passed to meet special needs. (W. LA.)

United States.—In the United States Sunday legislation, beginning with an enactment of the Virginia colony in 1617, was quite general in colonial times, and Sunday laws of varying types have been passed by all the States. Their general trend is to prohibit the carrying on of any business on Sunday that is neither necessary nor charitable in nature. In some States general provisions to this effect are in force; others prohibit the conduct of particular trades and occupations. Many States forbid Sunday sports, prohibiting games and theatrical performances from being conducted for profit. Violation of the Sunday laws entails three effects. It subjects the violator to the criminal penalty prescribed by statute. It makes unenforceable contracts, including promissory notes, executed or to be performed on Sunday. In a few States, it subjects the violator to a civil disability, thus preventing a traveller on Sunday from recovering for a negligent injury done to him inasmuch as his own illegal act was a cause of the injury. The criminal enforcement of Sunday laws throughout the United States is notoriously lax. (J. M. La.)

SUNDERLAND, CHARLES SPENCER, 3rd Earl of (*c.* 1674–1722), English statesman, was the second son of the 2nd earl, but on the death of his elder brother Henry in Paris in September 1688 he became heir to the peerage. He married Arabella, daughter of Henry Cavendish, 2nd duke of Newcastle; she died in 1698 and in 1700 he married Anne Churchill, daughter of the famous duke of Marlborough. Having succeeded to the peerage in 1702, the earl was one of the commissioners for the union between England and Scotland, and in 1705 he was sent to Vienna as envoy extraordinary. Through the influence of Marlborough he was foisted (1706) into the ministry as secretary of state for the southern department. From 1708 to 1710 he was one of the five Whigs, called the Junta, who dominated the government, but in June 1710 he was dismissed.

Sunderland was active in communicating with the court of Hanover. He made the acquaintance of George I. in 1706, but when the elector became king the office which he secured was the comparatively unimportant one of lord-lieutenant of Ireland. In August 1715 he joined the cabinet as lord keeper of the privy seal, and after a visit to George I. in Hanover he secured in April 1717 the position of secretary of state for the northern department. This he retained until March 1718, when he became prime minister. The South Sea bubble led to his political ruin. He had taken some part in launching the scheme of 1720, but he had not profited financially by it; but it was only through the efforts of Walpole that he was acquitted by the House of Commons. In April 1721 he resigned his offices, but he retained his influence with George I. until his death on April 19, 1722.

For the career of Sunderland *see* W. Coxe, *Memoirs of Marlborough* (1847–48); Earl Stanhope, *History of England* (1853), and I. S. Leadam, *Political History of England, 1702–1760* (1909).

SUNDERLAND, ROBERT SPENCER, 2nd Earl of (1640–1702), English politician, was the only son of Henry Spencer (1620–1643), who succeeded his father William, as 3rd Baron Spencer of Wormleighton in 1636. Henry was created earl of Sunderland in June 1643, and was killed at the battle of Newbury when fighting for the king a little later in the same year. He married Dorothy (1617–1684), daughter of Robert Sidney, 2nd earl of Leicester. She was the *Sacharissa* of the poems of her admirer, Edmund Waller.

Their son Robert, the 2nd earl, was educated abroad and at Christ Church, Oxford, and in 1665 married Anne (d. 1715), daughter of John Digby, 3rd earl of Bristol. Sunderland was successively ambassador at Madrid, at Paris and at Cologne; in 1678 he was again ambassador at Paris. In February 1679 he entered political life as secretary of state for the northern department, and became at once a member of the small clique responsible for the government of the country. He voted for the exclusion of James, duke of York, from the throne, and made overtures to William, prince of Orange, and consequently in 1681 he lost both his secretaryship and his seat on the privy council. Early in 1683, however, through the influence of the duchess of Portsmouth, Sunderland returned to power. By this time he had made his peace with the duke of York, and when in February 1685 James became king, he retained his position of secretary, to which was soon added that of lord president of the council. He carried out the wishes of the new sovereign and after the intrigues of a few months he secured the dismissal of Lawrence Hyde, earl of Rochester, from his post as lord treasurer. Sunderland signed the warrant for the committal of the seven bishops, and appeared as a witness against them. While he was thus serving James II., he was receiving a pension from France, and through his wife's lover, Henry Sidney, afterwards earl of Romney, he was furnishing William of Orange with particulars about affairs in England. But although he had in 1687 openly embraced the Roman Catholic faith, he hesitated to commit himself entirely to the acts of the fierce devotees who surrounded the king, and in October 1688 he was dismissed by James with the remark "I hope you will be more faithful to your next master than you have been to me."

Sunderland now took refuge in Holland, and from Utrecht published in his own defence *A Letter to a Friend in the Country.* He had been too deeply involved in the arbitrary acts of James II. to find a place at once among the advisers of William and Mary, and he was excepted from the act of indemnity of 1690. However, in 1691, he was permitted to return to England, and he declared himself a Protestant and began to attend the sittings of parliament. William III. visited him at Althorp in 1691, and it was on his advice that the king chose all his ministers from one political party, the modern system. (*See* Cabinet.) Sunderland also effected a reconciliation between William and his sister-in-law, the princess Anne. From April to December 1697 he was lord chamberlain, and for part of this time he was one of the lords justices, but the general suspicion with which he was regarded terrified him, and in December he resigned. He died at Althorp on Sept. 28, 1702.

SUNDERLAND, seaport, municipal, county and parliamentary borough, Durham, England; at the mouth of the river Wear, on the L.N.E. railway, 261 m. N. from London. Pop. (1921) 173,696. The borough includes the township of Bishopwearmouth, which lies on the south bank of the river; and that of Monkwearmouth, on the north bank. The borough was extended in 1927, its present area being 2,942 ac. and estimated population 187,800. Adjacent to Monkwearmouth is the urban district of Southwick, within the parliamentary borough. A great cast-iron bridge crosses the river with a single span of 236 ft. and a height of 100 ft. above low water. It was designed by Rowland Burdon, opened in 1796, and widened under the direction of Robert Stephenson in 1858. The only ancient building is the church of St. Peter, Monkwearmouth, in which part belongs to the Saxon building attached to the monastery founded by Benedict Biscop in 674. The church of St. Michael, Bishopwearmouth, is on an ancient site, but was rebuilt in the 19th century. There are six parks in the borough, and four public libraries.

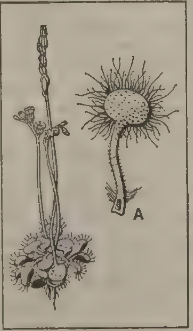
The prosperity of Sunderland rests on the coalfields of the neighbourhood, the existence of which gave rise to an export trade in the reign of Henry VII. For 5 m. above its mouth the Wear resembles on a reduced scale the Tyne in its lower course. The harbour of 150 ac. is formed by two stone piers. It is constantly undergoing improvement and the south pier is now 2,844 ft. long. There is a total length of quayage of 12,000 ft. There are several graving docks (area, 10½ ac.), the largest, built in 1925, being 515 ft. long. The parliamentary borough returns two members.

History.—The history of Sunderland is complicated by the name Wearmouth (*Wiramuth, Wermuth*) being applied impartially to the Monk's town on the north bank of the Wear; the Bishop's town on the south and the neighbouring port now known as Sunderland. In both Monk's and Bishop's Wearmouth the settlement was connected with the church. Benedict Biscop in 674 founded the Benedictine monastery of St. Peter on the north bank of the river. The abbey, where Bede was educated, was destroyed by the Danes and probably not rebuilt until Bishop Walcher (1071–81) settled Aldwin and his companions there. Bishop William of St. Carileph (1081–99) transferred monks there from Durham and Wearmouth became a cell of the larger house. There seems no doubt that the borough, identical with that to which Bishop Robert de Pinset granted his charter, was in reality Sunderland, the name Wearmouth being used to cover Bishop's and Monk's Wearmouth and the modern Sunderland. The shipping trade of Bishop's Wearmouth showed a steady increase. In 1382 there was probably a dock here and from the 16th century, Bishop's Wearmouth seems to have been completely identified with Sunderland: in 1567 Wearmouth was one of the three ports in Durham where precautions were to be taken against pirates, while no mention is made of Sunderland. Monk's Wearmouth remained purely agricultural until 1775, when a shipbuilding yard was established and prospered to such an extent that by 1795 five similar yards were at work.

Sunderland was at farm in 1183 and rendered 100 shillings and the town of Sunderland rendered 58 shillings tallage in 1197 during the vacancy of the see. In 1382 Thomas Menvill held the borough. Edward IV. in 1464, *sede vacante*, granted a lease of the borough. Bishop Morton incorporated Sunderland in 1634, stating that it had been a borough from time immemorial, under the name of the New Borough of Wearmouth.

SUNDEW, in botany, the popular name for a genus of plants, *Drosera,* so called from the drops of viscid, transparent secretion borne by the tentacles which cover the leaf-surface. It is a cosmopolitan genus of slender glandular herbs, with leaves arranged in a basal rosette or alternately on an elongated stem, and is represented in Great Britain by three species, and in North America by seven species, found in spongy bogs and heaths. They are included in the family Droseraceae, and comprise about 100 species, most numerous in Australia.

The common sundew (*D. rotundifolia*) has extremely small roots, and bears five or six radical leaves horizontally extended in a rosette around the flower-stalk. The upper surface of each leaf is covered with gland-bearing filaments or "tentacles," of which there are on an average about 200. Each gland is surrounded by a large dew-like drop of the viscid secretion. A small fibro-vascular bundle consisting mainly of spiral vessels, runs up through the stalk of the tentacle and is surrounded by a layer of elongated parenchyma cells outside of which is the epidermis filled with a purple fluid. The glandular head of the tentacle contains a central mass of spirally thickened cells (tracheïds) in immediate contact with the upper end of the fibro-vascular bundle. Around these is a layer of large colourless thin-walled cells which reach the surface at the base of the head and act as absorbing cells. Outside these are two layers filled with purple fluid.



ROUNDLEAVED SUNDEW, (DROSERA ROTUNDIFOLIA) WHOLE PLANT; A. SINGLE LEAF ENLARGED TO SHOW GLANDULAR HAIRS

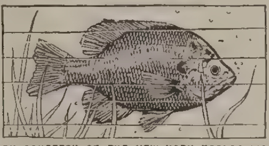
Insects are attracted by the leaves; a fly alighting on the disk, or even only touching one or two of the exterior tentacles, is immediately held by the viscid secretion; the tentacles to which it is adhering begin to bend, and thus pass on their prey to the tentacles next succeeding them inwards, and the insect is thus carried by a curious rolling movement to the centre of the leaf. The tentacles on all sides become similarly inflected, and the insect, bathed in the abundant secretion, is drowned in about a quarter of an hour.

Closely allied to *Drosera* is *Drosophyllum lusitanicum,* which catches such vast numbers of flies in a state of nature that the Portuguese cottagers call it the fly-catcher, and hang up branches of it in their houses for this purpose. Its long narrow leaves are thickly covered with stalked glands, which resemble in the main the tentacles of *Drosera,* save in that they are incapable of movement, and that the secretion is more fluid. There are many minute colourless sessile glands, which, when stimulated by the absorption of nitrogenous matter, excrete an acid digestive secretion similar to that of the sundew.

SUN-DIAL: *see* DIAL.

SUNDSVALL, a seaport of Sweden in the district (*län*) of Vesternorrland, on a wide bay of the Baltic, at the north of the Selånger River, 360 m. N. by W. of Stockholm, the terminus of a branch from Ange on the northern railway. Pop. (1928), 17,637. It was rebuilt in brick and stone after a fire in 1888.

SUNFISH, a name sometimes given to the *Centrarchidae,* a family of perch-like fishes inhabiting the fresh waters of North America, and especially to the common sunfish or pumpkin-seed (*Eupomotis gibbosus*), abundant, especially in ponds, from Maine to Minnesota and southward near the Atlantic coast to Florida. This favourite of juvenile anglers has a strikingly coloured, ovate, compressed body—whence the popular name pumpkin-seed—which is sometimes 8 in. long, though usually smaller, greenish and bluish olive above, spotted with orange on the sides, and orange below. The female deposits her eggs in a nest scooped in the muddy bottom of shallow water by the male, who guards it until the young are hatched. The name sunfish is applied also to the *Molidae,* marine fishes of the order Plectognathi. These curious fishes appear tailless, the body ending abruptly behind the dorsal and anal fins; they have a small mouth, with a single sharp edged tooth-plate in each jaw. *Mola* include two species, large, stout, deep-bodied fishes with a rough skin; they are oceanic, inhabiting warm seas, and may often be seen resting at the surface; they reach a length of 8 ft. and a weight of perhaps two tons. The oblong sunfish (*Ranzania truncata*) is longer and more compressed, smooth, with tessellated scutes; it reaches 2 feet.



BY COURTESY OF THE NEW YORK ZOOLOGICAL SOCIETY

THE COMMON SUNFISH (EUPOMOTIS GIBBOSUS) OR PUMPKIN-SEED

SUNFLOWER. The common sunflower, known botanically as *Helianthus annuus,* a member of the family Compositae, is a native of the Great Plains region of the United States. It is an annual herb with a rough hairy stem 3 to 15 ft. high, broad coarsely toothed rough leaves 3 to 12 in. long, and heads of flowers 3 to 6 in. wide in wild specimens and often 1 ft. or more in cultivated. Double forms are in cultivation, one (*globosus fistulosus*) having very large globular heads. The plant is valuable from an economic as well as from an ornamental point of view. The leaves are used as fodder, the flowers yield a yellow dye and the seeds contain oil and are used for food. It is cultivated in Russia, England and other parts of Europe, in Egypt and in India for the seeds, the yellow sweet oil obtained by compression from which is considered equal to olive or almond oil for table use. Sunflower oilcake is used for stock and poultry feeding, and is exported by Russia to Denmark, Sweden and elsewhere. The genus *Helianthus* contains about 60 species, chiefly natives of North America, a few being found in Peru and Chile. They are tall, hardy annual or perennial herbs, several of which are of easy cultivation in gardens with moderately good soil. *H. decapetalus* is a perennial about 5 ft. high with solitary heads about 2 in. across in slender twiggy branchlets; *H. multiflorus* is a beautiful species with several handsome double varieties; *H. orygalis* is a graceful perennial 6 to 10 ft. high, with drooping willow-like leaves and numerous comparatively small yellow flower-heads. *H. atrorubens* is a smaller plant, 2 to 5 ft. high, the flower heads of which have a dark red or purple disk and yellow rays. There are many fine forms of this, some of which grow 6 to 9 ft. high and have much larger and finer flowers than the type. Other fine species are *H. giganteus,* 10 to 12 ft.; and *H. mollis,* 3 to 5 ft. *H. tuberosus* is the Jerusalem artichoke.

SUNG DYNASTIES: *see* CHINA, *History;* CHINESE PAINTING; CHINESE SCULPTURE.

SUNIUM, a cape at the S. extremity of Attica, with a temple of Poseidon as landmark for ships, the modern Cape Colonna. The rocky promontory was fortified by wall and towers, in 413 B.C., against the Spartans in Decelea; but was soon after seized by fugitive slaves from the Laurium mines. In the 4th century it was still a fortress. The temple, probably built in the time of Pericles, in the place of an earlier one, similar but of tufa or "poros" stone, is shown by an inscription to be dedicated to Poseidon, not, as formerly supposed, to Athena, whose temple, of peculiar plan, with colonnade on two sides only, lies about a quarter of a mile away to the N.E. Of Poseidon's temple there are still standing nine columns of the S. side, two of the peristyle on the N., one of the *antae* and an inner column of the *pronaos*, of local white marble, which has suffered from the weather.

SUNLIGHT TREATMENT. (*See* also HELIOTHERAPY; VITAMINS.) In countries where, relatively, there is much persistent cloud, in extreme northern or southern lands where night is long in winter, on the sunless slopes of mountains or in sunless valleys, in factory towns where smoke defiles the atmosphere with its soot particles, in slums where the houses are crowded together and men, women and children are herded in dark damp rooms with vitiated air it is found that resistance to infective disease is low, rheumatism and tuberculosis are rife, expectation of life is below normal, infant mortality is high. To these conditions, no doubt, many causes contribute but it is generally believed a deficiency of sunlight is a powerful factor. The tendency at the present day regarding the attributes of the sun's rays is to lay much stress upon the invisible ultra-violet rays of the solar spectrum as well as upon the invisible infra-red and the visible rays.

Treatment by Direct Sunlight.—This is difficult or impossible under such conditions as have been mentioned above; some methods of supplying it are by the provision of open spaces and playing fields in the neighbourhood of crowded areas, establishment of open-air schools, cult of outdoor sports, etc. But even if sunlight be available the atmospheric conditions may permit of little penetration by the ultra-violet rays. Hence, methods have been adopted to supply these from abundant supplies such as the electric arc and the mercury-vapour quartz lamp, and to minimize screening effects by the use in buildings of such material as glass made of quartz which admits a maximum of ultra-violet and other beneficial rays, by the use of lighter and more porous clothing, or even by exposure of much of the body. Thus in one way or another, whether as a curative or preventive measure against disease there is a great movement towards supplying, naturally or artificially, that sunlight which is deficient. As a preventive measure the use of sunlight is modern, but the curative side has been recognized for centuries, having been used by the Chinese, Egyptians and the South American Indians and is represented by the numerous health spas and resorts throughout the world.

Mode of Action of Direct Sunlight.—The rays of sunlight, when analysed by the prism, range between the infra-red (heat) rays of relatively long wave-length and slow frequency to the ultra-violet (chemical) rays of shorter wave-length and greater frequency. Within this range the penetrating power of the infra-red and of ultra-violet rays into human tissues is definitely less than that of the visible rays. Hence heat from the visible rays of sunlight passes through the skin and, largely, is taken up by the blood and distributed by way of the circulation throughout the body; infra-red heat rays warm the superficial layers of the skin and from them heat is carried to other parts. Ultra-violet light produces its effects in the skin itself and its action is manifested by the inflammation, peeling and tanning that exposure to the sun occasions in most persons. The pigment of coloured races prevents the penetration of ultra-violet rays deeper than the pigment layer and thus is a protection in tropical countries.

Warmth.—The increased warmth, when moderate, stimulates metabolism, induces a sense of well-being, increased appetite and mental activity; when greater, as in the height of summer or in the tropics, leads to sweating, desire for cool drinks and cool breezes and disinclination for food, particularly sugars and fats the oxidation of which supplies a large proportion of animal heat; and when excessive it leads to the pathological condition of sunstroke or heat-stroke (*q.v.*).

Ultra-violet Rays.—But the ultra-violet rays are now known to have special qualities. For long it has been known that the skin has the property of regulating heat loss and so contributing towards maintenance of a stable body temperature in warm-blooded animals. Recently it has been shown experimentally that even a short exposure to ultra-violet radiation modifies the bactericidal power of the blood and its leucocytic content. Moreover, the discovery that vitamin D (*see* VITAMINS) can be produced in ergosterol—an impurity apt to be present in all cholesterols but found originally in ergot of rye (*q.v.*)—has indicated a variety of action of which the full importance is, probably, still unknown. In investigations on rickets (*q.v.*) it was found that cod liver oil is beneficial; later, that ultra-violet irradiation is beneficial, even in the absence of cod liver oil, and ultimately that ultra-violet rays act on the non-saponifiable part of a natural fat, *i.e.*, the sterol, and produces vitamin D. From this it appears that the ultra-violet rays of summer sunlight act upon the ergosterol impurity in the cholesterols present in all animal cells and build up a store of vitamin D for our use during the winter when the ultra-violet radiation of sunlight is deficient.

The fact that ergosterol when exposed to ultra-violet radiation produces vitamin D has been turned to practical and commercial account. Under the rays ergosterol changes from a white crystalline solid to a pale yellowish oily fluid which possesses the highest vitamin D potency known. Thus artificially produced, there can be supplied to foodstuffs (*e.g.*, milk, butter, margarine) in their preparation an element deficient when produced in winter but normally present in sufficient quantity when produced in summer. Under natural conditions we eat foods containing ergosterol and this is acted upon in our bodies by the ultra-violet radiation reaching our skin, or (*e.g.*, in the consumption of New Zealand butter) we incorporate during the relatively sunless period in England vitamin D formed in the New Zealand sunny period.

Experiments and Theories.—The subject is a very complicated one but there is no doubt that the mortality from many diseases normally reaches its highest point in England in the winter months of January, February and March. Confidence in the therapeutic value of sunlight is strengthened by the beneficial results accruing in the monkey-house of the Zoological Gardens, London, where electric lamps of fused quartz have been installed to allow of the passage of ultra-violet rays to the animals. It must be noted, however, that this artificial sunlight must be used with great caution and for short periods as otherwise it has proved harmful. Indeed there is reason to believe that while a moderate exposure to ultra-violet radiation builds up vitamin D an excessive exposure destroys it. A natural extension of knowledge recently acquired concerning the effects of sunlight has been into the fields of animal and plant rearing. So far investigations have been conducted, mainly, by replacing ordinary glass by special glass admitting a maximum of the beneficial rays and the results are hopeful. Here it may be mentioned that the output of ultra-violet radiation from an electric system, though dependent upon the current and voltage between the poles of the arc, varies widely according to the type of electrode used. A positive carbon electrode with an iron core, disposed *below* the negative plain carbon electrode, instead of *above*, is a powerful source of ultra-violet radiation.

Lastly, mention must be made of Dr. Rollier of Leysin, Switzerland, and of Sir Henry Gauvain of the Treloar hospital for cripples at Alton, Hants., England, pioneers in the modern sunlight treatment of disease and of a remarkable journalistic success in the *Sunlight and Health Supplement* to *The Times* newspaper issued in London on May 22, 1928, to which the writer of this article is much indebted. (W. S. L.-B.)

SUNN or **INDIA HEMP** (*Crotalaria juncea*), a plant which is a native of India and Ceylon. It frequently receives other names, *e.g.*, false hemp, Bombay hemp, etc. The plant is an annual, requires a light soil, and is easily cultivated. Sometimes the seed is sown in October for the winter crop, and sometimes in May or June for the summer crop. When the seeds are sown in May, the bright yellow flowers appear in August, when the plant may be gathered. It is not unusual, however, to defer this operation until the seed is ripe, especially if a fibre of great strength is desired. The fibre has an average length of 3 to 4 feet. It is extensively used for rope and cordage and also for paper-making in its native country, but it has made little progress elsewhere.

SUNNIS (SUNNITES): *see* ISLAM.

SUNSHINE. As a meteorological element sunshine requires some conventional definition. There is uninterrupted continuance of gradation from the burning sunshine of a tropical noon to the pale luminosity that throws no shadow, but just identifies the shape of the sun through the thin clouds of northern skies.

The Campbell-Stokes Sunshine Recorder.—In the British Isles the sun is allowed to be its own timekeeper and the scorch of a specially prepared card used as the criterion for bright sunshine. The practice arose out of the use of the sunshine recorder which depends upon the scorching effect of a glass sphere in the sun's rays. The original form of the instrument was suggested by J. F. Campbell of Islay in 1857. He used a glass sphere within a hemispherical bowl of wood. The scorching of the wood along successive lines of the bowl as the sun alters its declination from solstice to solstice leaves a rugged monument of the duration and intensity of the sunshine during the half-year, but does not lend itself to numerical measurement. The design of a metal frame to carry movable cards and thus give a decipherable record of each day's sunshine is due to Sir G. G. Stokes. The excursions of the sun to the north and south of the equator are limited by the tropical circles, and the solar record on the hemispherical bowl will be confined within a belt 23° 27′ north and south of the plane through the centre parallel to the equator or perpendicular to the polar axis. Thus a belt 46° 54′ in angular width will be suitable for a sunshine recorder for any part of the world. Whatever place be chosen for the observation the same belt will do if it is set up perpendicular to the earth's polar axis. As examples of the cutting of the belt for different latitudes we may put side by side the recorder as used in temperate latitudes (fig. 1) and the special form designed in the Meteorological Office, London, for use on the National Antarctic Expedition, 1901–1904 (fig. 2). A belt cut for a particular latitude is serviceable for some 10° on either side of that latitude if the cards are not trimmed too closely to the cutting of the belt. The belt must always be adjusted round the parallel to the polar axis. If the cut of the belt is too oblique for the latitude of the place where it is exposed, and the cards are cut strictly to the belt, the northern side of the cut will be below the horizon and the southern side above it, some sunshine may be lost near sunrise or sunset in the winter because there is no card to receive it. The part projecting above the horizon in summer will partly shadow the globe, and faint sunshine may be lost, for at most only half the globe can be solarized at sunset. But the loss due to this cause is unimportant. Stokes designed the complete belt to use successively three cards of different shape for different times of the year. The equinoctial card forms a portion of a cylinder round the polar axis for spring and autumn, the summer card and the winter card each forms a part of a cone making an angle of 16° with the polar axis.

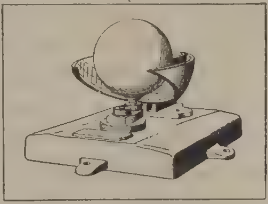


FIG. 1.—CAMPBELL-STOKES SUNSHINE RECORDER

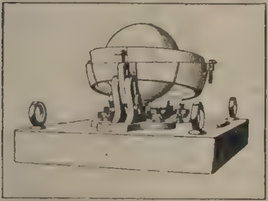


FIG. 2.—ANTARCTIC SUNSHINE RECORDER

Measurement of the Sunshine Record.—It was mentioned that the Campbell-Stokes recorder involves a conventional definition of sunshine. The recorded day of sunshine is less than the actual time during which the sun is above the horizon by about twenty minutes at sunrise and sunset on account of the want of burning power of a very low sun. Some further convention is necessary in order to obtain a tabulation of the records which will serve as the basis of a comparison of results for climatological purposes. The spot which is scorched on the card by the sun is not quite limited to the image of the sun, and a few seconds of really strong sunshine will produce a circular burn which is hardly distinguishable in size from that produced by a minute's record. Consequently with intermittent sunshine exaggeration of the actual duration of burning is very probable.

Other Types of Sunshine Recorder.—There are, however, various other conventions as to sunshine which are used as the basis of recorders of quite different types. The Jordan recorder uses ferro-cyanide paper and the sun keeps the time of its own record by the traverse of a spot of light over the sensitive paper, arranged as a cylinder about a line parallel to the polar axis. The effect thereby recorded is a photochemical one, and the composite character of the sun's radiation, modified by the selective absorption of the atmosphere, makes the relation of the record to that of the sun's scorching power dependent upon atmospheric conditions, so that the two records give different aspects of the solar influence on different occasions. Other recorders prefer to use the thermal or photographic effects of the sun's rays and record duration by a clock instead of allowing the sun to keep its own time. In the Marvin sunshine recorders of the United States weather bureau an electrical contact is made by the thermal effect of the sun and the duration of the contact is recorded. An instrument which gives a corresponding result is described by W. H. Dines (*Quart. Journ. Roy. Met. Soc.* xxvi. 243). These define sunshine by the effect necessary to produce or maintain a certain thermal effect, but the definition once accepted there is no uncertainty as to the record. The Callendar sunshine recorder gives a record of the difference of temperature of two wires, one solarized and the other not, and it is therefore a continuous record of the thermal effect of solar and terrestrial radiation.

Exposure.—We now consider what the daily sunshine record for a particular station means. An ideal exposure has an uninterrupted view of those parts of the horizon in which the sun rises or sets; and elsewhere the view of the sun must not be obstructed by the ground, buildings, trees or any other obstacle; but ideal exposures are not always to be obtained. In mountainous districts particularly it may be impossible to find a site in which the sun is not obstructed for an appreciable part of the day. In these circumstances it becomes a question whether the amount of sunshine recorded should be referred to the maximum possible for an uninterrupted horizon or the maximum possible for the particular exposure. The answer to the question really depends upon the purpose for which the information is wanted. As a climatological factor of the locality the shadow cast by the surrounding hills is of importance, it is part of the difference between the fertility of the southern and northern slopes of hill country. This importance is, of course, in many respects exclusively local, and indeed the possible duration of sunshine at any station is a local characteristic which it is desirable to know. Consequently as evidence of the peculiarity of the site the recorded sunshine might be referred to the total possible with a free horizon. On the other hand, taking the record of sunshine as an indication of the clearness of the sky for the purposes of general meteorology, the screening of the sun by hills must be regarded simply as limiting the time during which observation is possible and the duration of the sunshine recorded should be referred to the possible duration at the particular site.

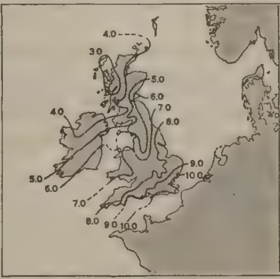


FIG. 3.—DAILY SUNSHINE FOR JULY.

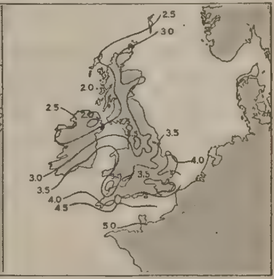


FIG. 4.—DAILY SUNSHINE OCTOBER

Sunshine Records for the British Isles.—The interest in the use of sunshine recorders is more widely extended in the British Isles than elsewhere, and it is, so far as the public are concerned, the most important meteorological element, but it is singular that up to the present a knowledge of the total amount of sunshine recorded during the day, the week, the month or the year is all that is apparently required.

In figure 3 the mean daily duration of sunshine for the month of July 1928 is represented by a number of isohels or lines of equal sunshine, the figures being given in hours. Figure 4 gives similar data for October 1928. Further, figure 5 represents the average weekly distribution of sunshine in different sections of the British Isles according to the average of twenty-five years. (X.)

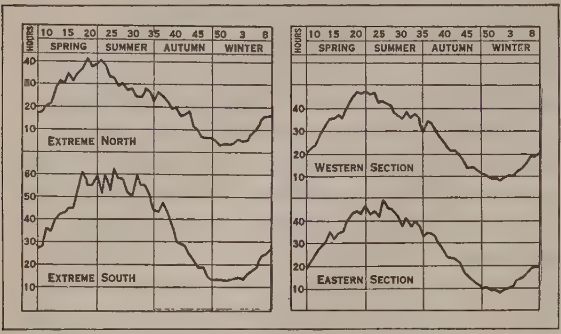


FIG. 5.—AVERAGE WEEKLY SUNSHINE IN DIFFERENT PARTS OF THE BRITISH ISLES

The United States.—Continuous records of sunshine in the United States are kept at nearly two hundred different points well distributed over the country, the records being obtained by means of the Marvin electrical sunshine recorders, the character of which is described on page 569. Sunshine data may be expressed either in the actual hours of sunlight at each individual station, or in percentage of the hours of actual sunshine as compared with that possible. Both systems have their advantages, but in the contrasting of different climates it appears that data on the percentages of possible sunshine actually received afford the better comparison of different regions, since the possible hours vary greatly for different seasons and localities, and their values must be made known before comparisons are feasible.

Considering first the annual sunshine, it becomes apparent that the United States, as a whole, is a country of abundant sunshine, nearly two-thirds of the entire area receiving annually on the average more than 60% of the possible amount, a proportion exceeded by only a few of the localities commonly referred to as having sunny climates.

Over a large part of the south-west, extending westward from central Texas, and including the western portions of Oklahoma and Kansas, nearly to the Pacific Coast, the annual amounts average more than 70% of the possible, and localities in the far south-west, including extreme western Texas, the southern portions of New Mexico and Arizona, and portions of Nevada and the interior of southern California, have averages in excess of 80%, Yuma, Arizona, having the maximum amount of recorded sunshine in the country, 88% of the possible.

Small areas of the northern portions from the Upper Lakes westward to Washington, much of the lower Ohio Valley and nearby portions of the Great Lakes, and small portions of the North Atlantic States have annual percentages ranging between 50 and 60%, while only limited portions of the far North-west, the districts around Lake Superior, and the area from the upper Ohio Valley north-eastward to northern New England have averages less than 50% of the possible.

In general during the colder months the percentages of the possible sunshine are less than during the warm season, but even then a large part of the central and southern areas west of the Mississippi River have amounts in excess of 60% of the possible, while the warmer months mainly have decidedly high percentages, the summer months particularly having values ranging from 60 to 80% in nearly all parts, and even exceeding 90% of the possible in portions of interior California and nearby areas of Nevada.

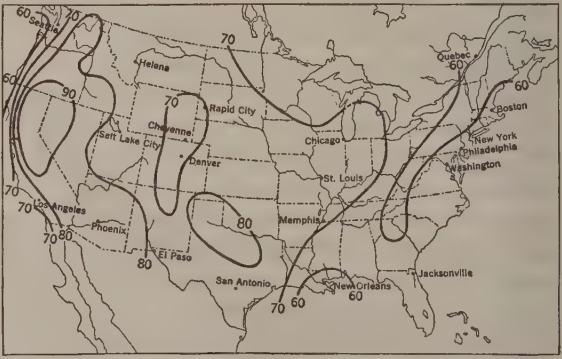


FIG. 6.—PERCENTAGES OF THE POSSIBLE AMOUNTS OF SUNSHINE IN THE UNITED STATES IN JANUARY, BASED ON MANY YEARS OF OBSERVATION

The accompanying charts (Figs. 6 and 7) show the percentages of the possible sunshine in all parts of the country for January and July, and indicate the approximate sunshine conditions for winter and summer respectively. (C. F. M.)

Sunshine Results for Other Parts of the World.—Maps showing the average annual distribution of sunshine over Europe and North America are given in Bartholomew's *Physical Atlas,*

Monthly and annual percentages of sunshine at points in the United States and in the vicinity of the Mediterranean Sea.

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Albany, N.Y.	40	51	53	53	56	59	58	57	57	50	37	36	51
Atlanta, Ga.	47	53	56	64	68	69	60	58	66	65	63	47	60
Bismarck, N.D.	53	58	56	58	58	62	71	69	62	60	52	49	59
Boise, Ida.	38	48	57	66	71	79	87	86	79	69	50	40	64
Chicago, Ill.	45	51	54	59	64	71	73	70	65	60	47	41	58
Columbus, O.	39	44	48	57	62	67	70	68	65	59	45	34	55
Denver, Colo.	67	67	64	62	60	69	67	67	71	71	68	64	66
El Paso, Tex.	74	79	83	87	89	89	79	77	81	84	78	75	81
Los Angeles, Calif.	67	68	67	68	62	71	77	79	76	76	78	73	72
Memphis, Tenn.	46	54	58	65	67	73	73	72	72	70	62	45	63
New Orleans, La.	48	50	57	60	66	60	54	54	61	64	56	46	56
Oklahoma City, Okla.	55	60	60	62	63	71	76	77	73	67	64	59	66
Omaha, Neb.	55	57	57	56	62	68	75	69	65	63	55	52	61
Portland, Ore.	25	32	39	47	50	56	70	66	52	43	26	23	44
Sacramento, Calif.	46	56	65	80	81	89	96	96	89	82	64	44	74
Salt Lake City, Utah	45	48	54	62	66	77	78	76	76	68	58	44	63
San Antonio, Tex.	51	53	57	57	62	71	73	75	71	67	52	52	62
Tampa, Fla.	61	65	72	75	73	67	63	64	66	65	65	59	66
Washington, D.C.	46	54	54	58	61	62	64	61	63	61	56	51	58
Yuma, Ariz.	75	82	87	94	95	97	89	91	92	93	87	79	88
Athens, Greece	49	50	52	55	53	66	81	81	73	61	43	37	60
Cairo, Egypt	61	62	62	67	76	85	85	86	77	71	70	62	73
Lisbon, Portugal	47	49	55	61	63	69	77	82	70	56	47	44	62
Madrid, Spain	52	59	58	64	65	74	85	83	69	59	47	46	65
Nice, France	55	53	50	52	60	60	70	75	63	50	50	45	57
Rome, Italy	38	45	42	44	50	62	76	73	59	47	44	37	53

vol. iii. *Atlas of Meteorology.* Over Europe the largest totals, over 2,750 hours per annum, are shown over central Spain. In North America, values exceed 3,250 hours per annum in the New Mexico region. For other parts of the world the information available is not sufficiently extensive for the construction of charts.

Effect upon Sunshine Records of the Smoke of Great Cities.—Much discussion has taken place from time to time as to whether the climate of a locality can be altered by artificial means. One question of the kind to which the sunshine recorder gives an incontrovertible answer is as to the effect of the smoke of great cities in diminishing the sunshine in the immediate neighbourhood. This is not a question which comes out merely by taking averages. The answer can be seen directly by comparing the daily cards at the different localities. Thus it appears that the direct effect of the local contamination of the London atmosphere results in the diminution of the recorded sunshine for the whole year by 37%, and it is clear that the contamination extends in some degree as far as Kew, where the loss amounts to about 10%. There is evidence of various kinds to show that the effect of the smoke cloud of cities can be traced sometimes for great distances.

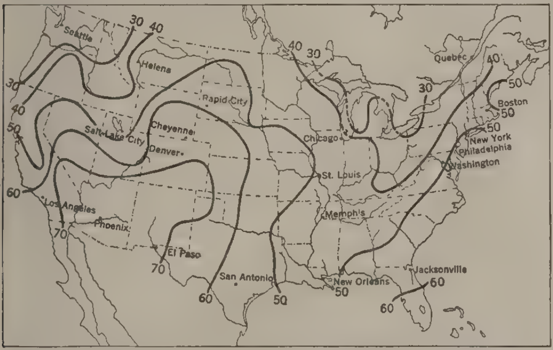


FIG. 7.—PERCENTAGES OF THE POSSIBLE AMOUNTS OF SUNSHINE IN THE UNITED STATES IN JULY, BASED ON MANY YEARS OF OBSERVATION

Ultraviolet Light.—A beam of sunshine contains radiation having a wide range of wavelengths. The human eye is only sensitive to about one octave of wavelength, from 0.4 microns (0.0004 mm.) to 0.8 microns (0.0008 mm.), corresponding to violet and red light respectively. Roughly one-half of the energy of a beam of sunshine is contained within the limits of visible light, and most of the remainder is accounted for by infra red or heat rays. Rays whose wavelengths are between 0.4 microns and about 0.014 microns are known as ultraviolet rays. Such rays are present in the solar beam, but with relatively small intensity. They are of little or no meteorological importance, so far as our present knowledge extends, but they are of very considerable importance in photography and in their actions on living organisms of all kinds. These rays are readily absorbed or scattered by impurities in the atmosphere, and even by relatively clear air, and one of the most serious effects of the smoke of great cities is the removal of the ultraviolet rays from the solar beam. Ordinary window glass also absorbs completely the ultraviolet rays of wavelength below 0.31 microns. Special types of window glass are however obtainable which transmit fairly freely ultraviolet light down to 0.2 microns. Ordinary sunlight contains no rays of wavelengths below about 0.29 microns.

Dr. Leonard Hill states (*Sunshine and Open Air,* page 47) that of the radiation reaching the outer limits of the earth's atmosphere some 40 per cent of the longer ultraviolet rays and 20 per cent of the shorter ultraviolet rays reach high level mountain resorts, and 23 per cent of the longer, and 7 per cent of the shorter ultraviolet rays reach sea level.

The intensity of solar radiation of different wavelengths can be measured by means of a spectrobolometer, in which a beam of sunlight is first spread out into a spectrum, and the light within a narrow band of wavelengths is allowed to pass on to a platinum strip. The strip of platinum forms one branch of a Wheatstone's bridge. The opposite branch is formed by an exactly similar platinum strip which is shielded from radiation. The energy absorbed by the first platinum strip raises the temperature and consequently increases the resistance of the strip. The increase in resistance is accurately measured by a galvanometer in the bridge circuit and the amount of radiant energy can be deduced.

Ultraviolet rays have marked biological effects, in particular those of pigmentation of the skin and of destroying certain bacteria. References to recent researches will be found in the *Annual Reports* of the British Medical Research Council, published by H.M. Stationery Office, London. Among recent results may be mentioned the discovery that ultraviolet rays between 0.28 and 0.30 microns are capable of activating ergosterol and producing vitamin D. (*See* a series of articles by various authors in a Supplement to *Nature,* April 21, 1928; *see* also RADIOLOGY; RADIO-THERAPY; SUNLIGHT-TREATMENT.)

SUNSTONE, a variety of the mineral felspar (*q.v.*) exhibiting a brilliant spangled appearance in certain directions, due to minute scales of iron oxide arranged parallel to a cleavage. It is somewhat similar to aventurine (*q.v.*). The best known locality in Tvedestrand, Norway. It is also found near Lake Baikal, Siberia, and at several localities in the U.S.A., especially at Middletown, Pa., and Statesville, N.C.

SUNSTROKE AND HEATSTROKE, a term applied to the effects produced upon the central nervous system, and through it upon other organs of the body, by exposure to the sun or to overheated air. Although most frequently observed in tropical regions, the condition occurs also in temperate climates during hot weather. A moist, still atmosphere greatly increases the liability to heatstroke.

Sunstroke has been chiefly observed and investigated among soldiers in India, where formerly, it constituted a considerable item of sickness and mortality. While any one exposed to great solar heat may suffer from sunstroke, anxiety, worry or overwork, irregularities in food, intemperance, the wearing of tight garments, marching in close order and living in overcrowded and insanitary dwellings are predisposing causes. A similar condition affects persons whose occupation exposes them to excessive heat, such as stokers, laundry workers, etc., particularly in hot weather. In the tropics Europeans, especially recent arrivals, are more readily affected than natives. But natives are not exempt.

The symptoms of heatstroke, which depend upon disorganization of the normal heat-regulating mechanism, vary in their intensity and to some extent in their form. A case of average severity usually begins with sickness, giddiness, mental excitement followed by drowsiness, and passes into syncope in which there are pallor and coldness of the skin, a weak, quick and intermittent pulse, and gasping or sighing respiration. The internal temperature is raised even as high as 108° F or more. The pupils are often contracted. Death may quickly occur; but if timely treatment is available recovery is probable.

Attacks of sunstroke are apt to leave traces of their effects especially upon the nervous system. A liability to severe headache, which may depend upon chronic meningitis, epileptic fits, mental irritability and alterations in the disposition are among the more important. Heat is ever afterwards ill borne and there also is an abnormal susceptibility to the action of stimulants.

Treatment.—Means should be adopted to prevent attacks in the case of those who must necessarily be exposed to the sun. These consist in the wearing of loose, light coloured clothing, protection of the head and back of neck, supply of sufficient water or cold tea to make up for fluid lost by sweating, avoidance of alcoholic and other excesses. Sleeping in the open air in very hot seasons is recommended. In an attack the patient should be at once removed into the most shaded, airy and cool place available. Rest in the recumbent position, the use of diffusible stimulants, such as ammonia or ether, etc., together with friction or warmth applied to the extremities may be sufficient, but in severe cases by far the best results are obtained by the use of cold (cold baths, rubbing the surface with ice, enemata of ice-cold water). The effect is a marked lowering of the temperature and stimulation of the respiratory function. Mustard or turpentine applied to the nape of the neck or chest is a useful adjuvant.

SUN YAT-SEN (1867–1925), Chinese republican leader. Dr. Sun (known in China by the more familiar title of Sun Wen) may truly be described as the Father of the Chinese republic. His father, a poor farmer living at Hsiang Shan near the island of Macao, was a convert to Christianity (under the London Missionary society) and his son continued to describe himself as a Christian till his death, before which he gave instructions that he should be buried with Christian rites.

In 1891 Sun entered upon a medical course at the newly formed medical school in Hongkong of which he was the first graduate in 1894. It was here that his life-long friendship with Sir James Cantlie began. Through a Chinese fellow student, Sun came into association with a secret revolutionary society. He was concerned in a revolutionary plot in 1895, but escaped, though the other conspirators were executed. Then began a long period in Sun's life, when, like Mazzini, he was working outside his native country with the object of bringing about a revolution. In 1898 he adopted the three fundamental principles of Nationalism, Democracy and Socialism; the five spheres in which they were to be worked out were: the executive government, the legislative field, the judicial field, the civil examinations and the department of censorship or impartial scrutiny of public matters and officials.

It was not, however, until 1905 that Sun publicly declared his adherence to these ideas and worked them out in fuller detail. He attempted to use the reaction after the Boxer outbreak of 1900 as a means of establishing a democratic government and ending the Manchu régime, but this attempt as others proved abortive. In 1905 the Chinese Revolutionary League was formed in Europe and Japan, and through this Dr. Sun enlisted the support of a great number of Chinese not resident in China. During this period he raised large sums of money, and was thus able to spread his ideas through secret agencies in China itself. A large price, finally amounting to £100,000, was placed upon his head. On one occasion in 1896 he was kidnapped while in London and held at the Chinese legation for several days. His release came about through a note to Sir James Cantlie, which was smuggled out of the legation. Lord Salisbury then took the matter up.

Sun's personal influence had much to do with the inner organization of the revolution of 1911 against the Manchu government (*see* CHINA, *History*). While there was a widespread feeling that the dynasty had outlived its usefulness, there was little understanding of what was involved in establishing a republic and only the efficient organization of the Kuo-min-tang (Sun's creation, known as the Republican party) was able to turn the anti-Manchu tide into a pro-republican movement. Sun was in England when the revolution began. He returned to China, and on Jan. 5, 1912, he took the oath of office as provisional president of the new republic, at the request of the national convention in Nanking.

On Feb. 12 an imperial edict announced the abdication of the emperor and the substitution of republican for monarchical Government. Yuan Shih-K'ai was entrusted with the task of carrying through the changes involved, and Sun, realizing the impossibility of uniting the country under his own presidency, resigned his presidency in favour of Yuan. He accepted the post of Director-General of Transport and Trade, but was always more of the propagandist and inspirer than the practical administrator.

He became increasingly restless under the leadership of Yuan Shih-K'ai, and in 1917, after the latter's coup d'état and death, he put himself at the head of a movement for an independent republic of South China. The strength of his support had always been drawn from Kwang-tung province, and he soon found it impossible to co-operate with the military leaders in Canton. He therefore resigned from his position as president of the republic of South China. The military régime was maintained largely by Kwang Si troops until 1921 when Ch'en Ch'iung-ming drove them out and called in Sun again.

The following year he determined on an advance in force against the north, while Ch'en Ch'iung-ming desired to consolidate the work begun in the province of Kwang-tung. This led to an open breach and Sun was once more driven from his native province, finding refuge in Shanghai. In Feb. 1923 he called to his aid troops from Kwangsi and Yunnan and thus defeated his one time colleague and subsequent rival, General Ch'en. From that time until his death he was acknowledged as the chief executive of the province, but his effective sway did not extend far beyond Canton. He used and permitted violent methods, more particularly in the attack upon the Merchants Volunteer corps and the looting and burning of a considerable part of the city of Canton in March 1924. In this way he lost much of the support which had been given to him and to the Kuo-min-tang by Chinese overseas. But his socialist views ensured him the support of the mass of the workers, and he repeatedly secured rises in wages for the Canton workers.

So far as local support was concerned Sun's star seemed to be declining in the autumn of 1924, but he was still idolized by the student class and in his own party where his was a name to conjure with. It was then that Feng Yü-hsiang brought about his coup whereby Wu Pei-fu (a determined enemy of Sun's) was routed and Chang Tso-ling co-operated with Feng to put the old Anfu leader Tuan Ch'i-jui in the position of Chief Executive in Peking. Sun had been cultivating friendly relations with the parties now predominant, and he was called to Peking to confer with them in regard to the calling of a people's conference and other matters connected with the establishment of the new régime. He died of cancer on March 12, 1925, at Peking. An impressive memorial, built at Nanking, received his remains in 1929.

His public works include a number of speeches, articles and pamphlets, more particularly the following: *The Doctrine of Sun Wen; The International Development of China; The Principles of Democratic Government* (statement of 25 outstanding points). *See* Sir James Cantlie and C. S. Jones, *Sun Yat Sen and the Awakening of China* (1912); P. Linebarger, *Sun Yat Sen and the Chinese Republic* (1925); *Sun Yat Sen, Memoirs of a Chinese Revolutionary* (1927).

SUPERANNUATION. The custom of providing pensions for aged employees who, after meritorious service, are no longer able to discharge their duties efficiently, has become increasingly common since the middle of the 19th century. The problem of mitigating the hardships of old age has been attacked from many angles and a great variety of solutions has been tried. In England superannuation schemes for discharged seamen and soldiers date back to the middle ages; these were followed by systems applicable to civil servants and other public officials, and to employees of statutory undertakings. Finally the custom of making some kind of provision for old age has gradually spread to the employers of labour on a large scale and even to businesses with relatively small staffs. Simultaneously the question has received attention on national lines; this aspect of the subject is treated under OLD AGE PENSIONS, the present article being limited to the examination of superannuation schemes in which the title to benefits has its roots in service given to a particular employer during the pensioner's working life.

At the outset the granting of a pension is often merely an eleemosynary act dictated by the employer's wish to reward meritorious service, or to safeguard an old servant from penury in his declining years. Later, the occasional grant in these circumstances having become a custom, superannuation allowances come to be looked upon as a right by the officials, and as a means of securing efficiency by the employer, who realizes that the retention of aged officials no longer fitted to perform their duties adequately—especially if they hold responsible posts on the directing staff—seriously jeopardizes the conduct of his business. In such a case a definite scheme prescribing the ages between which retirement shall normally occur (generally between 60 and 65), laying down scales and conditions of benefit and defining the class of officials to be included is soon recognized, both by the employer and by the employees, to be essential. With regard to finance the need for sound principles was unfortunately in the past not realized so soon. The expenditure on pensions, being almost negligible in the early years, was often charged to current revenue, and until this burden became heavy as the numbers on the pension roll grew, causing expenditure to increase at an alarming rate, the need for making provision for accruing liabilities was not appreciated. Generally speaking, prudential considerations dictate that appropriate sums should be set aside and accumulated at compound interest throughout a person's service, while the liability for superannuation is accruing, in order that when he retires the sum in hand shall be sufficient to provide for his superannuation allowances. By this method full provision being made before the pension commences, the burden of superannuation is met *pari passu* with payments of salary during service.

The accumulation of the appropriate reserves can be effected either in a privately managed superannuation fund or by an assurance company on behalf of the managers of the scheme. Under the former arrangement it is usual to institute a trust fund definitely alienated from the ordinary business transactions of the employer. In Great Britain such funds enjoy certain privileges in regard to income tax upon their interest income. Similarly concessions are allowed in respect of contributions whether paid by the employer or employee to a superannuation scheme.

Provident Funds.—The simplest form of superannuation scheme is a fund supported by periodical contributions (of fixed amount or varying with salary) generally paid in equal shares by the employer and the staff. On retirement the employee is entitled to withdraw the contributions paid by himself and on his behalf by his employer, with their accumulations of interest. A development of this plan is an arrangement for the accumulated sum at retirement to be applied as purchase money for an annuity payable for the remainder of life; the amount of pension available in a particular case is not ascertainable in advance, but depends on the rate of interest earned while the contributions are accumulating in the fund and the annuity rates current at the date of retirement.

Superannuation Pensions Schemes.—The superannuation schemes which definitely provide for pensions are, however, generally considered to be more appropriate to the requirements of both the employer and the staff than the simple system described above. The pension may be of fixed amount, or may vary with length of service; in the latter case the amount of pension may be uniform for each year of service, or be related to the salary earned by the official during the whole or last few years of service. Systems under which the pension depends both on the duration of service and also on salary have become increasingly popular owing to their elasticity in application to the differing circumstances of a salaried staff consisting of many grades. There are, however, many schemes in which fixed pensions or pensions which grow by uniform increments for each year of service have been adopted as peculiarly appropriate to the needs of the case, *e.g.*, where a scheme is limited to workmen.

In systems based on salary it is common practice to express the pension as a specified proportion (*e.g.*, $\frac{1}{80}$) of pensionable salary for each year of service, subject to a maximum (*e.g.*, forty-sixtieths). There are numerous methods of defining pensionable salary, the most popular being probably the terminal salary, *i.e.*, that earned in the last year before retirement or, in order to avoid fortuitous inequalities of treatment, the average of the last few years of service. Another plan often adopted is to take the average salary throughout service. Where the employee contributes a fixed percentage of his salary throughout his service, and the employer makes annual payments equal to the aggregate contributions made by his staff, it has been argued that from the standpoint of equity the resulting pension should be related to the contributions which have been paid by, or on behalf of, the beneficiary and that accordingly the average salary method should be adopted. But a practical objection to this is that the pension based on average salary is likely to be insufficient to enable a senior officer to maintain a reasonable standard of comfort after retirement unless the scale is fixed so high as to be over-generous to the lower-paid ranks. In this connection it has to be remembered that while all new entrants, with trifling exceptions, start in junior grades entitled to low salaries, their progress varies widely. Judged on the principle that an official, retiring after long service, ought to be able to maintain approximately the style of living to which he has been accustomed, anomalies appear inevitable under the average salary system, and for this reason the terminal salary system has become increasingly popular. With regard to the contention that the average salary system is fairer to the lower paid grades, it may be said that as one of the main objects of an employer is to secure efficiency his contributions may fairly be allocated in the best way to achieve this purpose; and it is generally agreed that since even under the terminal salary method the employee, whatever his rank, receives at least full value for his own contributions and some part of the employer's subvention, the unequal distribution of the latter is not a valid criticism of the fairness of the scheme viewed as a whole.

The average salary system approximates more nearly to giving each employee the equivalent of his own contributions increased proportionately out of the employer's grant, but if exact equivalence is desired the scheme has to be framed on other lines. In such a case each contribution secures a definite amount of deferred pension, varying with the amount of the contribution, the age of the employee and the age at which the pension is to commence. On retirement instalments of pension purchased throughout service are aggregated. The system, generally known as the "money purchase" plan, is easy to work and is often adopted, especially in America and where it is found convenient to re-insure the liabilities for pension with an assurance company in lieu of instituting a private superannuation fund.

Subsidiary Benefits.—Apart from normal superannuation the claims of persons who become incapable of work owing to ill-health before reaching the normal pension age have also to be considered. The hardship of loss of income is obvious, and generally the rules provide for some compensation to be given. In contributory schemes the return (with interest) of the official's own contributions is commonly allowed, but many schemes go further and permit pensions (proportionate to duration of service) to be granted if permanent breakdown occurs after a prescribed minimum period of service. Difficulties may arise in administering a subsidiary benefit of this kind since the test of permanent incapacity is not easy to fix; if it is too rigid, cases of hardship arise, but the financial implications on the stability of the scheme caused by a lax interpretation are very serious. For this reason it is generally considered undesirable to provide for breakdown pensions unless the authority in whom administration is to be vested is prepared to assume responsibility for financial soundness. If an official dies in harness or resigns, voluntary return of at least his own contributions is customarily made; sometimes a minimum payment on death of a year's salary is guaranteed. Subsidiary benefits of the types described above are relatively costly, the effect of giving such concessions being to diminish the resources available for the main benefit, viz., ordinary pensions; to secure a fair balance between these opposing claims is often not easy when a scheme is being framed.

Financial Principles.—As indicated above, the need for sound financial arrangements was often overlooked when the earliest schemes were started; in the following section the underlying principles of contributory schemes are briefly examined. In order that a fund may be in a position to meet its obligations it is essential that the capital in hand, together with the real value of contributions payable in the future, is not less than the present value of future benefits. If this equivalence is maintained, the accumulated fund will continue to increase over many years until the expenditure on benefits becomes stabilized. Where, for example, the number of new entrants each year is constant over a long period the position will eventually be reached when the current expenditure will exactly balance the combined income from contributions and interest. When this occurs the active and retired staff will have reached a stationary condition and very substantial reserves are necessary since in many cases the current expenditure on benefits grows to more than twice as much as the contribution income, and the interest on a fund, which may amount to more than double the current salary bill of the firm, is required to secure equilibrium. The fund should be sufficient without relying on the contributions of future entrants, and its solvency should not be jeopardized if it is decided to close the fund to new entrants. In the past the reasons why large funds should be built up were not always appreciated, and it sometimes happened where a sound fund had been accumulated that an uninformed decision was taken to increase benefits without regard to the enhanced liabilities, often with disastrous results. This experience was not confined to one country in particular. Many instances in which a scheme having been started on unsound lines had to be reconstructed later can be found both in the British Empire and in America. In this connection reference can usefully be made to the *Report* of the New York City Pensions commission (1916) and to the history of superannuation schemes in the British railways. Thus, during the latter part of the 19th century the practice of providing superannuation benefits for railway officials, especially for salaried staff, spread over most of the British railways. Certain important weaknesses were disclosed in 1910 by a departmental committee (*Report on Superannuation and Similar Funds of Railway Companies:* Parliamentary Paper Cd. 5349); in many cases the benefits had been increased without full understanding of the financial implications and in certain instances little provision was made for accruing liabilities, so that the emerging charge under the company's guarantee would ultimately have become a very grave addition to the normal running expenses. The number of funds has since been materially reduced when the railways were amalgamated in a few large groups after the World War, and the opportunity was taken, where necessary, to readjust the financial arrangements.

Before a scheme is launched the actuary has to estimate the contribution required to provide the benefits, basing his calculations on the various elements affecting the problem; the principal of these are the rate of interest which will be earned on well-secured investments, the rates of mortality likely to be experienced by the active staff and pensioners respectively, the proportion of staff who will resign voluntarily or who will be retired on health grounds before reaching the normal pension age, and the rate of progression of salaries (on the average) from age to age during service. Such an estimate must necessarily be tentative since experience as to all or many of these elements may change in the future; it is necessary, therefore, that the financial structure of the scheme should be reviewed periodically by an actuary and, if the valuation discloses a deficiency or a disposable surplus, appropriate action should be taken to restore equilibrium.

Back-Service.—At the initiation of a scheme the determination of the terms on which existing officers should be included presents some difficulty. To put such persons into the position which they would have occupied had they become contributors to the scheme when they joined the staff is very costly, but some credit for back-service is generally deemed essential, otherwise the pension available in many cases would be too meagre for subsistence. In practice the problem has been dealt with in various ways; for example it is not unusual to provide for all back-service to count at one-half of the standard rate, the whole of the cost of the concession being borne by the employer. Even so the liability cast upon the fund at the outset is substantial and ordinarily its redemption is carried out over a period of years.

Life Office Schemes.—Assurance companies offer many facilities to employers desirous of setting up superannuation schemes, and often an arrangement for the liabilities to be reinsured with a company is preferred in lieu of instituting a private superannuation fund. There is a wide choice of contract, and though generally speaking it is not possible to secure quite so much elasticity (*e.g.,* in regard to disability) as under a self-contained scheme the method is popular because it is simple to work and because it protects the employer from the effects of fluctuations of experience. Again it is peculiarly adapted to occupations where migration from one employer to another is customary, and for this reason is common in America where, generally speaking, immobility is thought to be a clog on efficiency. Provident schemes and money purchase schemes can successfully be arranged with a life office, each contribution (whether fixed or a percentage of current salary) securing a definite endowment or pension, as the case may be, in accordance with a scale prescribed in the policy. Common forms of policy provide in return for periodical contributions, deferred annuities of a fixed sum payable on attainment of a specified age (with or without returns of premiums in the event of earlier death), or endowment assurances securing a lump sum (with or without bonuses) at a specified age or earlier death.

In those cases where the contribution is based on salary the amount of the annuity or the sum assured is fixed in relation to the salary current when the policy is taken out, supplementary contracts being effected when increases of salary occur. A variation of the deferred annuity system provides an annuity of fixed amount for each year's service; the increment of pension being secured by the contribution (increasing year by year) paid in the related year of service. Examples of the life offices schemes are provided by the Federated Superannuation system for universities, under which a percentage of salary is paid by the professor, together with a contribution from the college, as a premium to provide for such superannuation benefits as may be chosen through any one of a number of assurance companies constituting a panel, and by the Federated Superannuation scheme for nurses and hospital officers; in both of these cases the plan was definitely adopted after a comprehensive review of other alternatives. In America the superannuation of certain classes of teachers is arranged on similar lines, contracts being effected on especially favourable terms owing to subventions from the Carnegie foundation for the advancement of teaching, instituted in 1905. Another plan, which had its origin in America, is to make provision for pensions by a group assurance covering several provident benefits for the staff of a particular undertaking. These group policies at the outset afforded protection against death only, and were gradually extended to disability and superannuation.

Appended to this article is a short list of publications from which more detailed information can be obtained. Of these the reports deal with the subject primarily from the point of view of public or quasi-public services, whereas the books are more helpful to an employer contemplating setting up a superannuation scheme for his staff.

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(G. S. W. E.)

SUPEREROGATION, the performance of more than is asked for, the action of doing more than duty requires (late Lat. *supererogatio,* payment beyond what is due or asked). In the theology of the Roman Church, "works of supererogation" are those which are performed beyond what is required by God, thus forming a reserve store of works of merit which can be drawn upon for the dispensation of those whose works fall short of the standard. See *Catholic Encyclopaedia,* article "Supererogation."

SUPER-HETERODYNE RECEPTION, a means of radio reception in which the received current is combined with the current from a local oscillator (*q.v.*) and changed into a current of intermediate frequency. This is then amplified and detected to reproduce the original signal wave.

SUPERINTENDENT, a term which, apart from its general use for an official in charge, has a distinct religious connotation, being applied, *e.g.,* to the head of a Sunday school and to the chief minister in a Methodist circuit. In its most important historical sense it refers to certain ecclesiastical officers of reformed churches of the Lutheran model.

In the confusion of the Reformation the name of superintendent was given to a class of men who discharged many of the functions of the older bishops, while bearing a character which in several respects was new. Only in Denmark was the name of bishops reserved for the new officers after the Lutheran model had been adopted and the older bishops had been deposed and imprisoned.

It is still used there, though no claim is made that it is the sign of formal apostolical succession. In Scotland the *First Book of Discipline* provided not only for ministers, teachers, elders and deacons, but also for superintendents and readers. The superintendents (who were appointed because of the scarcity of Protestant pastors) took charge of districts corresponding in some degree with the episcopal dioceses, and made annual reports to the general assembly of the ecclesiastical and religious state of their provinces, in the churches of which they also preached.

Duties of Superintendents.—The distinctive character borne by the new officers was determined by the cardinal principles which Luther had laid down in his work regarding the religious functions of the state. He conceived of the secular government as an ordinance of God, and as being set to direct and control the external fortunes of the Church. He hoped that righteous magistrates would at all times form a sound court of appeal in times of ecclesiastical disorder, and that they would guard the interests of truth and justice more securely than had been done under papal jurisdiction. The superintendents, who now had to undertake large administrative responsibilities in the Church, were therefore to be appointed by the civil power and to be answerable to it. They were to stand as intermediaries between the prince or magistrates on the one hand, and the ministers in their districts on the other.

The character of the office and duties of the superintendent were not everywhere the same. Luther shrank from imposing any stereotyped forms and asked that the special circumstances of each separate district should be consulted. He hoped that as few changes as possible would be made, and trusted that the reformed doctrines would spread peacefully throughout the country. After the Diet of Speyer (1526) the civil authorities were invited to reorganize the Church in their respective dominions as they thought best. In the free towns superintendents were answerable to the city fathers for their good order. There were difficulties in the territories of the German princes, and in the case of Saxony Luther proposed to the elector that his first step should be to send out a commission of visitation which should report on the moral and spiritual condition of his principality, district by district. His proposal was carried out, and Luther himself became one of the visitors (1527–1528). He found the people in a state of such religious indifference and ignorance, and the clergy living often in such grossness, that his faith in their fitness to govern themselves ecclesiastically sank even lower than before, and he resisted all schemes for self-government such as had been proposed by Francis Lambert. The church organization which he devised for Saxony provided no place for democratic or representative elements: the grasp of the state must at all times be felt. The superintendent must speak at all times as a minister of the state, and the state must be represented in the synod to which he makes his first report, for upon the synod there must sit not only the pastors but also a delegate from every parish. If any appeal should be made from the decisions of the synod it must be heard in the court of the electoral prince, for he, as supreme civil ruler, possessed the *jus episcopale*, the right of oversight of the churches. Luther proposed that he should exercise this right by appointing a consistorial court composed in part of theologians and in part of canon lawyers, and it was thus that in 1542 the Wittenberg ecclesiastical consistory was formed. Other principalities adopted the model, so that the institution became common throughout the Lutheran churches.

In this scheme the superintendent (or superattendant) was charged with such part of the duty of the older bishops as had been purely administrative. He must concern himself with the discharge of their duties by the pastors of the churches, as well as with their character and demeanour. He must supervise their conduct of public worship, as well as give them licence to preach. He must take cognizance of their ministry to the indigent in their parishes, and of their management of the schools. He must further direct the studies of candidates for the pastoral office. He was answerable to the civil authorities to report all evil-living and false teaching.

The earliest occasion of the appointment of such a superintendent would seem to be found in the decisions of Prince John of Saxony about 1527. He assigns the duties of the office, and summons the newly appointed officer to give diligent heed to the conduct and teaching of the pastors under him, faithfully to warn them of all errors, and, in case they prove obstinate, to report them to the electoral court. He must further give close attention to the due observance of the marriage laws, for in this matter the previously appointed visitors to the principality had reported grave laxity.

Some of the smaller principalities appointed but a single superintendent for their territory, who, instead of being answerable to a consistory, sat as spiritual member on the territorial council, whilst in towns the superintendent was summoned to the town council whenever Church matters arose for discussion. In larger states there were various classes of superintendents with their respective duties severally assigned.

In modern times the functions of the superintendent have been somewhat confused in consequence of the introduction into Lutheran Church theory of inconsistent elements of Presbyterian and synodal type.

See T. M. Lindsay, *History of the Reformation* (1906), i. 400–416; and the articles "Kirchenordnung" and "Superintendent" in Herzog-Hauck's *Realencyklopädie für protestantische Theologie und Kirche.*

SUPERIOR, a city in the north-western corner of Wisconsin, U.S.A., at the western end of Lake Superior, opposite Duluth (Minnesota), with which it is connected by bridges; a port of entry and the county seat of Douglas county. It is on Federal highways 2 and 53, and is served by the Chicago, Milwaukee, St. Paul and Pacific, the Chicago, St. Paul, Minneapolis and Omaha, the Duluth, South Shore and Atlantic, the Great Northern, the Northern Pacific and the Soo Line railways, and many lake steamers. Pop. (1920) 39,671 (27% foreign-born white, largely from Sweden, Norway and Canada). The city occupies a spacious site (36·1 sq.m.) on gently rising ground facing three bays (Superior, Allouez and St. Louis). It has 29 m. of water front, and shares with Duluth (*q.v.*) one of the finest natural inland harbours of the world, ranking second only to New York among the ports of the United States in the amount of commercial tonnage handled (52,712,269 tons in 1927). There is ample waterpower, and the manufacturing industries are important, with an output in 1925 valued at $21,536,898. Superior has a cheap fuel supply and power is furnished by electricity generated on the St. Louis river. Superior is an important grain market. Flour is the principal product, and shipbuilding is important. Among steel ships, the type, now almost entirely extinct, known as the "whaleback" originated here; and iron and wooden ships, launches and small pleasure craft are also made. Other manufactures are railway cars, casks, cooperage, saw and planing mill products, furniture, wooden ware, windmills, gas-engines, and mattresses and wire beds. Much iron and copper ore is shipped from the Duluth-Superior harbour; and large quantities of coal, brought by lake boats, are distributed from here throughout the American and Canadian North-west. Superior is the seat of a State Teachers college (established 1893).

Pierre Esprit Radisson and Medard Chouart des Groseilliers probably visited the site of Superior in 1661, and it is practically certain that other French *coureurs-des-bois* were here at different times before Daniel Greysolon, Sieur Du Lhut (Duluth), established a trading post in the neighbourhood about 1678. About 1820 the Hudson's Bay Company established a post here, but there was no permanent settlement until after the middle of the 19th century. Attention was directed to the site by a survey made by George R. Stuntz, a government surveyor, in 1852, and in 1853 a syndicate of capitalists, at the head of which was William Wilson Corcoran, the wealthy Washington banker, associated with whom were Senators Stephen A. Douglas (for whom the county was named), R. M. T. Hunter and J. B. Bright, Ex-Senator Robert J. Walker, Congressmen John C. Breckinridge and John L. Dawson, and others, largely Southern politicians and members of Congress, bought lands here and platted a town which was named Superior. The proprietors secured in 1856 the construction of a military road to St. Paul, Minnesota, 160 m. long. The town grew rapidly, and in 1856–1857 had about 2,500 inhabitants. The panic of 1857 interrupted its growth, and the population dwindled so that in 1860 there were only a few hundred settlers on the town-site. The Civil War increased the depression, and the lands of those who had taken part against the Union were confiscated. In 1862 a series of stockades was built as a protection from the Indians. Within the area under the government of the town of Superior, which was at first co-extensive with the county, West Superior was platted in 1883 and South Superior soon afterwards. A village government was established in September 1887, including the three settlements mentioned, and in April 1889 Superior was chartered as a city. The harbour was surveyed in 1823–1825 by Lieut. Henry Wolsey Bayfield (1795–1885) of the British Navy. In 1860–1861 it was resurveyed by Captain George G. Meade, who was engaged in the work at the outbreak of the Civil War. A branch of the Northern Pacific railway was built to Superior in 1881.

SUPERIOR, LAKE, the most north-westerly of the Great Lakes of North America, and one of the largest bodies of fresh water in the world, is bounded on the east and north by the Province of Ontario, on the west by the State of Minnesota, and on the south by Wisconsin and Michigan.

Physiography.—It has deep, extremely cold, clear water, and high and rocky shores along a large portion of its coast. Its general form is that of a wide crescent convex towards the north, but its shores are more irregular in outline than those of the other lakes. Following the curves of its axis from west to east the lake is about 383 m. long, and its greatest breadth is 160 miles. Its maximum recorded depth is 1,180 ft., and its mean height above sea-level 602 ft., about 21 ft. above that of Lakes Michigan and Huron, to which it is joined at its eastern extremity through the river St. Mary. The lake receives the waters of 200 rivers, and drains a territory of 49,080 sq.m., the total area of its basin, including the water surface of the lake, being 80,900 sq. miles. The largest river which empties into it is the St. Louis, at its western end. The principal rivers on the north shore are the Pigeon, which forms the international boundary line, the Kaministikwia, the Nipigon, which drains the lake of the same name and together with the lake is about 200 m. long, the Pic, the White and the Michipicoten. No large rivers empty into Lake Superior from the south. There are not many islands in the lake, the largest being Isle Royal, 44 m. long, Michipicoten island in the eastern part; St. Ignace, in the northern part, off the mouth of the Nipigon river; Grand island between Pictured Rocks and Marquette; Manitou island east of Keweenaw Point, and the Apostle Group, to the north of Chequamegon bay.

The boundary between the United States and Canada follows a median line approximately to about mid-lake; thence it sweeps north-westward, so as to include Isle Royal within the territory of the United States, and continues near the north shore, to the mouth of Pigeon river, which it follows westward, leaving the whole west end of the lake in U.S. territory.

Resources of Region.—The Lake Superior region is rich in minerals that have been extensively worked. The lake is, as it were, surrounded by iron, which is the probable cause of very strong magnetic fields of influence. Native silver as well as silver ores exist around Thunder bay, native copper was formerly worked on Isle Royal, and rich copper mines are worked on the south shore, while nickel abounds in regions of the country north of the lake.

Coasts and Currents.—It has a picturesque coastline, the north shore particularly being indented by deep bays surrounded by high cliffs; the islands also rise abruptly to considerable heights, the north shore furnishing the boldest scenery of the Great Lakes. On the south coast, opposite the broadest part of the lake, are precipitous walls of red sandstone, extending about 14 m., famous as the Pictured Rocks, so called from the effect of wave action on them. There are no appreciable tides and little current. A general set of the water towards the outlet exists, especially on the southern shore. From the Apostle islands to the eastward of Keweenaw point this current has great width, and towards the eastern end of the lake spreads out in the shape of a fan, a branch passing to the northward and westward reaching the north coast. Autumn storms raise dangerous seas. The level varies with the season, and also from year to year, the maximum variation, covering a cycle of years, being about 4 feet. The discharge of the lake is computed to be 75,200 cu.ft. per second at mean stage of water, and is controlled by dikes and sluice gates at the head of St. Mary's falls.

Navigation.—The season of navigation, controlled by the opening and closing of the Sault Ste. Marie canals, averages about eight months—from the middle of April to the middle of December. The lake never freezes over, though the temperature of the water does not, even in summer, rise far above freezing point. The bays freeze over and there is border ice, often gathered by wind into large fields in the bays and extremities of the lake.

Harbours.—Lake Superior is fairly well provided with natural harbours, and works of improvement have created additional harbours of refuge at various points. Marquette, Mich., Presque Isle Point, Mich., Agate Bay, Minn., Grand Marais, Minn., and Ashland, Wis., are on bays which have protective breakwaters across their mouths. Duluth, Superior, Port Wing, Wis., Ontonagon, Mich. and Grand Marais, Mich., are harbours with entrances formed by parallel jetties extending across obstructing bars. On the Canadian side Fort William, in the mouth of the Kaministikwia, and Port Arthur, 4 m. distant, an artificial harbour, are the only important shipping points, being the lake terminals of two great trans-continental railway systems, though the whole north shore is liberally supplied with natural harbours.

Commerce.—The traffic on Lake Superior grows constantly in volume. The data collected at United States and Canadian locks at the Sault was as follows in 1927: passengers 55,115; coal 17,107,500 tons; flour 938,344 tons; wheat 9,926,945 tons; other grain 2,948,295 tons; iron ore 50,098,068 tons; miscellaneous 2,334,912 tons. The total traffic was 83,354,064 tons, valued at over $1,000,000,000. The increase in the past 20 years has been about 100% in both tonnage and value. The principal freight shipped eastward consists of flour, wheat and other grains, through Duluth-Superior from the United States, and through Fort William-Port Arthur from the Canadian prairies; copper ore from the mines on the south shore; iron ore in immense quantities from both shores, the principal ore-shipping ports being Ashland, Two Harbors, Marquette and Superior, and lumber produced on the tributary rivers. West-bound freight consists largely of coal for general distribution and for terminal railway points.

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SUPERMAN, means generally an ideal man. The term plays an important rôle in the philosophy of Nietzsche (*q.v.*) who is mainly responsible for the vogue which the term has.

SUPERNATURALISM, a term that may be used for the attitude of mind in which experience of the unfamiliar or uncanny appears to invest it with a distinct character, as if it belonged to a world of its own. On the psychological side it involves the somewhat complex mood known as awe, in which, as W. McDougall shows, various primary feelings such as fear, wonder and submissiveness commingle in no very fixed proportions. On the institutional side it provides raw material alike for magic and for religion. As Hartland puts it, commenting on Marett's use of the term, supernaturalism furnishes the original "theoplasm, god-stuff." Primitive notions of the type of *mana* (q.v.) refer to this special class of experience in which the subject feels powerfully moved and the object seems powerfully moving, so that both inwardly and outwardly wonders happen, whether for better or for worse. It is certain, on the other hand, that the savage does not spend all his time in wonderland, but distinguishes another world, another level of experience, which as the Polynesians phrase it, is *noa,* "commonplace"—the routine of every day. Our word "natural" has to-day very similar associations, though as a matter of fact, if Hubert and Mauss are right, the Greek *physis,* literally "growth," from which our conception of nature is derived, originally meant much the same as *mana,* namely, the occult force that makes things grow and develop. If it is felt that the word "nature" ought to be reserved for the whole order of the universe, as being really rational and intelligible whatever appearances there may be to the contrary, the more pedantic term "super-normalism" may be substituted; though it cannot be denied that psychologically and historically men have been inclined to view the regular course of things, and certain strange and moving interruptions of it, as sharply contrasted aspects of mind and being.

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(R. R. M.)

SUPERNORMAL CHILDREN, EDUCATION OF, the specialized education of children of high intelligence to give them the fullest opportunity to develop to the limit their mental capacity, has attracted widespread attention in the United States, especially since the World War. The results of scientific studies of human heredity and the wide range of mental differences disclosed by the application of intelligence tests to millions of children and adults have exploded the absurd doctrine of human equality. There is a growing recognition of the importance of making the most of our resources of genius, and an increasing interest in the identification and training of gifted children.

That the reform movement in this direction is already under way is indicated by the fact that the 1920 and 1924 *Yearbooks of the National Society for the Study of Education* were both devoted to the education of gifted children. An enquiry which was sent out in 1925 to 413 cities of more than 20,000 population brought the information that 173 of 220 cities replying were making special provision of one kind or another for children of superior ability. In 33 of the 173 cities the special provisions involved little more than an effort to identify the gifted in order that they might be allowed to skip an occasional grade. In the remaining 140 cities, however, a great variety of experiments was under way. The practice of employing "coaching" teachers to prepare bright pupils for grade skipping is fairly common. The little city of Winnetka, Ill., has abandoned class instruction in favour of a system of individual teaching which is intended to allow each pupil to make as rapid progress as his ability permits. The Winnetka plan has aroused keen interest throughout the country, but has not been extensively adopted. An argument against it as a method of meeting the needs of the gifted is that it does not provide differentiated curricula for children of different grades of ability. Some 50 or more cities have attacked the problem in a more fundamental way by adopting the "multiple track" plan of classification of pupils by ability into X, Y and Z groups. By this plan there are three tracks, instead of one, from the first grade up to (and sometimes through) the high school, with a different curriculum for each. The "X" pupils usually include the ablest 5% or 10%. It is not a primary purpose of this plan to enable the bright pupils to complete the elementary or high school course at an earlier age. More important is the fact that the curriculum for the X group is greatly enriched and the methods of instruction considerably modified. Oakland, Cal., began the reorganization of its schools on this plan in 1918, Detroit in 1922, and New York city in 1928. There are in many cities "opportunity" classes for the more exceptionally gifted. These classes are sometimes the sole provision, sometimes only one feature of a larger plan. The degree of ability necessary for admission is not uniform, but the more commonly accepted standard is one that cannot be met by more than five or ten children out of 1,000. The purpose of the opportunity class is not to stimulate pupils to accomplish more work of the usual kind, but rather to develop the intellectual initiative that will enable them to work on a higher level. Drill and other forms of routine are reduced to a minimum. Complete freedom of movement is allowed. For the greater part of his time each pupil works at a project of his choice, either alone or in co-operation with one or more classmates. The spirit of enquiry and research is cultivated by extensive use of libraries, laboratories, shops, museums, field investigations and other teaching aids. It is possible to find twelve-year-olds in these classes who are functioning at a higher intellectual level than does the average college student. Curiosity is aroused, habits of idleness are overcome, and the occasional gifted child who was a social misfit in the ordinary classroom makes a normal adjustment. Opportunity classes are rapidly increasing in number and will doubtless become an accepted feature of city school systems.

SUPER POWER. The term has come into wide use, particularly in the United States, in connection with the extensive development of the electric power industry. It has been defined as "the systematic grouping and interconnection of existing power systems to the end that greater economy will be effected." It means in its final form, generation at large, highly efficient plants, transmission in bulk at very high voltage, such as 220,000 volts and supply to existing power systems in large blocks. It may be regarded as a power bank in which deposits and withdrawals are made at widely different points. Technically, the basis of super power lies in the economy effected in interconnecting systems with peak loads coming at different times, thus reducing spare capacity and therefore investment, and bettering the load factor of the interconnected generating plants. (*See* ELECTRICAL POWER TRANSMISSION; ELECTRICITY SUPPLY.)

SUPERSTITION. Like many words having a derogatory sense, "superstition" is often loosely and vaguely used, and is therefore not easy to define. To identify it, for example, with false belief or practice would be quite misleading. For in the first place, the field in which superstition is generally to be found, the magico-religious, is the very one in which the standard of truth and falsehood is most subjective and fluctuating; in the second, a custom or belief, religious or not, which is false may nevertheless be accepted at some times and places by men of enlightened intellect and conscience. To call a person superstitious, however, regularly implies more or less definite mental or moral deficiency. Thus, we should describe a man as superstitious who in a modern European or American community seriously believed that to break a mirror brought bad luck; but the original holders of that or a similar belief were perfectly reasonable in their views, according to their lights. Supposing that a shadow or reflection was in some sort a part of the soul, they naturally concluded that to break it, by breaking the substance upon which it was cast or reflected, was to injure the soul or life itself. They had merely been misled by a false inference. In like manner many savage customs and ideas, often described as superstitious by explorers or missionaries, turn out on investigation to be the product of quite sound reasoning, vitiated by the false premises on which it is based. To adhere irrationally to these premises after having their falsity clearly demonstrated might indeed be called superstition.

The word in question being of Latin origin, light may be thrown upon it by the usage of a Latin author. Vergil, in a well-known passage (*Aen.* viii. 187), characterizes *superstitio* as *uana* (empty, groundless) and also as *ueterum ignara deorum* (having no knowledge of ancient gods, *i.e.*, of well-tried and long-established religious ideas). If we turn to the Greek equivalent *δεισιδαιμονία*, literally "fear of superhuman powers," we find Theophrastos (*Characteres,* 28–[16]) ridiculing the *δεισιδαίμων*, not for holding polytheistic views nor for believing in omens, but for spending much time in the worship of obscure and foreign deities, and paying a ridiculous amount of attention to petty omens, such as a more sensible man would disregard.

We may now perhaps attempt to define superstition as *the acceptance of beliefs or practices groundless in themselves and inconsistent with the degree of enlightenment reached by the community to which one belongs.* It is clear that such a definition excludes, for instance, the mental attitude of one who, about the year A.D. 50, or in the middle ages, believed in astrology, which was accepted and defended by many, though not all, intelligent and well-educated persons of the time; it also excludes the action of a savage who adores what is to Europeans a ridiculous and non-existent godling. But it includes, for example, those contemporaries of Plato who let themselves be deceived by the lower practitioners of Orphism, or by those moderns who appear seriously to believe in mascots. Even so, a certain element of vagueness is unavoidable, since agreement is far from being reached as to what ideas, and consequently what practices, especially those having reference to things not obviously material, are false and unenlightened. A long list might be drawn up of things which some would regard as false and outworn, others as plausible or even certainly true; it would range from theistic belief and religious observances of any sort to such matters as second sight and dowsing or water-finding. There still remain, however, a great number of ideas and actions which the consensus of educated modern opinion would regard as superstitious in the sense above defined. These remaining superstitions fall into two categories, *survivals* and *accretions*.

Survivals.—It is well known (*see* Anthropology, Folklore) that a great many customs characteristic of a less advanced stage in social and intellectual evolution survive into higher stages, either as meaningless and fossilized customs or because a new significance and use has been found for them. Thus many performances originally magical survive, more or less modified, as games for children or adults; a new use, the satisfaction of the play-instinct, has been found for them, but in their details they show, on investigation and comparison, traces of their original purpose. Again, the very old Northern European custom, in origin probably a fertility-rite, of decorating the house with greens at Christmas, survives simply because it is a pretty and picturesque traditional usage. Some such customs have become matters of etiquette. The need being still felt for some kind of conventional gesture to express friendly feeling or desire for better acquaintance, the old, probably magical, gesture of "handshaking" is still in use, and from childhood, we are taught to use the right, or lucky, hand for the purpose. The reason now given is that it is polite to use the right hand rather than the left; here as in many other instances what is now polite was once magically good. Such things as these can hardly be called superstitions; certain customs being still found necessary in various spheres of modern life, and the old ones being in themselves inoffensive, it saves mental effort to retain them, although their original meaning was something quite foreign to our conceptions. But alongside of these some things survive which are useless or even obnoxious, on any theory of conduct, expressed or understood, save one involving some now exploded doctrine.

A good example is furnished by rest-days. The whole experience of mankind proves that it is advantageous to have occasional periods in which no avoidable work is done, since in the end the worker actually achieves more than if he had not rested, in addition to tiring himself much less; and for this there are sound physiological and psychological reasons. Moreover, it is the perfectly reasonable practice of members of the higher religions, such as Christianity and Islam, to set apart certain days (Sunday, Friday, etc.) for the intensified practice of their worship. But it is well known that, long before either an ethical religion appeared or the physiology of fatigue was studied, tabu-days, like the *gennas* of the Nagas, were observed by people in a savage or barbarous stage of culture, owing to the belief that, at regular or irregular intervals, the prevailing conditions were so magical that ordinary work would be unlucky or would prevent or hinder the beneficent effect to be expected from these conditions. Now the feeling that on certain days certain occupations, or all ordinary occupations, are particularly unlucky (or lucky) is quite common at far higher stages than these. Those who appear seriously to believe in the unluckiness of Friday for starting any work may rightly be called superstitious, for the ground of their conduct is ultimately the savage notion of the incompatibility of ordinary occupations with the spiritual atmosphere, so to call it, of a tabu-day, in this case a Church fast-day of comparatively modern origin. Not dissimilar considerations apply to the quite wide-spread avoidance of the number thirteen, ultimately based upon very ancient ideas of the peculiar character of this number.

Accretions.—Evidence of the survival, among a civilized population, of a savage type of mentality is furnished abundantly by the occurrence of quite new superstitious practices in our own day and in circles, not always uncultured, of Europeans and Americans. It is of course a commonplace that gamblers are superstitious, and many of their practices may fairly be deemed survivals, such as turning a chair around to "change the luck" (imitative or homoeopathic magic) or wearing a mascot (fetishism?). But examples are not wanting of entirely new beliefs, based upon modern conditions and having no near parallel in savage or ancient custom. A popular English newspaper finds it necessary, owing to its large circulation, to employ a number of presses. In order to check, and, where necessary, correct the work done by each of these, it has its title printed in a slightly different manner by each machine, the difference consisting of a varying number of small white dots in the large black lettering. A few years ago a firm belief grew up among its less instructed readers that these dots conveyed racing "tips"; thus, if there were three dots in the letter D, they signified that in the third race of that day a horse whose name began with D was the likely winner.

Here we have a definitely superstitious belief, although connected with no magical or religious idea, old or new. Clearly such a delusion would have been impossible but for two factors: (1) Instead of rationally crediting the paper with the possession of a good deal of information on various subjects, gathered through reporters and by other such means, these readers manifestly supposed it to have a quasi-omniscience, embracing such unknowable things as the result of a race not yet run. (2) Whereas it is in fact the custom of newspapers to state in plain language, in their sporting columns, which horse they think likeliest to win a given race, it seems to have been vaguely felt that it was more in keeping with the supposed oracular and infallible wisdom of the Press to adopt a symbolic style and set forth valuable information in a riddling form.

The above example throws some light on the question whether superstition is declining in modern civilizations. The statement that it is rapidly disappearing is often and confidently made; but on examination of the instances given in support of such assertions, it will be found that what are really disappearing are certain old and traditional forms of belief or custom, which have rather gone out of fashion than been overcome by reason. For example, in Britain and America very little is left of the old rites connected with the last sheaf. This is only partly due to the spread of education among country people; probably not many farm labourers could say either what the old rites were or why they were irrational; it is rather the result of the rapid drift of population towards industrial centres, and the consequent influence on the country of town ideas. Now the townsman, not being a producer of foodstuffs from the soil, is apt to laugh at the customs connected with them as rustic; compare the contemptuous tone of such words as *rustre, rusticus, boor, ἄγροικος*, etc. The irrational custom has been irrationally displaced. Here, therefore, is no evidence of the growth of a more logical and critical mentality, less prone than the old to superstition; and it has already been shown that superstitious beliefs are actually in process of creation in the towns themselves. To take another example; while the traditional belief in witches seems practically confined to a few country districts and small towns, and the old methods of divination hardly survive at all, save as amusements, fortune-telling by various methods, mostly pseudo-scientific, including a crude and degraded form of astrology, is by no means extinct, as may be seen by examining the advertisements of popular magazines and also the police-court reports. At best it may be said that superstition appears to be yielding, although very slowly, to the gradual rise of the average intelligence which there is some reason to suppose exists, and that it may in time disappear with other irrationalities.

Bibliography.—For classical superstitions, *see* art. Aberglaube in Pauly-Wissowa, *Realencyklopädie*. For others, *see* Anthropology, Folklore, bibliography. A comprehensive work on superstition in general is still a desideratum.

See also Lehmann, *Aberglaube und Zauberei* (1898); A. Wuttke, *Der deutsche Volksaberglaube der Gegenwart* (1900). (H. J. R.)

SUPER-TAX. A British tax imposed by the Finance Act of 1909 in which D. Lloyd George made a further graduation of the existing income tax by imposing a supplementary income tax or "super-tax" upon persons whose incomes exceeded £5,000 a year. This tax was not imposed upon the whole of the income but upon such part of it as exceeded £3,000 a year, thus creating a graduated super-tax. In later years this super-tax was amended again and again, and in 1928 was renamed the surtax. (*See* INCOME TAX: IN PRACTICE.)

SUPERTONIC, in music, the second degree of the diatonic scale, as D in the scale of C, that is, the note next above the tonic, whence its name. (*See* HARMONY; INTERVAL.)

SUPILO, FRANO (1870–1917), Yugoslav statesman, was born of poor Croat parents at Cavtat (Ragusa Vecchia) in southern Dalmatia. In 1900 he became editor of *Novi List,* a Croat paper published at Fiume, which became a rallying ground for opposition to the intolerable régime of Count Khuen Héderváry. In 1905, together with Trumbić, Čingrija and Smodlaka, he drew up the resolution of Fiume, which became the basis of political co-operation between Serbs and Croats in the critical period before the World War. When the Magyar coalition parties came into power in Hungary in April 1906 and placed the Serbo-Croat coalition in office at Zagreb, Supilo became a deputy at Budapest.

Within a year Magyarising tendencies produced an acute conflict between Budapest and Zagreb, and for a time Supilo was the soul of Croat resistance. He thus became a marked man and was specially aimed at in the notorious forgeries by which the Austro-Hungarian Foreign Office attempted to prove Serbia's revolutionary intrigues in Croatia and thereby to justify the annexation of Bosnia in 1908. At the Friedjung trial, however, in Dec. 1909 Supilo was triumphantly vindicated. He was the first to discover the secret negotiations with Italy which culminated in the Treaty of London (April 26, 1915) and earnestly warned Sazonov of the disastrous complications to which it would give rise; but he was unable to prevent the promise of wide Slav territories on the Eastern Adriatic to Italy in the event of victory. Supilo came into conflict with the Pan-Serb and reactionary tendencies of Pašić, and even withdrew from the Yugoslav Committee, which in the early stages of the War he regarded as unduly subservient to Belgrade. But before his premature death (in London, Sept. 23, 1917) he heartily endorsed the Declaration of Corfu, issued in July 1917, which laid down the lines upon which the Yugoslav State was to be constructed.

SUPPÉ, FRANZ VON (1820–1895), Austrian musical composer, whose real name was Francesco Ezechiele Ermenegildo Suppé-Demelli, was born at Spalato, in Dalmatia, in 1820, and died at Vienna in 1895. Originally he studied philosophy at the university of Padua, but on the death of his father devoted himself to music, studying at the Vienna conservatoire. He began his musical career as a conductor in one of the smaller Viennese theatres, and gradually worked his way up to be one of the most popular composers of ephemeral light opera of the day. Outside Vienna his works never won much success. Of his sixty comic operas *Fatinitza* (Vienna, 1876; London, 1878) was the most successful, while *Boccaccio* (Vienna, 1879; London, 1882) only enjoyed moderate favour. Suppé's overture to *Dichter und Bauer* is his most successful orchestral work. He also wrote some church music.

SUPPLEMENTARY ESTIMATES: *see* ESTIMATES.

SUPPLY, provision; more particularly the money granted by a legislature to carry on the work of government. In the United Kingdom the granting of supply is the exclusive right of the House of Commons, and is carried out by two committees of the house, one of supply and the other of ways and means (*see* PARLIAMENT). In the United States supply originates in the House of Representatives (*see* UNITED STATES: *Appropriation*).

SUPPLY AND DEMAND. Economics, or political economy, is sometimes defined as the science of supply and demand. Although this is an inadequate definition it cannot be said to be altogether misleading. A very important part of Economics, and the part which probably has the best title to the name of science, has to do with the operations of supply and demand and with the way in which variations of supply and demand are related to the movements of prices and to changes in the production and distribution of wealth. The "law of supply and demand" was not invented or discovered by the economists, however, nor do they lean very heavily upon it as a general explanatory formula. Long before there was any systematic analysis of economic processes men had observed that prices vary with supply and demand, and from the earliest days, traders have had to take account of that circumstance. The economist's task has been to scrutinize those characteristics of human behaviour and of the physical environment which determine the various forms or patterns in which supply and demand appear and to inquire into the complicated interactions of the demand for and the supply of different commodities and services.

Elementary Principles.—Consider the familiar theorem that the price of a commodity must be such as to make supply and demand equal. If supply is taken to mean the amount sold and demand the amount bought the theorem is mere tautology, for supply and demand become different names for the amount transferred from sellers to buyers at any price whatever. But if it be understood that demand means the amount which buyers would be willing to take at a specified price, that supply means similarly the amount which sellers would be willing to part with at a specified price, and that demand and supply vary in some systematic and continuous way and in opposite directions as the price is raised or lowered, the theorem has meaning and significance, for there will be one price, and only one price, at which supply and demand will be equal.

In another elementary theorem, namely that an increase of demand for a commodity will raise its price, that an increase of supply will lower it, and that a decrease of supply or of demand will have an opposite effect, other meanings are attached to changes of supply and demand. Here an increase of demand or supply means an increase of the amounts which will be taken at given prices, not an increase which is dependent upon a reduction of price. The general state of supply and demand, in the sense specified in the preceding paragraph, can be represented by lists or "schedules" of "supply prices" and "demand prices." In this other sense, however, supply and demand are regarded as independent variables, and a change of supply or demand means an alteration of the schedule of supply prices or demand prices, such as might come on the one hand from a change of consumer's preferences or an enlarging of the market or, on the other hand, from a change of costs of production.

It is proper to assume that at any given time the immediate general condition of supply might be represented by a schedule in which the progressively higher prices which are required to evoke a progressively larger supply are set forth. But if the commodity is one which can be produced more economically if produced in large quantities, the ultimate effect of an increase of demand, in the sense of an increase of the amounts which will be taken at specified prices, will ordinarily be to reduce the price per unit at which these larger amounts will be supplied. In a schedule of supply prices constructed on the assumption that sufficient time is allowed to permit the necessary economies to be effected, larger supply will be associated with lower prices. When the long-period schedule of supply prices is of this type, the commodity is said to be produced under conditions of decreasing costs or of increasing returns. When, on the other hand, because of the scarcity of some necessary productive factor, increased supply cannot be had, even in the long run, except at a higher price, the condition is described as one of increasing costs or of diminishing returns. The factors which give rise to increasing returns should not be confused with the circumstance that in many industries certain outlays (*e.g.,* for plant and equipment) have to be incurred in advance or with the further circumstance that in a growing industry such outlays are ordinarily considerably larger than the volume of output immediately in prospect would require. Under such circumstances the additional or "prime" costs incurred by reason of an increase of output may be relatively small. Furthermore, with a progressive increase of output there will be a progressive diminution of costs per unit of output, because the general, supplementary, or "overhead" costs will be spread over a large number of units. But although when the market is sluggish or when competition is especially keen, prices may be cut to a point where they barely suffice to cover the additional or "prime" costs, this condition, which cannot be lasting, should not be confused with a true condition of increasing returns, for this last condition is to be found only when a gradual increase of output is attended, in the long run, with genuine economies.

Interactions of Supply and Demand.—The results obtained by taking account only of the supply of and demand for a particular commodity in relation to its price are no more than a first approximation to the truth. In isolating, for reasons of practical convenience, the factors which determine the price of any one commodity, taken by itself, economists are accustomed to assume that the value of money, to both buyers and sellers, is constant. This means that no account is taken of the way in which changes in the amount of money which consumers expend for the one commodity will affect their ability to buy other commodities, or the way in which an increase of the production of the one commodity will affect the ability of producers to supply other commodities. There are many instances of joint or complementary demand, as for fruit and sugar or for automobiles and petrol, and of joint supply, as of mutton and wool, of coal-gas and coke, of cotton and cottonseed. The general rule is, however, that consumers' outlays for any one commodity can be increased only by reducing the amounts which they expend for other commodities, and that more of any one commodity can be produced only by displacing other possible uses of productive resources. This general rule is not inconsistent with the fact that, making abstraction of the use of money as a medium of exchange, the supply of any one commodity is an expression of the demand of its producers for other commodities and services.

There is a sense in which supply and demand, seen in the aggregate, are merely different aspects of a single situation. It is for this reason that some of the older economists held that general overproduction is impossible—a theorem which, though not really erroneous, has proved to be misleading. The *effective* demand of the producers of one commodity for other products depends not only upon how much they produce, but also upon the relative demand of other producers for that particular commodity as compared with other products. Only so far as the demand for a particular commodity is elastic is it true in any significant sense that an increase of its supply is an effective increase of demand for other commodities. There may be and often are maladjustments of supply and demand. Furthermore, production in general may at one time outrun and at another time fail to keep pace with the expansion of money incomes. In either event there will be general fluctuations of prices, attended, as experience shows, by changes in the relative levels of the prices of different classes of goods and services.

The general form of the relations of supply, demand, and price which obtain when all products are taken into account can be depicted mathematically in systems of equations, and thus the general character of the whole interdependent structure of prices can be laid bare. But empirical (statistical) studies of the relations between the fluctuations of the production of various staple commodities and fluctuations of their prices have shown that the first approximation previously referred to is generally a useful and often a surprisingly accurate approximation. It is necessary, of course, to allow for the effects of contemporaneous changes of the general purchasing power of money, and it is sometimes necessary to allow also for the effects of other important disturbing circumstances. But it is not necessary to take account of complications of a secondary order of importance in order to obtain "empirical laws of demand" for such commodities as wheat, cotton, sugar, beef and potatoes which appear to be fairly reliable, at least over periods of some years.

Inelastic Supply.—The rule that supply and demand may be regarded as functions of or dependent upon price must be so interpreted, of course, as to allow for the circumstance that the supply of something is fixed and is in no way responsive to an increase of price. As the production of other goods increases the prices of these non-reproducible forms of wealth must inevitably increase, unless the demand for them falls off. If these non-reproducible things are necessary instruments in the production of other goods, as land is, then other goods will be produced under conditions of diminishing returns, unless this disadvantage can be offset by improvements in productive processes or by cheaper supplies of other necessary productive instruments. For some purposes it is convenient to assume that the aggregate supply of reproducible goods, or of reproducible productive goods, is fixed for the time being. The problems of supply and demand then have to do merely with the apportioning, by exchange, of an existing stock of goods, or with the assigning of productive instruments to the most important of their various possible uses. Thus the increase of the supply of labour in a given industry or a given locality may be taken to depend largely upon a possible transfer of workers from other industries or other localities. Whether labour in the aggregate may be said to have a supply price (*i.e.*, to be responsive in the long run to an increase of wages) is a question to which the Malthusian theory of population gave a more nearly unqualified affirmative answer than would be supported by the present opinion of scholars. (*See* also DEMAND, ECONOMICS, and PRICE.) (A. Yo.)

SUPPLY AND TRANSPORT, MILITARY. In all ages the operations of armies have been influenced, and in many cases absolutely controlled, by the necessity of providing and distributing food, forage, munitions, and stores for men and horses. In modern history these supplies have become more and more varied as weapons developed in complexity, power, and accuracy of workmanship. In proportion, the branches of an army which are charged with the duties of "supply and transport" have become specialized as regards recruiting, training, and organization, in consequence also of the progress with transport which provides more reliable and efficient haulage.

HISTORICAL

The predatory armies of the middle ages not only lived upon the country they traversed but enriched themselves with the plunder they obtained from it, and this method of subsisting and paying an army reached its utmost limits in the Thirty Years' War. During the last stages of this war Germany had been so thoroughly devastated that the armies marched hither and thither like packs of hungry wolves, every soldier accompanied by two or three non-combatants—camp followers of all sorts, mistresses, ragged children, and miserable peasants who had lost all and now sought to live by robbing others under the protection of the army.

From these horrors there followed a revulsion to the other extreme. Unless ordered by higher authority for political reasons to sack a particular town or to pillage a particular district, the soldiers were rigidly kept in hand, rationed by their own supply officers and hanged or flogged if at any moment an outbreak of the old vices made the example necessary. After 1648 there were very few districts in Middle Europe that could support an army for even a few days, and the burden of their sustenance had to be distributed over a larger area. Thus, at the mere rumour of an army's approach, the peasantry fled with all their belongings into the fortified places; armies soon came to be supplied from "magazines," which were filled either by contract from the home country or by inducing the peasantry—by means of good conduct and cash payments—to bring their produce to market. These magazines were placed in a strong position, and if one was not available, a siege had to be undertaken to meet the demand.

Moreover, soldiers in Marlborough's time were not so easily obtained as in the Thirty Years' War, and they had to be housed and fed comfortably enough to make it worth their while to stay with the colours instead of deserting. From these and similar conditions there grew up a system of supply and transport usually called the "magazine system," under which an army was bound, under penalty of dissolution, to go no farther than seven marches from the nearest fortress, two days from the nearest field bakery, and so on. When an 18th century army foraged for itself it was because the regular supply service was interrupted, *i.e.*, when it was *in extremis*. But the relative rarity of wars in the 18th century, the habit of demanding nothing from the inhabitants of the country traversed by an army, and the virtual exclusion of the people from the princes' quarrels, gave Europe a century's respite in which to recover from the drain of the Thirty Years' War. And therefore, when the French Revolution came, the attempts of the armies of old Europe to suppress it without robbing a single Frenchman of a loaf of bread proved futile, and soon the national army created by the Revolution, unencumbered by tents, magazines, and supply trains, swept over southern Germany and Italy. The Revolutionary armies differed indeed from those of the old wars in this, that they did not devastate wantonly, nor did they murder for the sake of loot. But they were merciless in their exactions, and, moreover, the tides of their invasions flowed in particular channels, so that the greater part of the invaded country escaped. This had a considerable, sometimes even a predominant, influence on the strategy pursued, a retreat along their own lines of communication being often in fact avoided by the French as being the worst fate that could befall them. Napoleon, however, systematized the wasteful and irregular requisitioning that his predecessors had introduced, and in his hands the supply service, like all else connected with the art of war, underwent a thorough reform. His strategy[1] in the offensive passed through two distinct stages—(*a*) the swift and sudden descent into the theatre of war, and (*b*) the close grouping of his armies in view of the decisive blow. The first stage was characterized by extraordinarily swift movement, freedom from dependence upon supply columns (other than the reserves of ammunition) and thorough exploitation of the food resources of the traversed zone. If the troops suffered, as well as the inhabitants, this effect did not shake his purpose. But the second stage, which as a general rule involved three or four days' occupation, without considerable movement, of a restricted area, required other measures of supply. In this the army lived upon magazines, which were filled from the captured supply transport, from the available supplies in the area, and from the resources accumulated in requisitioned vehicles close to the head of the routes followed in the first period. These resources were collected in the towns within this concentration area, and placed "out of reach of an insult" (that is, made safe against raiders) with a garrison and field works to supplement the town walls and gates. From this *centre of operations* Napoleon never allowed himself to be severed, whereas to the preservation of the route between France and that centre of operations he gave very little thought and assigned few or no troops, and confusion of strategical thought has often ensued from a failure to perceive the essential distinction, in Napoleonic practice, between a centre of operations and a "base."

In the 19th century, however, there came the inevitable reaction. Purely political wars, and the consequent indifference of the inhabitants to the operations of war, produced as before a return to the system of cash payments and convoy supply, especially in the Austrian army. As regards Europe, the introduction of railways enormously facilitated the supply and transport service, and campaigns were neither as barren nor as prolonged as they had been under the old conditions. The French and British armies did not, at least to the same extent, wage political wars, but their ceaseless colonial warfare imposed upon them the magazine and convoy system, and habituated them to it. The French, in 1870, stood still in the midst of the rich fields of Lorraine, and as a prolonged halt is fatal to the system of living on the country, it would have failed, even had it been tried. The Germans, on the other hand, levied requisitions, civilian transport, and contributions in money in accordance with Napoleonic tradition, though (owing to the existence of railways) with much less than Napoleonic severity. Their system was adopted as the best for European warfare by all the great Powers, whose organizations and methods of transporting and issuing supplies became the same in principle.

This principle was based on the Napoleonic distinction between supplies required during an advance and those required during a concentrated halt.

This system has been considerably modified by the immense development of mechanical transport. The principle of supply now followed is that "field units should always have with them or within reach two days' rations and forage and an iron ration, and that the supply service should keep these stocks replenished by delivering one day's rations and forage every day at a point within easy reach of the troops."

No hard and fast rule can be laid down as to the source from which supplies shall be drawn, and all local resources are utilized as fully as possible in order to save unnecessary transport of supplies from the base. Food collected from local resources during a period of concentration will usually be stored in supply depots for subsequent issue to the troops. Such supplies should first be drawn from those districts adjoining the immediate area of concentration through which the army will not pass. Supplies within the area of concentration are left, as far as possible, for the use of the local inhabitants.

Generally, then, a force operating in Europe would be maintained in food, forage, fuel, and petrol from the base by rail and mechanical road vehicles, due allowance having been made for such supplies as can be obtained locally by formation supply officers, by purchase, or on requisition. As regards requisitioning, the rule is that only officers of a service detailed for the duty are authorized to purchase or requisition, but in cases of emergency requisitions may be carried out by the officer commanding the troops for whom the supplies are required. Authority to requisition is not delegated to any but a commissioned officer, and requisitioning on the part of a warrant officer, n.c.o., or man is treated as plundering, unless the case is one of extreme urgency and no commissioned officer is present. All purchases and requisitions should be made through the local civil authorities. Mobile reserves of supplies do not normally exist but would be found from reserve mechanical transport units and allotted to formations to meet special circumstances. When it is impracticable for a force on the move to be reached by a daily supply convoy, it will usually be accompanied by a supply column carrying supplies for several days. In such a case the radius of action of the force is limited by the amount of food accompanying it.

In savage or undeveloped countries the conditions are far less favourable and each case has to be dealt with on its merits. Such warfare formerly used to necessitate an almost complete dependence on magazine supply, as communications were necessarily uncertain and difficult. These conditions are more or less being overcome by the development of cross-country mechanical vehicles. Nevertheless the supply difficulties in expeditions in the Sudan, West Africa, or on the Indian frontier still far outweigh all difficulties of country or enemy. (X.)

THE WORLD WAR: WESTERN THEATRE

The administration of supply and transport became of the first importance as the World War developed into a struggle between two groups of nations, each using the full resources of civilization to exhaust the other. In the last stage, supply was the determining factor; munitions, food, equipment, railways, roads, ships, had become the most important things, and victory inclined to the force which could best maintain supply, as well as men, at some particular point; which could best develop, conserve and transport its material. At the same time, in foodstuffs, forage, clothing, timber and metals, and in transport material, the world shortage was acute. Thus the work of administration was not only very heavy because of the number of combatants and the development in scale of equipment, but also because of the economic scarcity owing to world exhaustion.

Position in 1914.—When the armies first took the field in 1914, Germany was at a clear advantage. She had prepared for the war with meticulous care. The French administrative services in 1914 appeared much weaker than the German if examination were confined to plans and *matériel.* The troops were not as well provided for, the transport organization not as well planned. But if the human factor were taken into consideration, much of the handicap was made up. The French showed a genius for improvization on the actual battle-field and a faculty for "getting there" with inferior means. Their food scales for man and beast (to give an example) spelt scarcity in British eyes: but they sufficed. The British administrative services in 1914 were well organized both in supply and transport. But the British force was small, and though its scale of transport was generous compared with the French, the total was only 250 motor-cars, 950 motor-lorries, and 40,000 horses. With railway transport it had at first no concern, as the French took charge of that.

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[1] H. Camon, *Guerre napoléonienne.*

Progress During the War.—As the war developed, the Germans suffered from a steady deterioration as compared with the French and the British. The war had become a contest of *matériel,* in which Germany could not keep up. The French, on the other hand, were able to develop their supply and transport on more generous lines with the help of British and American resources. The British developed a complete machine of administration, helped by the fact that the nation took the view that all reasonable expenditure was justified in securing for the troops the best possible chance of victory and the best possible comfort in the trenches. But the Germans, considering the depletion of their resources, kept up a wonderful efficiency in supply and transport. They realized, perhaps more clearly than the other armies, the importance of these services.

Siege Warfare Conditions.—During the long period of "trench warfare" which followed the battle of the Marne, the administrative systems of the three armies were adapted to new conditions, the chief of which were: an enormous increase of ammunition expenditure, and a great simplification of transport, which in a stabilized warfare could follow almost a civilian routine disturbed only by the chances of shell fire and aerial bombs. Administration thus, whilst it had to cope with the progressive increase in the scale and variety of supply per division, was given as a rule ample time to increase its transport facilities. It could add to its broad-gauge railway tracks, supplement them by light railways and tramways as well as by motor roads, and develop the canal systems as useful adjuncts. As the war opened out, with the development of great attacks on both sides, problems of supply and transport became more difficult. In facing such a German effort as the Verdun attacks of 1916, the French had a very difficult problem of transport, which was met by a motor-lorry mobilization, the success of which was one of the great feats of the war.

Re-organization of British System on Western Front.—From 1914 up to the date of the first battle of the Somme (July 1916) the British administrative services had had no very severe tests, but had developed their system almost completely. In munitions, the British army was now better supplied than any other force in the field. It had control of its own railway services, and supplementing the French broad-gauge railway system on its front—which it had taken over and increased—had a system of light railways, and a greatly increased scale of motor transport. But the Somme battles showed that supply had been increased beyond the scale that transport could cope with. There followed in Nov. 1916 a reorganization of the system. One feature of this reorganization was good. The division of authority which put the administrative services really under two heads, one for the battle area and one for lines of communication, was done away with. The military railways, which had been hitherto somewhat starved, were reorganized according to the plans of a civilian expert and were generously supplied with staff and material. But here, what proved in the result to be a mistake in organization was made: railways were separated from the control of the quartermaster-general (who kept control of other forms of transport) and put under a director-general of transportation. Thus there were two separate transport authorities.

Errors of Dual Control.—After the battle of the Somme the line was practically stable for a long time. Whilst this almost stationary trench warfare continued, the weakness of the division of authority and the mistake of allowing any but the military idea to rule in an essential part of an army organization were not apparent. When the Germans attacked in the spring of 1918 the mistake showed very clearly, and the railways were brought again under the control of the quartermaster-general, after an interval during which the traffic to be carried and its priority was regulated by a committee composed of staff officers and officers of the transportation directorate. But the transport situation in the interval was very critical. The German advance had brought the British front lateral railway—St. Just-Amiens-St. Pol-Hazebrouck—under shell fire at many points. The Germans, whose strategy under Gen. Ludendorff was dominated largely by transport considerations, sought to paralyse completely the whole railway system by continuous air attack on the British rear lateral—Eu-Abbeville-Étaples, especially at the points where it crossed the rivers Canche and Somme. Whole-hearted work in building "avoiding" lines and bridges and the efforts of the motor transport just kept the position in hand until a British advance in front of Amiens relieved the front lateral. Fortunately, the building up of a G.H.Q. reserve of motor vehicles had just been brought to completion.

Motor Transport System.—In the winter of 1917–18 the battles of Passchendaele had exposed a weakness in light railways—that they had to work along defined tracks which could be intensively shelled by the enemy—and therefore it was decided to trust more to motor transport. There was effected a complete reorganization of it, with the central idea of doing away as far as possible with the "earmarking" of motor vehicles for particular units or particular tasks and making its total strength completely mobile and elastic. Vehicles saved by this "pooling" were formed into a G.H.Q. motor reserve. In the spring of 1918 this G.H.Q. motor reserve was able to take up part of the traffic load and was largely responsible for saving the situation.

Transport Values.—One of the most interesting problems of supply and transport is that of the relative value of roads (motor and horse traction), light railways, and broad-gauge railways. Light railways (*q.v.*) at one stage of the war were perhaps over-estimated. There was an inclination to regard them as all-sufficing. The British system ultimately gave to them what was considered their proper rôle, recognizing that they were most valuable when the fighting line was stabilized for some length of time, but tended to be less valuable as the war became one of movement. In the spring of 1918 the British army had 920 m. of light railways in operation; in the summer, 100 m. less. Its advance was planned on the principle of concentrating labour in pushing forward the broad-gauge railways and then the roads from them, trusting to motor transport and to horse transport to carry on the load from broad-gauge railhead. Earlier in 1918, controversy on the subject was keen and the French were inclined to take a differing view. The Germans were tied to light railways, for they had not the means to extend their motor traction.

Position in 1918.—The autumn of 1918 will be the most useful date to compare the administrative machines of the Allied armies. Both French and American systems kept a dividing line as regards administration between base and the fighting line. The British system had abolished that in 1916. The French divided the zone of the armies into the zone of the advance and the zone of supply (with sometimes an intermediate zone). In the zone of the advance, administration was in charge of the *aide major-général chargé de la direction de l'arrière* at headquarters. But his administration had no functions of procurement, only of distribution. In some points of administration the dividing line between the zone of advance and the zone of supply was abolished, *e.g.,* all motor transport and all light railways, wherever operating, were controlled from headquarters. The French system of supply and distribution was fashioned for war in the home country or near to it; when it was transplanted (for instance to Salonika) it was adapted nearer to the British system. The American system put administration on the fighting line under an assistant chief of staff (G. 4) at G.H.Q., and on lines of communication under a general commanding service of supply (corresponding in some degree to the old British inspector-general of communications). Under the American system the chiefs of the supply service were not at G.H.Q. but at the headquarters of service of supply.

With both the French and the American systems, evacuation and hospitalization of casualties were purely "Q" services; in the British army they were under the adjutant-general, assisted by the quartermaster-general. Some other differences came from geographical conditions. The Americans had to have their real supply base in France (for the British, the United Kingdom, and for the French, France was the ultimate supply base); so they held great stocks in depots, 15 days of supplies in advance depots, 30 days of supplies in intermediate depots, 45 days of supplies in base depots. The American army relied more largely on local purchases (from the Allied armies and from European civilian sources) than did the armies with their home bases nearer at hand. Gen. Pershing founded a general purchasing agency to control these purchases. In 1918, of 17,600,000 ship tons used by the American army, only 7,600,000 tons came from the United States, and 10,000,000 tons were purchased locally, and to the end of the campaign the American army drew largely upon British and French supplies.

Relations with Navy.—The British administrative machine in one point was inferior to the American machine in 1918. Under the British system the navy had control of all supplies by ship until discharged from the transport. The navy could put a supply ship into any port it pleased and naturally was mainly guided by shipping considerations. The American system put the supply ships under army direction when they came within the three-mile limit from shore, and shipping could then be directed to the port of supply which was most convenient from the army point of view. The French and the Americans used the railway regulating stations as depots, the British used them as sorting stations only.

Among the lessons of administration of the World War one principle seems to be generally accepted—that it is wise to centralize all administration of supply and transport under one head over the whole war area, trusting to him to devolve and co-ordinate. Another conclusion is that if civilization has ever to face another great war it will be, even more than the contest of 1914–18, a war of material, a struggle in which supply and transport will be the governing factors. (T. C.)

THE WORLD WAR: EASTERN THEATRES

Outside the main theatre in France and Flanders very different and varied conditions had to be encountered. In East Africa there was bush; in West Africa, tropical jungle; in Macedonia, and to a lesser degree in Italy, mountainous regions; in Palestine, Damaraland and Mesopotamia, deserts where sand or mud had to be overcome; in Gallipoli, amphibious operations on a vaster scale than had ever been attempted in modern times; while, in conditions, north Russia was entirely different from all these. It speaks volumes for the efficiency of the British transport organization and its adaptability that so kaleidoscopic a field was covered successfully, for the armies in the field were maintained in every instance except that of Gallipoli until complete victory was won.

Failures there were, and such failures arrest the attention, because of their very fewness.

The campaign in Mesopotamia presented circumstances which as late as 1917 were not adequately appreciated. Scarcity of water tied the army to a line of advance either by the Tigris or Euphrates, rivers which in themselves provided admirable lines of communication had sufficient inland water transport been made available. To the paucity in this respect, added to a similar dearth of land transport, may be attributed directly the failure, ending in the surrender, of the Kut garrison and of the gallant efforts made towards its relief. Troops at Basrah could not be moved, and if they had been moved means did not exist for their maintenance. Moreover the army, tied as it was to the river, was not endowed with the power to manoeuvre.

It is true that in the rainy season in lower Mesopotamia, movement is difficult or impossible, as the country becomes a vast sea of mud and no roads exist. Nor is any stone available in the country for road construction. The fact, however, remains that, had the army engaged in the operations for the relief of Kut been furnished with any appreciable amount of light mechanical transport, it would, through its increased radius of action, have been able to obtain its object. After the arrival of Gen. Maude, who from the first devoted himself to putting transport matters in order, the advance was resumed and maintained without any real pause until the occupation of Baghdad.

MODERN ORGANIZATION

Like every other component part of the military machine, the system of supply and transport for the maintenance of an army in the field underwent development as a result of the World War. The experiences gained therein had naturally served to quicken experimental work, and consequently the decade following the close of hostilities was one of intensive research in the field of road and cross-country transport. In these activities British authorities and experts, military and civil, have played a prominent part. The aim and end has been to produce a vehicle which, while answering all essential military requirements, would yet serve commercial needs. These interests are by no means easy to reconcile in thickly populated and highly civilized countries possessing complete road systems, but in the partially or altogether undeveloped portions of the British dominions or colonies there is and will remain a wide scope for transport of a cross-country nature. Such possibilities gave special encouragement to British experiment and production, so that by 1928 certain satisfactory types had been evolved, notably the "subsidy-type" six-wheeler with a chassis designed by the War Department, which it was found possible to produce at an economic cost.

To apply the results obtained to the army is the stage which is now being entered upon. But such application can be but a gradual process, not only on account of the dictation of finance, but still more from the fact that no finality can be reached in the fields of scientific and mechanical research and automobile engineering—the output of which is, therefore, continually subject to modification and improvement. It is axiomatic to British military organization to provide for the major problems that the army is capable of encountering and to modify or scale down such organization to meet minor or unusual circumstances as they arise. For the British army there can be no normal circumstances, for it has to be prepared to operate not only in Europe but in the deserts, mountains and bush of Asia or Africa; and no one system of transport has yet been devised that can cover all these various conditions. Certain general principles are thus laid down in the training manuals and a definite organization drawn up to fit the case of war in a civilized country where the enemy to be met is equal in armament and training.

This organization is based on the premise that an army operating in the field must be able to be maintained wholly by resources sent up to it from behind. The extent to which the theatre of operations can contribute to those resources cannot be a known factor. In proportion as they may be able thus to help contribute are the mobility and striking power of the army enhanced. Such extraneous assistance cannot, however, be counted upon. It is, too, obvious that for armies of the size of those engaged in France and Flanders between 1914 and 1918 no areas, however rich, could provide more than a fraction of the foodstuffs or other commodities required. Again, the advent of automatic weapons and the enormous advance in the power and use of artillery have made the problem of the supply of munitions one that can only be solved by speedier and more flexible transport establishments.

The progress made in mechanical traction and automobile engineering has rendered possible a recasting and extension of mechanical transport formations. Except in certain minor instances, mechanical transport was not, prior to the World War, included in any formation lower than the Army Corps. From some few traction engines working chiefly at the bases in South Africa in 1900 to 1902, mechanical transport steadily made its way forward from the lines of communication until it had reached, in 1914, the larger fighting formations. Post-war organization brought it into the division and it has now been introduced as an integral part of the actual fighting units throughout the whole of the army. The maintenance of such a mass of mechanical vehicles requires in its turn a comprehensive and closely developed organization composed of highly trained technical personnel. No loose or casual methods can suffice in fixing a system, which has necessarily such wide ramifications throughout the military organism; which system furnishes in fact the motive power by which the life of that organism is generated. Only by the soundness of its supply and transport methods can an army be endowed with mobility, and by mobility is meant not only the power to move rapidly, but the power to move anywhere and to continue moving.

Organization of the Supply Service in War.—The basic organization of the supply service, as far as food, forage and fuel, including petrol, are concerned, in any theatre of war consists of the establishment of a chain of depots into which flow those supplies which are received from overseas or obtained by purchase or requisition within the theatre itself. These depots are classified under four headings: *Base or main supply depots* are located at or near the base ports or bases of operations as the case may be. *Advanced supply depots* are established when the lines of communications are unduly long, and these may be required to provide the daily supply for the troops based on them or may hold a reserve of supplies for use in the event of communication with base supply depots being interrupted. *Field supply depots* are, when required, established in forward areas to be used primarily as a reserve to meet sudden unforeseen demands for supplies by field formations. These depots are often located at or near supply railheads (*i.e.*, the point on the railway where supplies and stores are detrained and sent forward in road transport), especially during a rapid advance, when it is necessary to push reserves of supplies continually forward. Finally, there are the *intermediate supply depots*, which are situated on the lines of communication for the purpose of the subsistence and maintenance of troops on those lines, whether permanently located there or passing through. In conjunction with all these supply depots there may be field butcheries and bakeries.

Ammunition Supply.—The essential difference between supply in the sense of food, forage and fuel on the one hand, and the supply of ammunition on the other, lies in the fact that the former is to all intents constant and regular and therefore must be maintained at a comparatively even flow, whereas the latter entirely depends on the intensity of the actual operations taking place, and is therefore spasmodic. The problem of ammunition supply is in itself the prime limiting factor in the development of the armament of the fighting troops, as it obviously serves little purpose to provide them with weapons that cannot be used to the maximum extent of their capacity.

Two main principles govern it: first, that ammunition must be passed systematically from rear to front and that therefore troops in action should never have to turn their backs on the enemy to fetch further supplies. Second, that the control of ammunition should remain in the hands of higher formations as long as possible, thus enabling the higher commanders to keep control of the fighting. Ammunition depots are formed at the bases, on the lines of communication, and in forward zones. Special ammunition "dumps" are located in areas where they are likely to be needed in proximity to the artillery positions, but as a general rule it is preferable when possible to maintain ammunition "on wheels."

Transport of Field Units.—This is divided into three classes:

1. *First line transport*, which is an integral part of the war organization of fighting units, without which they cannot perform their tactical functions, and by which they must at all times be accompanied. Provision, therefore, must be made for the carriage of certain stores, supplies and equipment, for ammunition, and for water and medical service. Whether this transport is on a carrier pack, animal, wheeled, or mechanical basis must depend on the nature of the terrain; and according to where units are operating so must they be equipped. For the purposes of a "major" war, modern tendencies are towards a mechanization of first line transport, not only because of its lesser vulnerability to air and other hostile action, but also because of the possibilities it offers towards a general speeding up of movement and increased radius of activity.

2. *Second line transport*, which is essential to the war organization of field units, but by which they need not at all times be accompanied. In the case of the fighting units of divisions and cavalry divisions, this transport is concentrated in and operated by transport units of the Royal Army Service Corps, designated divisional R.A.S.C., which are equipped with medium lorries. The divisional R.A.S.C. consists of seven companies. One company is allotted to each of the three brigades in the division and one to divisional troops for the purpose of carrying supplies and baggage, in which therefore a total of four companies are engaged. There is a divisional ammunition company and a divisional repair unit, by which all field repairs of the wheeled mechanical transport in the division and replacement of broken down or seriously damaged vehicles are carried out. There is also a horse transport company, which is held available, in the nature of a reserve, in case ground has to be traversed that is impossible for mechanical transport.

3. *Third line transport* consists of "maintenance companies"—Royal Army Service Corps units equipped with heavy lorries. One company is provided for every division and cavalry division in the force, and for army corps troops, army troops and G.H.Q. troops in accordance with their requirements.

Working of the Supply and Transport System.—Supplies (and mechanical transport spare parts and stores) forwarded from the lines of communication are consigned by special trains to railheads, *i.e.*, the places where they leave the railway and are carried to their destinations by road. On reaching railheads they are taken over by the railhead supply officer, who issues them to the "maintenance companies" serving the divisions allotted to that railhead. The maintenance companies load in bulk for the brigades of their divisions, and their duty is to carry their loads as far as what are known as "refilling points," spots previously selected for the meeting of the "maintenance company" and the divisional train. The latter takes over the supplies for issue in detail to units of the division, and its duty is to carry them from the "refilling point" to "delivery points," that is, to the first-line transport of the individual unit. Variations may and normally are made in this system by the insertion of "rendezvous" between railhead and "refilling points," and of "meeting points" between refilling points and "delivery points"; and such insertions depend on the nature of the operations, requirements of concealment from air observation, state of congestion of the roads, or the tactical situation at the time. Thus there are normally two definite échelons of transport between units and railhead which are available for the purposes of supply. This should permit troops to operate freely within 100 m. of railhead.

The "mobile" supplies available are therefore as follows, assuming the issue of rations to be from mid-day to mid-day as is normally the case: On the man, his iron ration and any unconsumed portion of the previous day's issue. In the regimental first-line transport, one day's supplies. With the divisional R.A.S.C., one day's supplies. The total therefore is from two to two-and-a-half days, excluding the iron ration.

Turning to the question of ammunition, this is forwarded to ammunition railheads, located for various reasons quite apart from supply railheads. The maintenance company conveys both artillery and small arms ammunition, as in the case of supplies, to "refilling points." At these the divisional ammunition company, which forms part of the divisional R.A.S.C., takes over the ammunition in their medium lorries. It normally carries the artillery ammunition to the batteries, but under certain circumstances it may be required to proceed to the divisional ammunition column—an artillery unit. The small arms ammunition is taken to the infantry or cavalry brigade reserve—this reserve being formed by a system of "pooling" a portion of the first-line transport of units. These systems are specially designed to allow of elasticity. If distances are short, one échelon of transport may be dispensed with. If they are long, it may be necessary to interpolate an additional échelon—the necessary vehicles being found by the higher command from army corps or army resources.

As previously emphasized, the state of communications or the lack of them may demand the employment of pack carrier or even air transport for the whole or a portion of the "carry." But whatever the mode of conveyance, the principles remain the same. To sum up, they are: In the case of supplies, the maintenance within reach of the fighting troops of two days' complete rations and the "iron ration," and a daily delivery of one day's rations, petrol and forage to units. In the case of ammunition, the principle is to maintain, by a continuous replacement of expenditure, a definite establishment in rounds per gun, per automatic weapon, and per rifle throughout the échelons. The maintenance system, in its application to non-divisional units, is similar to that described above. Consequently, all types of fighting units are on the same basis as regards first-, second- and third-line transport.

Conclusion.—It would seem that the advent of an efficient six-wheeled mechanical vehicle is likely to go far to revolutionize the methods of war. For once a vehicle independent of roads is introduced, the whole problem of movement and maintenance is "speeded up" beyond anything previously conceived. It is a striking instance of the all-pervading influence of "transport." No army can afford to maintain permanently more than a fraction of its transport or even of its purely fighting transport.

The problem has been to achieve a design that, while wholly meeting military requirements has yet an economic commercial value. The solution has now been found and the time has therefore come when the operations of armies can be carried out at a far greater speed than heretofore. For, like that of a fleet, the speed of an army is that of its slowest component unit, which up to now has been the legs of the infantry soldier. If action is quicker, then thinking must be quicker also. This involves a still closer co-operation and unity between those directing operations and those on whom the services of maintenance fall.

These conditions have in their turn produced their own special problems. The provision of the necessary skilled personnel to carry out these duties is likely to be a matter of grave difficulty in the future because the advent of "mass production" methods do not demand more than a comparatively low proportion of skilled mechanics and artificers among the employees of the great automobile engineering firms. The main processes of construction and assembly have been so simplified that they can be carried out by workmen not possessing any specialized training. Such a type of labour will be very far from satisfying war requirements, and for a "major" war any technical personnel possessed by the army will require to be supplemented from civilian sources.

There remains to recall the question of petrol supply. The storage and transport of this commodity, which is in fact the life-blood of the modern army, present special circumstances and difficulties to be overcome. With animal transport, possibilities normally exist for obtaining some measure of foodstuffs within the theatre of operations, while over limited periods animals can perform their duties on short rations or even at need occasionally on their own reserves of strength. No such conditions obtain with motor vehicles. Without petrol they cannot move at all. Should the supply fail for one day there can be no movement that day. The revolution of road transport by mechanization has in fact made "fuel supply" one of the most important questions.

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THE UNITED STATES ARMY

The development of supply and transport in the U.S. army has followed that of war itself and the progress in rapid communication. We shall here consider only the evolution of this technique since 1917.

At the start of the World War the War Department found itself insufficiently organized for handling the great problems of supply and transport brought about by the enormous expansion of a small regular army into a national army of unexpected proportions. As a consequence, there came into being the super-agencies for war-time procurement, allocation, distribution and transport. The War Department itself supplemented the assistance of these superagencies by forming the purchase, storage and traffic division of the general staff, and by making its head the representative of the secretary of war in most matters before the various supercontrol agencies of the Government. This arrangement permitted an efficiency that would probably have been impossible otherwise. As the war went on it became necessary to form an air service, a motor transport corps, a construction corps, an embarkation service and other agencies, and to greatly increase the port and transport facilities of the quartermaster corps army transport service.

On the staff of Gen. Pershing was the assistant chief of staff, G-4, who co-ordinated the work of the supply departments at the general headquarters. These supply departments were: the quartermaster corps, the engineer corps, the signal corps, the motor transport corps, the transportation corps, the ordnance department, the air service, the medical corps, the chemical warfare service. In Feb. 1918, the line of communications was reorganized under the name of the services of supply with its single co-ordinating head, the commanding general, services of supply, with a general staff paralleling, in so far as necessary, the staff of Gen. Pershing. The principal functions of the services of supply were the procurement, storage and transportation of supplies, as well as the great construction projects necessary for the large force overseas. Even the control and transportation of replacements of men, as well as animals, were placed under the jurisdiction of the services of supply, which had control of the nine base ports. Similarly, an intermediate section, and an advance section close to the army zone, were organized. Within the advance section were organized advance depots and railway regulating stations.

The broad questions of policy of supply were handled by the assistant chief of staff, G-4, at the general headquarters and to supplement and co-ordinate American needs with those of the Allies in Europe there was formed, first in Aug. 1917, the general purchasing board, composed of representatives from every supply department in the A.E.F. In the summer of 1918 the general purchasing agent became a member of the interallied board of military supply.

There was the closest co-operation between the services of supply abroad and the War Department in the United States. When policies had been determined by the general headquarters, the commanding general, services of supply, was then authorized to communicate directly by cable and otherwise with the War Department in the United States, and such other agencies as were located in Europe, including the interallied board of military supply and our several representatives in neutral countries. The demobilization of the man-power and of industry was accomplished in short order, the former by a very carefully prepared and progressive plan without any strain upon the water or rail transportation or the demobilization camps available, while the latter was accomplished by co-operative reductions of plants, personnel and output by industry itself and a curtailment, adjustment or cancellation of contracts by the War Department.

The return of the army to a peace-time organization received early consideration by the general headquarters of the A.E.F. and the War Department and the National Defence Act of June 4, 1920, was placed upon the statute books. In the main the National Defence Act endeavours to put into effect the valuable elements of organization which obtained in the former peace-time army and war-time organization of the War Department and of the A.E.F. The several principal components of the U.S. army are given the same peace- and war-time organizations and the problems of supply and transport are thus standardized.

The War Department general staff organization is quite comparable to that which existed in the A.E.F. There is an assistant chief of staff, G-4, who co-ordinates the activities of the supply departments and makes studies of and recommendations for broad policies of supply and transport under the assistant secretary of war who is charged by the National Defence Act with the "supervision of the procurement of all military supplies and other business of the War Department pertaining thereto, and the assurance of adequate provision for the mobilization of *matériel* and industrial organizations essential to war-time needs."

The several supply branches and departments are: the quartermaster corps, the ordnance department, the air corps, the medical corps, the chemical warfare service, the signal corps and the engineer corps. At the headquarters of each of the several corps areas, territorial departments and tactical divisions there are assistant chiefs of staff (G-4) to co-ordinate the supply and transport policies and problems coming under the commands concerned. Each supply branch or department has its representative at each of the headquarters above mentioned.

An improvement in the procurement of supplies has been effected through the creation of the General Supply Committee of the Treasury Department, by the Act of June 17, 1910, which, in effect, budgets by means of this committee the requirements in supply of miscellaneous items of any two or more departments of the Government and in this way standardizes prices, quality and items, and makes contingent budgeted contracts subject to the current fiscal year calls for filling by the several departments of the Government. Another improvement is the creation of the Bureau of the Budget for budgeting of the financial estimates of the entire Government.

For the purposes of war-time plans and procurement the country has been divided, according to industrial density, into certain districts by the several supply departments and in order to meet local peace-time needs of troop supply with minimum transportation, convenient depots have been established. This system of districts and depots affords the necessary framework for war-time expansion with due regard to the requirements of existing industrial allocations. In the return of the army to a peace basis, in accordance with the organization prescribed by the National Defence Act, it will be noted that certain of the war-time branches or services have been abolished as distinct and separate services. Among these may be mentioned the construction corps, the embarkation service and the motor transport corps, all of which have been absorbed by the quartermaster corps. The war-time air service has become the present air corps and the war-time chemical warfare service has become the permanent peace-time service of that name. All problems and matters of transportation and the supply of the means and methods of transportation are handled by the quartermaster corps (transportation branch) which has control of water, animal (wheel, saddle and pack), motor and land transport except the small railways used by the engineer corps in certain construction projects. The matter of air transport is handled by the air corps. For proper maintenance and replacement of animal transportation the quartermaster corps maintains a remount service with certain breeding establishments and depots. The veterinary corps is a separate section of the medical department and is under the control of the surgeon general of the army.

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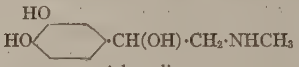
SUPRA-RENAL EXTRACT. In medicine, the sterilized glycerin extract of the supra-renal gland of the sheep, the dose being 5 to 15 minims. The active principle adrenaline or epinephrine occurs only in the medulla of the gland. It forms minute white crystals, soluble in weak solutions of hydrochloric acid and is most frequently used in 1% solutions of the chloride.

Adrenaline has no action on the unbroken skin, but applied to mucous membranes it causes blanching by stimulating the muscular fibres of the arterioles. It acts rapidly in a similar manner when hypodermically injected. The vessels of the uterus are strongly acted upon by it, but the effect on the cerebral vessels is slight, and the pulmonary vessels are unaffected. The heart is slowed and the systole increased. Adrenaline stimulates the salivary glands, produces a temporary glycosuria, and in poisonous doses causes haemorrhages into the viscera and oedema of the lungs.

In Addison's disease the use of supra-renal extract has been beneficial in some cases, but its chief use is in the control of haemorrhage. For this purpose it is given in conjunction with local anaesthetics such as cocaine in order to produce bloodless operations on the eye, nose and elsewhere. It is also useful in haemorrhage from small vessels, where it can be applied at the bleeding spot, as in epistaxis. In surgical shock and in chloroform syncope an injection of adrenaline often saves life through the rise of blood pressure produced. An attack of bronchial asthma may be cut short by a hypodermic injection of adrenaline solution. It should never be used in the treatment of haemoptysis. Similar commercial products on the market are hemisine, renaglandine, suprarenine, adnephrine, paranephrine and renostyptine. Supra-renal snuff containing the dry extract with menthol and boric acid is of use in hay fever. Rhinodyne is of this type. Suppositories containing supra-renal extract are employed successfully to check bleeding piles.

The chemistry of adrenaline has been mainly elucidated by the investigations of Pauly, Jowett and Bertrand; Jowett proposing a constitution (*see* annexed formula) now accepted as correct. Many substances having related constitutions have been synthesized, and resemble adrenaline in increasing the blood pressure. For example, the corresponding ketone, adrenalone (obtained in 1904 by Stolz) is active, and the methyl group can be replaced by hydrogen or another radical without destroying the activity. It seems that the para-hydroxyl group is essential. For instance, para-hydroxyphenylethylamine, $HO \cdot C_6H_4CH_2 \cdot CH_2NH_2$, which is one of the active bases of ergot, closely resembles adrenaline (G. Barger, *Journ. Chem. Soc.,* 1909, 95, pp. 1123, 1720; K. W. Rosenmund, *Ber.,* 1909, 42, p. 4778); as does also its dimethyl derivative hordenine, an alkaloid found in barley (G. Barger, *ibid.,* p. 2193). Adrenaline is optically active, the naturally occurring isomer being the laevo form; like nicotine, the laevo base has a much greater physiological activity than the dextro. (*See* ADRENALINE; ANIMAL EXTRACTS.)



Adrenaline.

SUPRA-RENALS: *see* DUCTLESS GLAND; ADDISON'S DISEASE.

SUPREME COUNCIL. This term was evolved to denote the organ of supreme control at the Peace Conference at Paris in 1919. It was thought by some that this device was a new one, and the phrase "Diplomacy by Conference" was coined to express it. But, in fact, a similar procedure was followed at Vienna during 1814–15 and subsequent years, with strikingly analogous results.

The Peace Conference started by excluding all but the Great Powers from anything but formal deliberations. The original supreme organ was known as "The Council of Ten" and consisted of the heads of the delegations of the Great Powers and of their respective foreign secretaries. This body was found too unwieldy, and it was considered that its numbers caused leakage and undue publicity. To meet this difficulty President Wilson proposed, and Mr. Lloyd George supported, the experiment of a Council of Four ("The Big Four"), who were the above-named, together with M. Clemenceau (France) and Sig. Orlando (Italy). The Japanese occasionally sent a representative when their interests were involved, thus making a fifth member. By this device business was transacted rapidly, informally and secretly. After the departure of President Wilson and Mr. Lloyd George on June 28, 1919, the Council of Four was superseded by a Council of Five which included Japan. The leading diplomat of each Great Power attended on behalf of his country. This arrangement ended in Jan. 1920, and the United States then withdrew her representative altogether. The Supreme Council (as it was now called) did not, however, die at once, though it ceased to sit at Paris *en permanence.* Part of its functions were transferred to the Ambassadors' Conference (*q.v.*) and part to the League of Nations (*q.v.*).

Nevertheless attempts were repeatedly made to establish a system of "periodic reunions" between the premiers or leading men representing each Great Power. There were nine such meetings in 1920, six in 1921 and two in 1922. At the Conference of London (Feb. 21–March 14, 1921) it became quite clear to the Great Powers that Germany had, in the military sense, become incapable of resisting them. It was also doubtful whether any forcible measures could actually produce substantial sums by way of reparation. On this point, grave divergences appeared between England and France. The supreme test came at the Conference of Paris (Aug. 8–13, 1921). At that meeting there was a complete division between the French and British views over the assignment of territory in Silesia respectively to Germany and to Poland as a result of plebiscite. Finding agreement impossible

Mr. Lloyd George appealed to the League of Nations to settle the Silesian boundary, and M. Briand agreed to accept the award of the League on behalf of France.

Mr. Lloyd George's appeal showed quite clearly that the Supreme Council was no longer a body able to settle disputes between its members, in spite of the informal and unofficial character of its proceedings and of the close personal intimacy between its members. None the less, two further meetings took place. That at Cannes (Jan. 6–13, 1922) failed because M. Briand was overthrown by the majority in the French parliament, while the Council was actually sitting (Jan. 12). A desperate effort by Mr. Lloyd George to retrieve the situation by summoning a new Council at Genoa (April 10–May 19, 1922) failed because of French hostility to the proceedings. The failure of the Supreme Council would appear to have been inherent in the circumstances of its origin and constitution.

Like the similar organism created by Lord Castlereagh in 1814, it was evolved to meet a certain need, and decayed when that need ceased to be imperative. It was necessary at Vienna in 1814 and at Paris in 1919 to devise some method by which the work of the Peace Conference could be rapidly thrown into shape and decided without too many plenipotentiaries encumbering the discussion and too much outside pressure embarrassing the decision. The fact is that "Diplomacy by Conference" appears to be a method, a system or a means for oiling the wheels and for easing pressure. But it cannot, of itself, remove pressure or create harmony and cannot at present be accepted as a permanent system for conducting the affairs of the world.

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SUPREME COURT OF JUDICATURE, in England, a court established by the Judicature Act 1873, consisting of the "Court of Appeal" and the "High Court of Justice." *See* COURT; JUDICATURE ACTS.

SUPREME COURT OF THE UNITED STATES, THE. The Supreme Court of the United States is the highest judicial tribunal of that Government. A new Government in Federal form was established by the Constitution of the United States. That instrument confined the authority of the central Government to those powers specifically or impliedly delegated; and all other powers were reserved to the respective States or to the people. Thenceforth there have co-existed two separate Governments, each exercising for different purposes sovereignty over the same territory. This division of sovereign power required a tribunal with authority to adjudicate controversies in the light of the Constitution. It was foreseen that the exercise of power under the respective Governments would give rise to disputes which must be settled to preserve internal peace. To settle such controversies the Supreme Court was established.

This tribunal was created and its jurisdiction defined by sections 1 and 2 of Article III. of the Constitution, which reads:

> The judicial power of the United States shall be vested in one Supreme Court, and in such inferior Courts as the Congress may from time to time ordain and establish. The Judges, both of the supreme and inferior Courts, shall hold their Offices during good Behaviour, and shall, at stated Times, receive for their Services, a Compensation, which shall not be diminished during their Continuance in Office.
>
> The judicial Power shall extend to all Cases, in Law and Equity, arising under this Constitution, the Laws of the United States, and Treaties made, or which shall be made, under their Authority;—to all Cases affecting Ambassadors, other public Ministers and Consuls;—to all Cases of admiralty and maritime Jurisdiction;—to Controversies to which the United States shall be a Party;—to Controversies between two or more States;—between a State and Citizens of another State;—between citizens of different States;—between citizens of the same State claiming Lands under Grants of different States, and between a State, or the Citizens thereof, and foreign States, Citizens or Subjects.
>
> In all Cases affecting Ambassadors, other public Ministers and Consuls, and those in which a State shall be Party, the Supreme Court shall have original Jurisdiction. In all the other Cases before mentioned, the Supreme Court shall have appellate Jurisdiction, both as to Law and Fact, with such Exceptions, and under such Regulations as the Congress shall make.

At an early day, however, the States insisted that their sovereignty be respected by denying the authority of the Supreme Court to hear any suit between a State and any individual, except possibly "Ambassadors, other public Ministers and Consuls," though it might still hear suits between different States. For this reason the original grant of jurisdiction to the Supreme Court was limited by the Eleventh Amendment, which became effective on February 7, 1795. This Amendment is as follows:

> The Judicial power of the United States shall not be construed to extend to any suit in law or equity, commenced or prosecuted against one of the United States by Citizens of another State or by Citizens or subjects of any Foreign State.

The jurisdiction of the Supreme Court is both original and appellate. Its original jurisdiction is limited by the Constitution to "all Cases affecting Ambassadors, other public Ministers and Consuls;—and those in which a State shall be Party." In all other cases it "shall have appellate Jurisdiction, both as to Law and Fact, with such Exceptions, and under such Regulations as the Congress shall make." It is only its original jurisdiction that is safeguarded by the Constitution. Its appellate jurisdiction is determined by Congress, which sets up also the various Federal courts whose decisions shall be reviewed.

The first Judiciary Act was passed on September 24, 1789. This Act provided for a Supreme Court consisting of a Chief Justice and five Associate Justices; it enumerated the various inferior courts and fixed their jurisdiction; and provided for appellate jurisdiction from the State courts in certain cases presenting Federal questions. Subsequent Judiciary Acts steadily evidenced a tendency to decrease the obligatory jurisdiction of the Supreme Court. This is seen particularly in the Judiciary Act of 1925. This Act gives to the court a strictly limited jurisdiction and confines its judgments to Constitutional questions and matters that are of national importance.

The official title of the Chief Justice has varied in legislation as well as in the commissions issued to the different Justices. The first seven Chief Justices were commissioned under the title of "Chief Justice of the Supreme Court of the United States," but since that time the Chief Justices have been commissioned as "Chief Justice of the United States."

The judges of the Supreme Court, as well as all the Federal judges, are nominated by the President, confirmed by the Senate, and commissioned by the President. In the nomination of the judges, the President is left by the Constitution to his own discretion, as section 2 of Article II. of the Constitution provides that the President "shall nominate, and by and with the advice and consent of the Senate, shall appoint Ambassadors, other public Ministers and Consuls, Judges of the Supreme Court, and all other officers of the United States, whose Appointments are not herein otherwise provided for." The Constitution does not prescribe the qualifications for holding a judicial office. In the confirmation or rejection of the President's nominee, the Senate has sole discretion. Under the provisions of the Constitution in issuing the commission, however, the President exercises simply a ministerial power.

The term of the judges is during good behaviour, so that the term is for life unless a judge shall resign or by conviction on impeachment be expelled from office, as provided in section 4, Article II., of the Constitution. Only one Justice of the Supreme Court has been impeached—Samuel Chase, who was acquitted in 1805.

The Court consists (1929) of a Chief Justice and eight Associate Justices. From its number of five in the original Judiciary Act of 1789, it had been increased to six in 1807, to eight in 1837, and to nine in 1863. An Act of 1866 would have reduced the Associate Justices to six, but before sufficient vacancies had occurred thus to reduce the Court, the Act of 1869 was passed, which reconstituted the Court with a Chief Justice and eight Associate Justices, as it remains at present.

While the existence of the Court has generally been regarded as necessary in the Federal form of Government, yet no institution under the Constitution has been subject to more bitter opposition. Its powers, its jurisdictions, and its decisions have been under constant challenge by one political party or another.

In spite of all manner of attack, the Court has held the confidence and respect of the people. Its decisions have influenced the growth and development of the nation. It has had to deal with problems which were in a large sense political and which involved the true relation between the States and the central Government. As long as this form of Government endures, these political, social and economic problems will recur and will continue to impose upon the Supreme Court the ultimate decision of the conflict between local and national interests.

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SUQ-ASH-SHUYUKH, a town in Mesopotamia in 31° N. and 46° 30′ E. The town lies on the lower Euphrates in a region which has probably always been of considerable fertility. There is communication with Basra by river and also by land routes, the railway lying a few miles to the southwest. The population is estimated at 12,000, most of whom are Arabs. The town is noted for the manufacture of the "aba," the woollen cloak worn by the Mesopotamian Arab. There is also a good deal of local metal work and a boat building industry. The town is 63 miles above Qurna by river but the channel has now ceased to carry much water and is almost unnavigable, except at highwater.

SURABAYA (Dutch *Soerabaja*), the chief port and naval station in Java, D.E. Indies; pop. (1927), 249,674, including 24,593 Europeans. One of the most important centres of trade and commerce in the Far East, Surabaya is situated in the east of Java, on Surabaya strait, which divides Java from Madura, thus securing the shelter of that island for its roadstead, whilst its position on the Kali Mas, one of the mouths of the Brantas river, affords facility for transportation to the heart of the city. From the entrance to Surabaya the lofty ranges of the Tengger and Arjuna mountains are seen with Semeru, the highest active volcano in Java, in the far distance. A look-out station, Wilhelmina Tower, flanked by a small park is situated at the river's mouth and from here railway, steam tramway and road run inland, in a southerly direction, past the old Ft. Prins Hendrik, to, first the old town, then the upper town, and beyond that to the suburbs of Gubeng and Wonokromo, where a new residential and well-planned Surabaya is fast arising. It has electric trams and light, taxi-cabs, telephone system, cable communication with Batavia, Semarang, and Balik Papan, in Borneo, and an air service to Batavia.

Surabaya's interests are wholly naval and commercial. The naval station on the south side of the canalized Kali Mas, with the commercial docks opposite, consists of an outer and inner naval basin, with torpedo boat harbour, dock-yards and cholera barracks. The commercial port consists of breakwaters on the west side of the Kali Mas enclosing a harbour basin. Alongside the west pier of the basin is a wharf, 920 metres (Genoa Quay), and the Holland pier, 1,650 metres long. The eastern part of the basin is for lighters, and in the north-eastern corner there is a harbour for three floating docks of 14,000, 3,500 and 1,499 tons capacity, also, north of the Genoa Quay, a wharf for the tankers of the Standard Oil Company. On the west border of the basin a new shipping canal has been made, the Kali Perak, and the Kali Mas has been improved as much as possible by widening and the construction of stone walls along the banks. All quays and warehouses are connected by direct, wide roads and railways with industrial centres in the hinterland.

Exports from Surabaya in 1926 were 212,352,634, and imports 204,817,021 guilders. The bulk of the chief product of Java, sugar, is sold in Surabaya, with a few exceptions, all the sugar estates on the island being amalgamated in the Java Sugar Producers' Association at Surabaya, which is the central sales' agency for sugar. It is also an important market for coffee, tobacco, maize and tapioca, whilst the Java hides are sold there chiefly. There is steamer communication with the chief ports of the world and with most of the ports of the archipelago; lying on the main route from Singapore and Batavia to Australia, Surabaya also benefits from this traffic. (E. E. L.)

SURABAYA, a residency in the east of Java, D.E. Indies; area, excluding that portion it gained when this residency was divided between Surabaya and Semarang, 3,682 sq.m. It is bounded west by Semarang, south by Madiun, Kediri and Pasuruan, north by the Java sea and east by the Straits of Madura. Surabaya is one of the flattest residencies in Java, well watered by the Solo and the Brantas, and possessing a soil admirably adapted for the cultivation of sugar, the chief product, whilst tobacco, cassava (tapioca), coffee, coca, are grown, and the usual native crops—rice, pulses, fruit and vegetables. Cattle are bred extensively, forests in the western and Rembang portion yield quantities of teak (there is a central lumber yard at Chepu), and in this part too are extensive oil-fields with a large refining installation of the Dordrecht Petroleum Company at Chepu. The population, excluding Rembang, is 2,555,596, almost entirely Javanese. The capital is Surabaya, pop. 249,674 (*q.v.*). Other towns are Grissee, 25 m. N. of Surabaya (pop. 24,382), a port of the old Dutch East India Company, and one of the first places of Dutch settlement in Java, where there is a trade in edible birds' nests; Mojokerto (pop. 18,990), a sugar industry centre, and the site of the Majapahit empire, with a museum of relics; Jumbang (pop. 14,068), a sugar centre; Lamongan and Sidoarjo. The main railway line from Batavia crosses the residency, there are lines from Semarang to Surabaya City and thence to Pasuruan along the coast, and there is also excellent sea communication from the port of Surabaya. In 1618 the Dutch allied themselves with the Adipati of Surabaya, who favoured the Dutch against his overlord, the Sultan Ageng, and this helped to establish Dutch power in Surabaya. (E. E. L.)

SURAJ-UD-DOWLAH (d. 1757), ruler of Bengal. The date of his birth is uncertain, but is generally placed between 1729 and 1736. His name was Mirza Mohammed, and he succeeded his grandfather Aliverdi Khan as nawab of Bengal on April 9, 1756. He was a cruel and profligate fanatic. Being offended with the English for giving protection to a native official who had escaped with treasure from Dacca, he attacked and took Calcutta on June 20, 1756. He then permitted the massacre known in history as "The Black Hole of Calcutta." (*See* Calcutta: *History,* and India: *History.*) This atrocious act was soon avenged. Calcutta was retaken by Clive and Admiral Watson on Jan. 2, 1757, and on June 23, Suraj-ud-Dowlah, routed at Plassey, fled to Rajmahal, where he was captured. He was put to death on July 4, 1757, at Murshidabad, by order of Miran, son of Mir Jafar, who had conspired against Suraj-ud-Dowlah.

SURAKARTA, a residency of central Java, Dutch East Indies; area 6,239 sq. kilometres. It is extremely hilly, except along the valley of the Solo, the principal river, which, with its tributaries, the Kaduan, etc., is of great value to the residency for agricultural purposes, watering the rich volcanic soil brought down from the mountains which flank either side of the Solo valley from north to south, and making Surakarta one of the most fertile portions of Java. In the west the mountains are dominated by the Merbabu and Merapi groups: in the east by the Lawu group. Surakarta is bounded on the N. by Semarang, on the W. by Kediri and Jokjakarta, on the E. by Madiun, and on the S., a very small portion of coast-line, less than ten miles long, by the Indian Ocean. Surakarta is the chief tobacco-growing centre in Java, producing, in 1926, 10,000,068 kilos, or a third more than the whole of the rest of Java and half as much as the whole of Sumatra. Coffee is also a very important crop, whilst sugar-cane is grown very extensively on the volcanic ground at the foot of the

Merapi mountain: the residency has also the usual native cultures —rice, pulses, cassava, fruits and vegetables. The population of Surakarta is 2,257,177 (5,045 Europeans and Eurasians), and is almost entirely Javanese.

The Susuhunan, or sultan of Surakarta resides in the capital, Surakarta, pop. 156,162 (2,851 Europeans and Eurasians), also known as Solo where, too, is the headquarters of the Dutch Resident. In the city, which has all modern conveniences such as electric light and power, a telephone system, motor-cars and, except in the oldest part of the town (where there is an old Dutch settlement, and Ft. Vastenburg, as well as the native quarter), fine, wide streets, well-planned and with magnificent shade trees at their side, with many modern shops and residential buildings. Surakarta has also a zoological garden, some very interesting houses of native nobles, and a large market, whilst in the streets of the purely native city the scenes of native life—strolling actors, with hideous masks, performing in the open air, members of the Court, wearing curious sugar loaf, stiff caps and the *kris,* accompanied by an umbrella bearer, hawkers selling their wares—is an absorbing sight. Surakarta is on the banks of the Solo, it is also on the main railway line from Batavia to Surabaya, which crosses the residency in the centre, from west to east, and it is the starting point of a line of railway to Semarang, via Gundih. A tram line runs from Surakarta to Boyolati, the starting-point for the ascent to the sanatorium of Selo, 4,500 ft., on Mt. Merapi.

The Dutch agreement of 1755 recognized two native rulers in Java, the sultan of Jokjakarta and the susuhunan of Surakarta. From about 1830 onwards the native princes of Java have ceased to be of any political importance.

See T. S. Raffles, *History of Java* (1817); M. L. van De Venter, *Daendels-Raffles* (London, 1894). (E. E. L.)

SURAT, a city and district of British India in the northern division of Bombay. The city is on the site where the English first established a factory on the mainland, and so planted the seed of the British empire in India. In 1514 the Portuguese traveller Barbosa described it as an important seaport, and during the reigns of Akbar, Jahangir and Shah Jahan it rose to be the chief commercial city of India. At the end of the 16th century the Portuguese were undisputed masters of the Surat seas. But in 1612 Captain Best, and after him Captain Downton, destroyed the Portuguese naval supremacy and made Surat the seat of a presidency under the English East India Company, while the Dutch also founded a factory. In 1664 Sir George Oxenden bravely defended the factory against Sivaji, but its prosperity received a fatal blow when Bombay was ceded to the Company (1668) and shortly afterwards made the capital of the Company's possessions and the chief seat of their trade. From that date also the city began to decline. At one time its population was estimated at 800,000, but by the middle of the 19th century the number had fallen to 80,000; in 1921 it had risen to 117,434. It is still of commercial importance.

The city is situated on the left bank of the river Tapti, 14 m. from its mouth, and has a station on the Bombay, Baroda and Central India railway, 167 m. north of Bombay. A moat and city wall indicates the dividing-line between the city, with its narrow streets and handsome houses, and the suburbs. The city is a centre of trade and manufacture. There are cotton mills, factories for ginning and pressing cotton, rice-cleaning mills and paper, ice and soap works. Fine cotton and silk goods are woven, and there are special manufactures of silk brocade, gold and silver wire, carpets, sandalwood and inlaid work.

The District of Surat has an area of 1,651 sq.m., and the population in 1921 was 674,351. The district has a coast-line of 80 m., consisting of a barren stretch; behind this is a rich, highly-cultivated plain, nearly 60 m. in breadth, at the mouth of the Tapti, but narrowing to only 15 m. in the southern part, and on the north-east are the wild hills and jungle of the Dangs. The principal crops are cotton, millets, rice and pulses. The chief centres of trade are Bulsar and Surat. The district is traversed by the main line of the Bombay, Baroda and Central India railway, with a branch along the Tapti valley to join the Great Indian Peninsula railway at Almaner.

The Surat Agency consists of three native states: Dharampur (*q.v.*), Bansda (*q.v.*) and Sachin, together with the tract known as the Dangs. Sachin has an area of 49 sq.m., and a pop. (1921) of 19,997. There are 14 dangs or states, under Bhil chiefs, with an area of 653 sq.m. and a pop. of 24,576.

SURBITON, an urban district in Surrey, England, 12 m. S. of Waterloo, London; on the S. railway. Pop. (1921) 19,547. It has a frontage upon the right bank of the Thames opposite to Hampton Court. The district is largely residential.

SURETY, in law, the party liable under a contract of guarantee (*q.v.*). In criminal practice sureties bound by recognizance (*q.v.*) are means of obtaining compliance with the order of a court of justice, to keep the peace or otherwise. (*See* Principal.)

SURFACE. There is no agreed definition of a surface. We may think of it as the boundary of a solid body, or as the division between two portions of space, or as the locus of an ∞^2 set of points, selected by some law from the ∞^3 points of space, and having a certain amount of continuity; in each case a plane is the simplest example; but none of these gives a precise or satisfactory definition. A very simple model illustrates the kind of difficulty that arises. If a surface partitions space, it must have two sides: but a long strip of paper, with the ends joined after one has received a half-twist, forms a surface with only one side.

At an ordinary point O of a surface, there exists a *tangent plane,* the unique limit of the plane OPQ, when the adjacent points $P,Q\rightarrow O$ by any paths lying on the surface, the angle POQ remaining finite. Any point where this limit does not exist is *singular.* The *normal* is the perpendicular to the tangent plane at its point of contact O.

A surface can also be regarded as the locus of a point satisfying a geometrical condition expressed by a single equation between its rectangular cartesian coordinates, say $f(xyz)=0$. From this point of view, the definition of a surface depends on what types of function are admissible for f, and the question of continuity arises in another form. The surface is *analytic* if f is an analytic function, and in particular is *algebraic* if f is a polynomial. We shall use f as the name of the surface whose equation is $f=0$.

We may also consider a surface as the locus of a curve varying according to some definite law. Thus a sphere is the locus of a meridian circle which rotates about the polar axis, or of a circle of latitude whose centre advances along the axis, while the radius first increases from zero and then decreases. Any surface can be thus regarded, for it is always the locus of its own sections by a fixed pencil of planes.

In particular, a *ruled surface* is the locus of a variable line, whose different positions are the *generators.* There are two chief kinds of ruled surface: (1) If adjacent generators do not intersect, we have a *skew* surface; the simplest example is a hyperboloid of revolution, locus of a line which rotates about an axis which it does not meet. The shortest distance between adjacent generators determines a point on each, whose locus is the *curve of striction* of the skew surface. (2) If adjacent generators intersect, the surface is *developable,* and the locus of the point of intersection is the *edge of regression,* which is a cuspidal curve on the surface. The generators are the tangent lines to this curve.

By the principle of duality, any surface is also the envelope of a continuous ∞^2 set of tangent planes, selected from the ∞^3 planes of space by some definite law. From this aspect, a point is the simplest example. Exceptionally, a developable surface has only ∞^1 tangent planes, each touching it along a generator, instead of at a point, viz., the intersection of the plane with its consecutive. If each tangent plane is rotated about its generator of contact through an infinitesimal angle till it coincides with the consecutive plane, the whole surface is flattened out or *developed* into one plane, without tearing or stretching. Part of the plane is covered twice by the deformed surface, and part is uncovered, the edge of regression furnishing the boundary.

Whether regarded as a locus or an envelope, a surface f has ∞^3 tangent lines, defined as the limit either of the join of two adjacent points or of the intersection of two adjacent tangent planes. To touch f imposes one condition on the ∞^4 lines of space, and f has in general ∞^2 *bitangents,* each touching it at two distinct points, and ∞^2 *inflexional tangents*, each meeting f in three adjacent points.

Degree, Class, Rank.—The *degree* of an algebraic surface is that of its equation, *i.e.*, that of the polynomial f. It is the degree of a plane section, and is also the number of intersections, real, coincident or imaginary, of f with any line. These are particular cases of more general properties of the degree. Two surfaces of degrees n, n_1 intersect in a curve of degree nn_1, or in an aggregate of curves of this equivalent total degree, when curves of contact and common multiple curves are counted a proper number of times. Three surfaces of degrees n, n_1, n_2 have n,n_1,n_2 distinct points of intersection, or the equivalent of this when points of contact and common multiple points are properly counted.

The *class* of f is the degree of its equation regarded as an envelope, connecting the tangential coordinates of any one of its tangent planes. The properties of the class are dual to those of the degree; it is the class of the tangent cone drawn to f from a general point and the number of tangent planes through a general line.

The *rank* is an intermediate numerical characteristic, the number of tangent lines that can be drawn through a given point and in a given plane through that point; it is the class of the plane section, and the degree of the tangent cone.

If the polynomial f falls into rational factors $f\equiv f_1.\ f_2$, of degrees n_1, n_2 where $n_1+n_2=n$, then each factor by itself represents a distinct algebraic surface, and if a point lies on either, its coordinates satisfy the equation of f; regarded still as a single surface, f is *degenerate*, breaking up into the components f_1, f_2.

Polars.—The point P_λ dividing the segment PP_0 in the ratio $\lambda:1$ has four homogeneous co-ordinates of the form $x\lambda=x+\gamma x_0$. The condition that $P\lambda$ lies on f is that λ satisfies

$$F\equiv\lambda^n f_0+\lambda^{n-1}\Delta f_0+\cdots+\frac{\lambda^r}{(n-r)!}\Delta^{n-r}f_0+\cdots+\frac{1}{n!}\Delta^n f_0$$

$$\equiv\frac{\lambda^n}{n!}\Delta^n{}_0 f+\cdots+\frac{\lambda^r}{r!}\Delta^r{}_0 f+\cdots+f=0,$$

where f_0 is $f\,(x_0, y_0, z_0, w_0)$ and $\Delta\equiv x\dfrac{\partial}{\partial x_0}+$etc., $\Delta_0\equiv x_0\dfrac{\partial}{\partial x}+$ etc.

The surface $\Delta^r{}_0 f$, for $r=1,\cdots,n-1$, is the rth *polar surface* of P_0 with regard to f; the first polar passes through all the multiple points of f. In particular, $\Delta_0{}^{n-1}f$ or Δf_0 is its *polar plane*, and $\Delta^2 f_0$ its *polar quadric*. The locus of points whose polar quadrics are cones is the Hessian of f. Its equation of degree $4(n-2)$ expresses that the determinant of second derived functions of f vanishes.

If two roots of $F=0$ are infinite, then P_0 lies on f, and P on the tangent plane at P_0; the two conditions are $f_0=0, \Delta f_0=0$. The latter represents the tangent plane at P_0, which is the polar plane of its point of contact. If P_0 is a multiple point, the tangent plane does not exist, and all the first derived functions of f vanish there.

If two roots of $F=0$ are equal and finite, its discriminant vanishes. This equation of degree $n(n-1)^2$ in x, y, z, w is satisfied if PP_0 touches f at $P\lambda$; in general it represents the tangent cone from P_0 to f. Hence the class of f cannot exceed $n(n-1)^2$. It is less than this if f has multiple curves; for the condition is satisfied if $P\lambda$ is a multiple point of f, and the cone vertex P_0 standing on a multiple curve separates itself from the tangent cone.

If two roots of $F=0$ are 0, then PP_0 touches f at P, and $f=0$, $\Delta_0 f=0$. The curve of contact of the tangent cone drawn from any point P_0 to f is the whole or part of the intersection of f with the first polar of P_0, any residual intersection consisting of the multiple curves of f. This curve of proper contact passes through all the isolated multiple points of f.

Indicatrix; Curvature.—In order to examine a surface in the neighbourhood of a particular point, we take this as origin O of rectangular cartesian coordinates, and arrange f in homogeneous functions of x, y, z, say, $f=u_0+u_1+\ .\ .\ .\ +u_n$. If f consists of a single homogeneous function u_n it represents a cone vertex O of degree n. If f is general, the condition that O lies on the surface is $u_0=0$.

If $P\ (x, y, z)$ is a general point of space near O, at a distance small of first order, then the perpendicular distances of P from all general planes through O, viz.: x, y, z and all general linear functions of them, are small of first order. If P lies on f, the linear function u_1, being equal to $-(u_2+\ .\ .\ .\ +u_n)$, is small of second order; $u_1=0$ is the equation of the tangent plane, which in the neighbourhood of O lies infinitely closer to f than any other plane. Whenever we can safely neglect small quantities of second and higher order, the surface can be replaced by its tangent plane.

If we neglect terms of third and higher orders only, f can be replaced by the quadric u_1+u_2, or more generally by any of the family $q\equiv u_1+u_2+u_1v_1$, where v_1 is a general linear function. These are the *osculating quadrics* of f at O, any one of which is a second approximation to the surface. The sections of f and q by any plane through O have the same curvature at O.

Let O be an ordinary point of f, with z as tangent plane, and therefore $x=y=0$ as normal. Then $f\equiv z+u_2+\cdots+u_n$, and the simplest osculating quadric is $q\equiv z+v_2$, where v_2 is the result of putting $z=0$ in u_2.

A plane $z=$ a small constant ζ, parallel and close to the tangent plane, cuts f approximately in the conic $v_2=-\zeta$, with centre on the normal, called the *indicatrix*.

If a plane through the normal meets the indicatrix in a diameter of length $2r$, the radius of curvature of the normal section is ρ, where $\dfrac{1}{\rho}=\dfrac{2\zeta}{r^2}$. An oblique plane meeting the tangent plane in the same line, and making a finite angle ϕ with the normal, cuts f in a section of radius of curvature $\rho\cos\phi$, the projection of ρ upon the plane (Meunier's theorem). This vanishes for the tangent plane, when the section is singular.

The major and minor axes of the indicatrix lie on the *principal* normal planes, making sections of maximum and minimum radii of curvature, say ρ_1, ρ_2. For a normal section inclined at an angle θ to the first principal section, $\dfrac{1}{\rho}=\dfrac{\cos^2\theta}{\rho_1}+\dfrac{\sin^2\theta}{\rho_2}$ (Euler's theorem).

According to the nature of the indicatrix, O is an *elliptic hyperbolic* or *parabolic point* of f. If it is elliptic, all the normal curvatures are of the same sign, and the surface bends away from the tangent plane on one side only. The part near O of the section by $z=\zeta$ is a small real closed curve for ζ of one sign, and imaginary for ζ of the opposite sign. The section by the tangent plane $z=0$ has no real part in the neighbourhood except O itself, which is a double point with imaginary tangents. The surface is *synclastic*.

At a hyperbolic point, the surface is *anticlastic*. The principal curvatures are of opposite signs, and f bends away from the tangent plane on opposite sides in these directions. Two normal sections have inflexions, the curvatures vanishing; their planes pass through the inflexional tangents at O, which are parallel to the asymptotes of the indicatrix, and touch the section of f by the tangent plane, which has two real branches through O along which f crosses the plane. All sections near O have real branches there. If there is a line lying on f, it is one of the inflexional tangents at each of its points. *Conjugate* tangent lines are those parallel to conjugate diameters of the indicatrix.

At a parabolic point, the inflexional tangents coincide; the section by the tangent plane has a cusp. These points lie on the Hessian.

The normal at O does not in general meet the normal at an adjacent point, unless this lies on a principal section, in which case the normals intersect at one of the two *centres of curvature* of f at O. These coincide if the indicatrix is a circle; then O is an *umbilic*, all normal sections have the same curvature and all adjacent normals meet the normal at O.

Quadrics.—A surface of degree 2 is a *quadric* q; in general its class and rank are each 2 also. The simplest example is the sphere (*q.v.*). Every plane section is a conic. Parallel sections are similar and similarly situated conics, whose centres lie on a line, a *diameter* of q. The diameters concur at the *centre* (which may lie at infinity), which bisects every chord of q through it.

There are three mutually perpendicular planes of symmetry, the *principal planes*, intersecting by pairs in the *principal axes* which meet q in its *vertices*.

Through each point P of q there pass two generators, real or imaginary, lying wholly on q; their plane is the tangent plane to q at P, cutting q in this pair of lines. The generators fall into two systems, any one generator meeting all those of the other system and none of its own. A quadric is determined by any three generators of one system, and may be defined as the locus of a line meeting three fixed skew lines. There are six directions (only two real) of planes of circular section; the points of contact of the tangent planes parallel to these are the *umbilics*.

A quadric has three *focal conics* (two real), to each point S of which there corresponds a *directrix* l, such that the distance of any point of q from S is proportional to its distance from l measured parallel to one of the planes of circular section; S and l are focus and directrix of the section of q by the plane Sl, which is the normal plane at S to the focal conic. A focus can also be defined as a sphere of zero radius touching q twice, the directrix being the chord of contact.

A quadric is fixed when its three principal sections are given, *i.e.*, it is determined by its centre, trihedron of principal planes, and lengths of principal axes. It depends on nine parameters. If the centre is finite, there are three main types of quadric, according to the types of the principal sections: *ellipsoid* (three ellipses), *hyperboloid of one sheet* (one ellipse, two hyperbolas), *hyperboloid* of two sheets (two hyperbolas, one section imaginary). If the centre is at infinity, one principal section is wholly at infinity; the other two are parabolas, meeting in the one finite vertex, and q is an *elliptic* or *hyperbolic paraboloid* according as these parabolas lie on the same or opposite sides of the tangent plane at the vertex. If the principal axes vanish, q is a quadric cone; if also the centre is at infinity, it is a cylinder. Finally, a degenerate quadric is a pair of intersecting, parallel or coincident planes.

The hyperboloid of one sheet and hyperbolic paraboloid have real generators, and models can be constructed by threads or wires; they are everywhere anticlastic. The ellipsoid, hyperboloid of two sheets and elliptic paraboloid have imaginary generators, and are everywhere synclastic. Referred to its principal axes, an ellipsoid of semi-axes, a, b, c has the equation $\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1$. An elliptic paraboloid referred to its vertex as origin can have the equation $\frac{x^2}{a^2}+\frac{y^2}{b^2}=\frac{2z}{c}$; and the other types of quadric can be represented by equally simple equations.

Cubic Surfaces.—A general cubic surface f is of class 12, or lower if it is singular. It possesses 27 lines lying on it, of which each meets 10 others, arranged in 5 intersecting pairs. There are 45 triangles lying on f, whose planes are tritangent, touching it at the vertices. We can also select, in 36 ways, a *double-six* from the 27 lines, consisting of two sets of six lines, each line meeting five of the other set and none of its own. Any plane through a line l cuts f in a residual conic meeting l in two points, at which the plane touches f. For two such planes, the conic touches l, at a parabolic point of f, lying on the Hessian.

There can be as many as four double points on a cubic surface. If these lie at the vertices of the tetrahedron of reference, the equation can take the form $\frac{1}{x}+\frac{1}{y}+\frac{1}{z}+\frac{1}{w}=0$. Each of the six edges of the tetrahedron absorbs four of the 27 lines, and there is one triangle of distinct lines, each meeting two opposite edges of the tetrahedron. A cubic surface can have one double line; it is then skew, each plane through the double line meeting it in a residual generator. Two of these pass through each point of the double line, and their plane meets f in a fixed line of the surface, the simple directrix.

Singularities.—A *singular point* of a locus is one at which there is no definite, single tangent plane. If the origin O is singular, and as above $f\equiv u_0+u_2+\cdots+u_n$, the four conditions are those involved by $u_0=0$, $u_2\equiv 0$. The simplest case is the *conic node*, an ordinary double point represented by $f\equiv u_2+u_3+\cdots+u_n$, where u_2 is a general quadratic function of x, y, z, giving the proper tangent cone.

Any line through O meets f in two points coinciding at O, a generator of u_2 meets it in three points, and the six *lines of closest contact* given by $u_2=u_3=0$ meet it in four. The section of f by a general plane through O has a double point with two quite distinct branches, the tangents being generators of u_2; that by a plane through a line of closest contact has an inflexion on one branch. The section by a plane touching the tangent cone has a cusp, the two branches merging into one cycle.

If a general line through O meets f in s points there, in the simplest case O is an ordinary s-fold point with a proper tangent cone u_s, where $f=u_s+u_{s+1}+\cdots+u_n$; this involves $\frac{1}{6}s(s+1)(s+2)$ conditions. Any plane through O, or any surface having O as an ordinary point, meets f in a curve having an s-fold point there. If O is s_1-fold on the second surface, the two tangent cones having no common sheet, the curve of intersection has ss_1 branches through O. If O is also s_2-fold on a third surface, the three have ss_1s_2 points of intersection absorbed at O.

If the tangent cone breaks up, the simplest case is the *binode*, a double point whose quadric tangent cone consists of two *biplanes*, intersecting in the *edge*. The section by a general plane through O has a double point as for a conic node, that by a plane through the edge has a cusp, and that by one of the biplanes has a triple point. Taking the biplanes as planes of reference, we have $u_2=xy$; then the equation says that either x or y is small of second order, or else both are small of orders between 1 and 2. A general point of f near O is close to a definite one of the two biplanes, and, in this sense, we can speak of two sheets of f, one touched by each biplane; they are not separate sheets, but become indistinguishable near the edge $x=y=0$. There are three lines of closest contact in each biplane; these are in general different from the edge, which meets f in three points only.

The conic node and binode are *ordinary* singularities; *i.e.*, the tangent cone, proper or degenerate, has no repeated sheet. At an *extraordinary* singularity, the tangent cone u_s not only breaks up, but has a repeated sheet, u_r say, so that $u_s\equiv u_r^2\ s-2v$. The simplest case is the *unode*, a double point with a repeated tangent plane, $f=u_1^2+u_3+\cdots+u_n$. The surface has two connected half-sheets, the general section having a cusp. There are three lines of closest contact; the section by a plane through one of these has a tacnode, that by the tangent plane has a triple point.

A general point O of a double curve is a binode of a special kind. The two sheets of f are quite distinct; every simple point of f near O belongs definitely to one sheet or the other, the points of the double curve belonging to both. There is no continuous passage at all from one sheet to the other near O; but on the double curve there lie a certain number of *pinch-points*, unodes of a special kind (which may be absorbed in higher singularities), at which the two tangent planes coincide, and the two sheets become connected.

A *tacnode* of the surface is a double point where the general plane section has a tacnode, which is the plane singularity equivalent to two adjacent double points. Thus O has an infinite set of double points of f adjacent to it, one in every direction in the tangent plane, which may be considered as an infinitesimal double curve adjacent to O. In a similar way, a tacnodal curve is equivalent to two adjacent ordinary double curves.

In general, a singular point, whether isolated or lying on a singular curve, is characterized, first, by its multiplicity, *i.e.*, the number of intersections of f with a general line through the point that are absorbed there; next, by the nature of the tangent cone and its sheets, and of the singularity of a general section; and further by the nature and arrangement of the higher singularities of special sections. By a series of suitable transformations, any singular point or curve of a surface can be analysed into an equivalent set of component singular points and curves of standard types, and any surface can be transformed into one having only elementary singularities, and in particular into one having no isolated singular points, but only ordinary multiple curves and such points of higher singularity as necessarily lie on them; or alternatively into a surface having only a double curve and a number of triple points which are also triple for the double curve. The complete theory is complicated. Isolated singular points may give rise on transformation to singular curves; and a singular curve may give rise, from the transformation of its special points of higher singularity, to other singular curves, whose general points may be of more complicated nature (though not of higher multiplicity) than the general points of the original curve.

Singular tangent planes are defined dually to the above. Any surface of degree $\geqq 3$ must have singularities of one or other kind, or of both. A surface f of degree n with no singular points is of class $n'=n(n-1)^2$; a surface of class n' with no singular planes is of degree $n=n'(n'-1)^2$. These two equations are incompatible unless $n=n'=2$, and f is a quadric.

If f has no point singularities, it has in general two series of double and stationary tangent planes, and its reciprocal has a double and a cuspidal curve. The characteristic numbers of these modify the equations relating degree and class, and make them compatible. If f has higher singularities, there exists a complicated set of relations between the numerical characteristics; the simplest are the Plücker equations for the general plane section and tangent cone.

Curves on a Surface.—The interest of f depends partly on the simpler curves lying on it. There are always its plane sections, and its curves of total intersection with other surfaces; lower curves may arise as partial intersections, components of a total intersection that breaks up through acquiring additional singularities, the cutting surface either touching f or passing through one or more of its singularities. All curves on a plane are its total intersections, with cones standing on the curves. On a quadric, the conic section by a tangent plane acquires a double point at the point of contact and breaks up into a pair of generators. A cubic surface contains 27 pencils of conics, cut out by planes through the 27 lines, and many other systems of curves of degrees 3, 4, and 5, cut out by quadrics containing various sets of the lines.

Other important curves on f are defined by infinitesimal properties. An *asymptotic curve* is one whose tangent at any point is one of the inflexional tangents, parallel to an asymptote of the indicatrix. A *curve of curvature* is one whose tangent at any point is a principal tangent, parallel to an axis of the indicatrix. Two curves of each of these kinds can be drawn through any general point of f. A *geodesic* is a curve whose small arcs are each the shortest distance on the surface between their extremities. On a plane, these are lines; on a developable surface, curves which become lines when the surface is flattened out. An infinite number of geodesics can be drawn through a general point of f, one starting in any direction.

Families of Surfaces.—If an equation contains a parameter λ, it represents a singly infinite family of surfaces; the most important case is the linear family or *pencil*, when the coefficients are linear functions of λ and the equation has the form $f+\lambda\phi=0$. One and only one member of the family passes through each point of space. The total intersection of any two of the family is the same, being that of f, ϕ. More generally, if f, ϕ are any two algebraic surfaces, the equation of any other containing their total intersection can be expressed as $\alpha f+\beta\phi=0$, where α, β are polynomials (Noether's theorem). In the same way, $f+\lambda\phi+\mu\psi$ gives an ∞^2 linear family or *net* of surfaces; one and only one passes through any two given points; any three surfaces of the net have the same *base*, or set of common points and curves, as f, ϕ, ψ.

If f is of degree n, it has $N\equiv\frac{1}{6}(n+1)(n+2)(n+3)-1$ independent ratios of coefficients; all such surfaces form a linear family of N degrees of freedom, and one can be made to pass through N points in general position, each of which presents one independent condition to f. Thus a quadric can be drawn through nine points, and these determine it if they are general. However, seven points determine a net of quadrics, whose base consists of eight points, viz., the seven and another, associated with and determined by the seven, which offers no independent condition; but the passage of the quadric through it is a necessary consequence of its passage through the others. Thus nine points do not determine a quadric if any eight of them are an associated set of this nature.

To have a given point as a double point imposes four conditions on f; to contain a given line, $n+1$ conditions. The number of independent conditions presented to f by an assigned element of any sort is the *postulation* of that element. The conditions for a combination of elements may force f to contain other fixed elements, or to break up. If six out of nine points lie on a plane, the only quadric containing them all consists of this plane and the plane of the other three points.

Two surfaces are *orthogonal* if at every common point the angle between them, *i.e.*, between their normals, is a right-angle. If three surfaces are mutually orthogonal, their curves of intersection are curves of curvature on each surface. If three linear families are such that the three surfaces through any point are at right angles to each other, they form an *orthogonal system; f* can form part of such a system only if it satisfies a certain differential equation of third order. In the same way, a cubic family, with three members through any point, can be an orthogonal system, *e.g.*, the confocal quadrics

$$\frac{x^2}{a^2+\lambda}+\frac{y^2}{b^2+\lambda}+\frac{z^2}{c^2+\lambda}=1.$$

Among the infinite number of surfaces having the same boundary, *i.e.*, a given closed curve through which each is to pass, the *minimal surface* is that whose area is least. This is the form assumed by a soap film bounded by a wire in the form of the given contour. The same property must attach to any small portion of the surface, and leads to a differential equation of second order, the boundary conditions determining the arbitrary elements of the solution. A minimal surface is anticlastic everywhere. If it were synclastic at a point P, a plane near the tangent plane at P on one side would cut it in a small plane closed curve, approximately the elliptic indicatrix, whose area would be less than that of the cap on which P lies; and the total area could be reduced without affecting the given boundary.

Parametric Representation; Genus.—The coordinates of any point on f can be represented as functions of two parameters. We may consider x, y as the parameters, and z given as an implicit function of these by the equation $f=0$. More often it is convenient to express each coordinate as an explicit function of two other parameters, says $x=\phi\ (u,v)$, $y=\psi\ (u,v)$, $z=\chi\ (u,v)$.

In general, ϕ, ψ, χ are many-valued functions; if there are r sets of values of x, y, z for each set of u,v, and we take $u.v.$ as coordinates of a point of a plane, then f is represented on this plane by an r, 1 point transformation. The nature of the representation depends largely on the form of the expression for the element ds of length of arc traced on the surface, given by

$$ds^2 = dx^2+dy^2+dz^2 = Edu^2+2F du\, dv+Gdv^2, \text{ say,}$$

where E, F, G are certain functions of u, v. Here $E^{\frac{1}{2}}\ du$, $G^{\frac{1}{2}}\ dv$ are the elements of length along the curves represented by $v=$ const., $v=$const., at the point whose parameters are u,v; while F depends also on the angle between these curves. If they are everywhere at right-angles, *e,g.*, if they are the curves of curvature, then $F=0$.

Rational surfaces are those which can be represented on a plane by a 1, 1 point transformation. Then the coordinates of any point on f are rational functions of two parameters, the coordinates of the corresponding point of the plane. Of the different plane representations of f, the lowest is that for which the curves in the plane corresponding to the plane sections of f are of lowest degree. Any two of these have n variable intersections, corresponding to the points of f on the common line of the two planes of section; the remaining intersections are fixed, at points of the plane fundamental for the representation. An important family of curves on f are those corresponding to the lines of the plane. Any two of these have one and only one variable intersection, the remainder falling at points of f fundamental for the representation. All quadrics and cubics are rational. Surfaces of higher degree are not, unless they have a sufficient number of singular points and curves.

There are several numerical characteristics of a surface that vanish if it is rational, and may be regarded as answering to the genus of a curve. The simplest is the *genus* as defined by Noether (*Flächengeschlecht*), the number of linearly independent *adjoint* surfaces of degree $n-4$, passing $s-1$ times through every ordinary s-fold curve of f, and s^{-2} times through every ordinary isolated s-fold point, with other conditions at extraordinary singularities. It is also the number of linearly independent double integrals of the form $\iint F(x,y,z)dxdy$, where F is a rational function, and x,y,z are connected by $f=0$. If f has no singularities, its genus is $\frac{1}{6}(n-1)(n-2)(n-3)$.

Bibliography.—The best known text-books are: G. Salmon, *A Treatise on the Analytic Geometry of Three Dimensions* (vol. i. 6th. ed., 1914; vol. ii., 5th ed., 1915); J. G. Darboux, *Leçons sur la Théorie Générale des Surfaces* (1887–96). Full references are given in the *Encyklopädie der mathematischen Wissenschaften*, Band iii.

(H. P. Hu.)

SURFACE TENSION. The title under which many surface phenomena—including Capillarity—are usually considered.

When the surface of water (or other liquid) in a tank is carefully examined it is found not to be perfectly level. The statement that water finds its own level is only approximate. The surface in fact becomes considerably curved near its edges where the liquid comes in contact with the wall of the tank.

If a vertical tube with a very narrow bore is placed with one end in the water, the liquid rises some distance above the level of the outer surface. The rise is greater the smaller the diameter of the bore. The rise of oil through a wick is a phenomenon of the same kind.

If a small quantity of mercury is poured on a horizontal plate it forms a drop. If the quantity is only a few cubic millimetres the drop is nearly spherical—a much larger quantity spreads out into a cake-shaped mass with a nearly flat top and with rounded edges.

A drop of oil placed on a clean water surface spreads almost instantaneously so as to form a very thin film. The thinness of the film can be judged from the colours that flash out (*see* Interference) or from the size of the area covered by even a small drop.

The phenomena of soap bubbles and the formation of froth in solutions of soap are also familiar ones. In these cases, also, thin films are formed.

The propagation of ripples of very short wave-length follows a different law from the propagation of deep sea waves.

When camphor is scraped so that the fragments fall upon a clean surface of water, they rush about on the surface with very rapid and rapidly changing motion. A minute quantity of oil placed on the surface brings them almost instantaneously to rest.

These and many allied phenomena, can all be studied under one heading. They arise from the existence of surfaces separating one medium from another. The special forces which come into play are thence known as Surface forces. The rise in tubes of narrow bore—which are known as capillary tubes because the bore is as "fine as a hair"—is due to these forces. From the special way in which the effects arise in this case the action is called *capillary action*. This name, though often applied in other cases, is hardly applicable except to the case of narrow tubes; while the term *surface action* is applicable in all. The forces which are concerned in these phenomena are those which act between neighbouring parts of substances. These also produce the effects of cohesion. Newton in the third edition of his *Opticks* refers to them in the following passage:—"The parts of all homogeneal hard Bodies, which fully touch one another, stick together very strongly . . . I . . . infer from their Cohesion that their Particles attract one another by some force, which in immediate Contact is exceeding strong, at small distances performs the chymical Operations above mention'd, and reaches not far from the particles with any sensible Effect. . . . There are therefore Agents in Nature able to make the Particles of Bodies stick together by very strong Attractions. And it is the Business of experimental Philosophy to find them out."

These forces must be distinguished from those of gravity which also act between the particles of matter because these latter can act over very great distances. (The earth is controlled in its motion round the sun by gravitation.) Cohesion acts to any measurable extent only over minute distances. Sticks of chalk for drawing are made by highly compressing finely ground chalk and other materials. If a stick is broken and the two parts are brought into their original position as nearly as possible by hand they do not stick together because the neighbouring particles are still so far apart as to exert no sensible attraction. High pressure is needed for them to begin sensibly to attract each other. Before considering in detail how these attractions arise we give a historical summary of the development of the subject.

Historical.—(The following historical summary is taken from James Clerk Maxwell's classical article in the ninth edition of this Encyclopaedia, as modified by the 3rd Lord Rayleigh in the tenth edition.) According to J. C. Poggendorff (*Pogg. Ann.* ci. p. 551), Leonardo da Vinci must be considered as the discoverer of capillary phenomena, but the first accurate observations of the capillary action of tubes and glass plates were made by Francis Hawksbee (*Physico-Mechanical Experiments*, London, 1709, pp. 139–169; and *Phil. Trans.* 1711 and 1712), who ascribed the action to an attraction between the glass and the liquid. He observed that the effect was the same in thick tubes as in thin, and concluded that only those particles of the glass which are very near the surface have any influence on the phenomenon. Dr. James Jurin (*Phil. Trans.*, 1718, p. 739, and 1719, p. 1083) showed that the height at which the liquid is suspended depends on the section of the tube at the position of the meniscus, and is independent of the form of the lower part. Sir Isaac Newton devoted the 31st query in the last edition of his *Opticks* to molecular forces, and instanced several examples of the cohesion of liquids, such as the suspension of mercury in a barometer tube at more than double the height at which it usually stands. This arises from its adhesion to the tube, and the upper part of the mercury sustains a considerable tension, or negative pressure, without the separation of its parts. He considered the capillary phenomena to be of the same kind, but his explanation is not sufficiently explicit with respect to the nature and the limits of the action of the attractive force.

It is to be observed that, while these early speculators ascribe the phenomena to attraction, they do not distinctly assert that this attraction is sensible only at insensible distances, and that for all distances which we can directly measure the force is altogether insensible. The idea of such forces, however, had been distinctly formed by Newton, who gave the first example of the calculation of their effect in his theorem on the alteration of the path of a light-corpuscle when it enters or leaves a dense body.

Alexis Claude Clairault (*Théorie de la figure de la terre*, Paris, 1808, pp. 105, 128) appears to have been the first to show the necessity of taking account of the attraction between the parts of the fluid itself in order to explain the phenomena. He did not, however, recognize the fact that the distance at which the attraction is sensible is not only small but altogether insensible. J. A. von Segner (*Comment. Soc. Reg. Götting.* i. [1751] p. 301) introduced the very important idea of the surface-tension of liquids, which he ascribed to attractive forces, the sphere of whose action is so small "ut nullo adhuc sensu percipi potuerit."

In 1756 J. G. Leidenfrost (*De aquae communis nonnullis qualitatibus tractatus*, Duisburg) showed that a soap-bubble tends to contract, so that if the tube with which it was blown is left open the bubble will diminish in size and will expel through the tube the air which it contains.

In 1787 Gaspard Monge (*Mémoires de l'Acad. des Sciences*, 1787, p. 506) asserted that "by supposing the adherence of the particles of a fluid to have a sensible effect only at the surface itself and in the direction of the surface it would be easy to determine the curvature of the surfaces of fluids in the neighbourhood of the solid boundaries which contain them; that these surfaces would be *lintéariae* of which the tension, constant in all directions, would be everywhere equal to the adherence of two particles, and the phenomena of capillary tubes would then present nothing which could not be determined by analysis." He applied this principle of surface-tension to the explanation of the apparent attractions and repulsions between bodies floating on a liquid.

In 1802 John Leslie (*Phil. Mag.*, 1802, vol. xiv. p. 193) gave the first correct explanation of the rise of a liquid in a tube by considering the effect of the attraction of the solid on the very thin stratum of the liquid in contact with it. He did not, like the earlier speculators, suppose this attraction to act in an upward direction so as to support the fluid directly. He showed that the attraction is everywhere normal to the surface of the solid. The direct effect of the attraction is to increase the pressure of the stratum of the fluid in contact with the solid, so as to make it greater than the pressure within the fluid.

In 1804 Thomas Young (Essay on the "Cohesion of Fluids," *Phil. Trans.*, 1805, p. 65) founded the theory of capillary phenomena on the principle of surface tension. He also observed the constancy of the angle of contact of a liquid surface with a solid, and showed how from these two principles to deduce the phenomena of capillary action. His essay contains the solution of a great number of cases, including most of those afterwards solved by Laplace, but his methods of demonstration, though always correct, and often extremely elegant, are sometimes rendered obscure by his scrupulous avoidance of mathematical symbols. Having applied the secondary principle of surface tension to the various particular cases of capillary action, Young proceeded to deduce this surface tension from ulterior principles. He supposed the particles to act on one another with two different kinds of forces, one of which, the attractive forces of cohesion, extends to particles at a greater distance than those to which the repulsive force is confined. He further supposed that the attractive force is constant throughout the minute distance to which it extends, but that the repulsive force increases rapidly as the distance diminishes. He thus showed that at a curved part of the surface, a superficial particle would be urged towards the centre of curvature of the surface, and he gave reasons for concluding that this force is proportional to the sum of the curvatures of the surface in two normal planes at right angles to each other.

The subject was next taken up by Pierre Simon Laplace (*Mécanique céleste,* supplement to the tenth book, pub. in 1806). His results are in many respects identical with those of Young, but his methods of arriving at them are very different, being conducted entirely by mathematical calculations. For those who wish to study the molecular constitution of bodies it is necessary to study the effect of forces which are sensible only at insensible distances; and Laplace has furnished us with an example of the method of this study which has never been surpassed. He found for the pressure at a point in the interior of the fluid an expression of the form

$$p=K+\tfrac{1}{2}H(1/R+1/R'),$$

where K is a constant pressure, probably very large, which, however, does not influence capillary phenomena, and therefore cannot be determined from observation of such phenomena; H is another constant on which all capillary phenomena depend; and R and R′ are the radii of curvature of any two normal sections of the surface at right angles to each other.

The next great step in the treatment of the subject was made by C. F. Gauss (*Principia generalia Theoriae Figurae Fluidorum in statu Aequilibrii,* Göttingen, 1830, or *Werke,* v. 29, Göttingen, 1867). The principle which he adopted is that of virtual velocities, a principle which under his hands was gradually transforming itself into what is now known as the principle of the conservation of energy. Instead of calculating the direction and magnitude of the resultant force on each particle arising from the action of neighbouring particles, he formed a single expression which is the aggregate of all the potentials arising from the mutual action between pairs of particles. This expression has been called the force-function. With its sign reversed it is now called the potential energy of the system. It consists of three parts, the first depending on the action of gravity, the second on the mutual action between the particles of the fluid, and the third on the action between the particles of the fluid and the particles of a solid or fluid in contact with it.

The condition of equilibrium is that this expression (which we may for the sake of distinctness call the potential energy) shall be a minimum. This condition when worked out gives not only the equation of the free surface in the form already established by Laplace, but the conditions of the angle of contact of this surface, with the surface of a solid.

In 1831 Siméon Denis Poisson published his *Nouvelle Théorie de l'action capillaire.* He maintained that there is a rapid variation of density near the surface of a liquid, and he gave very strong reasons, which have been only strengthened by subsequent discoveries, for believing that this is the case.

The result, however, of Poisson's investigation is practically equivalent to that already obtained by Laplace. In both theories the equation of the liquid surface is the same, involving a constant H, which can be determined only by experiment. The only difference is in the manner in which this quantity H depends on the law of the molecular forces and the law of density near the surface of the fluid, and as these laws are unknown to us we cannot obtain any test to discriminate between the two theories.

We have now described the principal forms of the theory of capillary action during its earlier development. In more recent times the method of Gauss has been modified so as to take account of the variation of density near the surface, and its language has been translated in terms of the modern doctrine of the conservation of energy. *See* Enrico Betti, *Teoria della Capillarità: Nuovo Cimento* (1867); a memoir by M. Stahl, "Ueber einige Punckte in der Theorie der Capillarerscheinungen," *Pogg. Ann.* cxxxix. p. 239 (1870); and J. D. Van der Waals' *Over de Continuiteit van den Gasen Vloeistoftoestand.* A good account of the subject from a mathematical point of view will be found in James Challis's "Report on the Theory of Capillary Attraction," *Brit. Assn. Report,* iv. p. 235 (1834).

J. A. F. Plateau (*Statique expérimentale et théorique des liquides,* 1873), who made elaborate study of the phenomena of surface tension, adopted the following method of getting rid of the effects of gravity. He formed a mixture of alcohol and water of the same density as olive oil, and then introduced a quantity of oil into the mixture. It assumes the form of a sphere under the action of surface tension alone. He then, by means of rings of iron-wire, discs and other contrivances, altered the form of certain parts of the surface of the oil. The free portions of the surface then assume new forms depending on the equilibrium of surface tension. In this way he produced a great many of the forms of equilibrium of a liquid under the action of surface tension alone, and compared them with the results of mathematical investigation. The debt which science owes to Plateau is not diminished by the fact that, while investigating these beautiful phenomena, he never himself saw them, having lost his sight in about 1840.

G. L. van der Mensbrugghe (*Mém. de l'Acad. Roy. de Belgique,* xxxvii., 1873) devised a great number of beautiful illustrations of the phenomena of surface tension, and showed their connection with the experiments of Charles Tomlinson on the figures formed by oils dropped on the clean surface of water.

Athanase Dupré in his 5th, 6th and 7th Memoirs on the Mechanical Theory of Heat (*Ann. de Chimie et de Physique,* 1866–68) applied the principles of thermodynamics to capillary phenomena, and the experiments of his son Paul were exceedingly ingenious and well devised, tracing the influence of surface tension in a great number of very different circumstances, and deducing from independent methods the numerical value of the surface tension. The experimental evidence which Dupré obtained bearing on the molecular structure of liquids must be very valuable, even if our present opinions on this subject should turn out to require modification.

GENERAL THEORY OF CAPILLARY ACTION

It is found by experiment that the forces between molecules to which cohesion is due only act preceptibly across very short distances. If we regard the forces between two particles as acting according to a law depending only upon their positions it must vary inversely as the distance according to a higher power than that of the inverse square which is obeyed by gravitation. The experiments of Quincke and others show that the extreme range through which sensible effect is produced by them is certainly much less than a thousandth of a centimetre and it is probably less than one millionth.

In order to illustrate the important bearing of this limitation in range consider a molecule, A, well within a substance. A sphere of a thousandth of a centimetre radius may be drawn round it and the molecules outside this sphere will have no sensible influence on A. Those within the sphere attract A but in the case of a homogeneous isotropic body their pulls will be uniformly distributed and the resultant *force* on A will be zero. There will, however, be a pressure throughout the sphere due to the attraction: each spherical layer, being attracted, will compress the particles lying inside it. But if we consider a particle B very near the surface—nearer in fact than the range of action—the state of things will be found to be different. There will be more particles pulling B downwards than upwards so that all such particles as B will experience a resultant-*force* downwards. There will also be a *pressure* at B but its value is less the nearer B is to the surface. There is, therefore, a thin, indefinitely bounded, layer near the surface which is in a different condition from the main body of the substances. Many of the properties will be different in this surface layer from elsewhere. For example, corresponding to the different pressure, the density will be different. Since work is done in producing compression the potential energy will differ in the two regions. In the main body it can be written

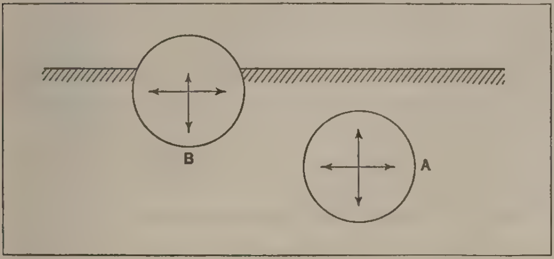

FIG. 1

$$\int \chi_0 \rho_0 dV = \chi_0 \rho_0 V_0$$

where V = volume, ρ density and χ the potential energy per unit mass; in the film, owing to its minute thickness, e, which we divide up into still thinner layers, de, and surface S we write

$$\text{Total mass} = V\rho_0 - S\int_0^e (\rho_0 - \rho)\, de$$

while the total potential energy (in terms of χ its value per unit mass) is

$$\int \chi \rho dV$$

or

$$V\chi_0\rho_0 - S\int_0^e (\chi_0\rho_0 - \chi\rho)\, de.$$

Multiplying the total mass by χ_0 and subtracting from the last expression

$$E - M\chi_0 = S\int_0^e (\chi - \chi_0)\rho de.$$

The right hand side is therefore an expression for that part of the energy which depends upon the existence of a surface S. The integral which multiplies it is the constant (or rather, factor) known as the *surface tension*. This integral is a measure of the work done in increasing the area of the surface. It must be carefully distinguished from the corresponding increase in the total energy because heat is drawn in simultaneously if the change takes place at constant temperature. It is in strictness a measure of the change in the "free-energy." (*See* THERMODYNAMICS: Applied to *Chemistry*.)

By the principles of energy the potential energy (at constant temperature) tends to a minimum; in other words, any change that takes place spontaneously involves a diminution of this energy. Hence, whenever the surface tension is positive there will be a tendency for the surface to decrease, and the diminution will in fact take place unless it is resisted by other forces. This diminution takes place not by a contraction of the liquid but by a passage of the surface molecules into the body of the liquid. The properties of the body are not changed thereby. In this respect the phenomenon is quite different from the case of a stretched india-rubber film. In the case of the liquid the surface tension remains constant during the contraction of the surface area; in the case of the stretched india-rubber it diminishes along with the contraction.

We may express it otherwise by saying that if an imaginary straight line be drawn anywhere in the surface, when *equilibrium exists* there must be a force acting across the line in such a direction as to prevent further contraction of area. It is easy to show that this force per unit length of line is numerically the same as the surface-tension as defined above.

Dupré has described an arrangement by which the surface-tension of a liquid film may be illustrated. A piece of sheet metal is cut out in the form AA' (fig. 2). A very fine slip of metal is laid on it in the position BB' and the whole is dipped into a solution of soap. When it is taken out the rectangle $AA'CC'$ is filled by a liquid film. This film tends to contract on itself and the loose strip of metal will, if let go, be drawn towards AA'. If S is the area *of one face of the film* the potential energy is σS. If $AA' = b$ and $AC = a$ it is equal to σab. Hence if F is the force by which the slip is pulled towards AA', $F = \frac{d}{db}(\sigma ab) = \sigma a$; so that the force per unit length for one face is σ. Hence, σ is either the force per unit length or the potential energy per unit area.

It must be added that we have only considered one of the two faces and the force due to it. There is an equal force on the strip due to the second surface so that the total force is twice as great as the value taken. But the total area is twice as great also so that the conclusion remains unchanged.

There are other ways of illustrating the existence of the tension. Form a film as before but in a fixed frame. Tie a short length of spider line or fine unspun silk so as to form a flexible ring. If it is placed carefully on the film it usually takes an irregular shape. If the film inside the ring is destroyed by piercing it with a hot wire the spider line opens out into a circular form, this being the form which makes the surrounding surface least for a given length of line. Again, a small drop of mercury or a falling rain drop is practically spherical—the sphere being the form which has the smallest area for a given volume. A large drop fails to be spherical because gravitational forces are then strong enough to compete successfully with surface forces. Sometimes a difficulty is felt in connection with the assertion that the surface-tension is constant. Take a film such as we considered and place it vertically. The upward force on $AA' = 2\sigma a$ for the two faces, the downward force at the level CC' is also $2\sigma a$. The remaining force on the portion of the film between these lines is its weight. Hence the resultant force on the mass of the film is its weight and its acceleration should therefore be that of a freely falling body. Yet whatever may be found true for a pure substance, it cannot be true in general that the tension is the same at all parts of a large area. In the case of a soap film some adjustment must automatically take place (either by alteration of concentration or otherwise) which makes the upper tension a little greater than the lower. It is probably the power of such an adjustment being made in the case of a soap solution which is the leading requisite permitting a *durable* film to be made. Otherwise the film would literally fall to pieces.

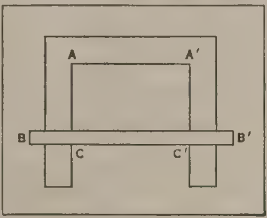

FIG. 2

Theory of Cohesion.—The mode in which cohesion is explained by assuming the existence of forces between elements (*i.e.*, infinitesimal volumes) of matter can be illustrated by supposing the substance of a body to be distributed continuously instead of partitioned into molecules. Such was the mode in which Laplace, more than a century ago, regarded it; and indeed it is the assumption that has always been made until recent times regarding the distribution of the substance of a body.

Let the force between two elementary volumes be supposed proportional to the product of the volumes and inversely as the *n*th power of their distances apart. The force required is that across unit area drawn anywhere well inside the body arising from the volumes on each side of it. The calculation is made in successive stages.

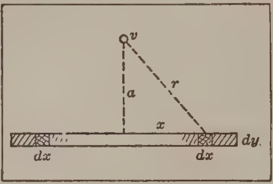

FIG. 3

(i.) Take a lamina of thickness dy. The force on an elementary volume v due to a zone of radius x and width dx is $v \cdot \frac{2\pi x\,dx}{r^n} \cdot \frac{a}{r}\,dy$ since the tangential components will cancel each other. Hence the whole lamina attracts the element with a force

$$2\pi va \int_a^\infty \frac{x dx}{r^{n+1}} \cdot dy = 2\pi va \int_a^\infty \frac{dr}{r^n}\,dy.$$

This becomes $\frac{2\pi va}{(n-1)a^{n-1}}\,dy$ or $\frac{2\pi v}{(n-1)a^{n-2}}\,dy$ since we assume the forces to vanish at infinity.

(ii.) Let v be an element in a parallel lamina of thickness da. Then the total force per unit area on such a lamina II. is obtained by putting $v = da$. Hence we find the force on a semi-infinite solid above lamina II. due to lamina I. by integrating from 0 to ∞ that is

$$\text{Force on semi-solid (per unit area)} = \frac{2\pi dy}{n-1}\int_0^\infty \frac{da}{a^{n-2}}$$

$$= \frac{2\pi}{(n-1)(n-3)} \left| \frac{1}{a^{n-3}} \right|_0^\infty$$

(iii.) The force (per unit area) on such a semi-infinite body due to a semi-infinite body in contact with it is obtained by integrating with respect to y from $y = 0$ to $y = \infty$. This force is the cohesion per unit area and is given by

$$K_0 = \frac{2\pi}{(n-1)(n-3)(n-4)} \left| \frac{1}{a^{n-4}} \right|_0^\infty$$

The unit of force used is that between two unit volumes separated by unit distance.

Lord Rayleigh remarks: "The pressure will therefore be infinite whatever n may be. If $n-4$ be negative the attraction of infinitely distant parts contributes to the result; while if $n-4$ be positive the parts in immediate contiguity act with infinite power. For the transition case, discussed by W. Sutherland (*Phil. Mag.* xxiv. p. 113, 1887) of $n = 4$, K is also infinite." He adds "It seems therefore that nothing satisfactory can be arrived at under this head."

In more recent times, however, it has been realized (particularly by the Dutch school of physicists) that to treat the body as a *continuum* is bound to give erroneous results. Every substance is known to be built up of molecules. If we assume the existence of attractions depending on the distance between the centres of the molecules it is at the same time necessary to recognize that the two halves of the body can never approach to absolute contact. The lower limit in the last integration should be the least distance of separation between the lines of centres of contiguous layers. This will be a magnitude comparable with the molecular diameter, say s. The value we seek then becomes

$$K_0 = \frac{2\pi}{(n-1)(n-3)(n-4)} \cdot \frac{1}{s^{n-4}}.$$

There is now no objection on the above grounds to the power law provided that $n > 4$.

There can be no doubt that if the amount of matter compressed into unit volume (*i.e.*, the density ρ) be increased the value of the intrinsic pressure would be increased. Moreover, a factor Γ (akin to the gravitation constant) is also needed if K is to be expressed in ordinary dynamical units. Hence finally

$$K = \Gamma \cdot \frac{2\pi\rho^2}{(n-1)(n-3)(n-4)} \cdot \frac{1}{s^{n-4}}.$$

The quantity, K, is called the Laplace pressure or intrinsic pressure. More generally we could assume that the force between elementary volumes is $f(r)$. The successive integrals then become

i. $$2\pi a \int_a^\infty f(r)\,dr\,dy = 2\pi a\phi(a)\,dy;$$

ii. $$2\pi dy \int_y^\infty a\phi(a)\,da = 2\pi dy\,\psi(y);$$

iii. $$K_0 = 2\pi \int_s^\infty \psi(y)\,dy$$

where ϕa, ψy are written as the values of successive integrals. Finally K is obtained in ordinary units by multiplying by $\Gamma\rho^2$ For example if $f(r) = \epsilon^{-kr}$ where k is a constant we have

$$\psi(s) = \frac{ks+1}{k^3}\,\epsilon^{-ks}.$$

The difficulty in testing these formulae arises from the occurrence of three variables (k, s, Γ). The only one of these about which we know the value independently is s which for liquids must be of the same order as the molecular diameter. Caution is necessary in considering forces which vary so fast with the distance as cohesive forces undoubtedly do. A small error in the assumed value for s would lead to very considerable error in k and Γ. The intrinsic pressure *at the breaking point* of a solid in tension should be the breaking stress itself. The latter as actually measured is, however, only a lower limit of K since flaws in the material and irregularities in the application of the tension will lead to fracture occurring at a value lower than the ideal stress. The effect of cohesion on the characteristic equation of a gas was allowed for by van der Waals who, following Laplace, took the intrinsic pressure as varying with the density square alone. The equation becomes

$$(p + a\rho^2)(v - b) = RT$$

where at the same time b is introduced to represent the fact that the volume of the gas cannot be reduced to zero. Here $K = a\rho^2$ which for water at ordinary densities is between 10–20 Atmos. The fact that the equation turns out to be approximate only makes caution necessary. Moreover a is found to vary nearly inversely as the absolute temperature. We are obliged to assume, therefore, either that Γ is a function of the temperature or, what is more likely, that s is such a function. The latter assumption is indeed a very plausible one, for the least average distance of approach of the molecules must be affected by the motion of agitation amongst them and this increases as the square root of the absolute temperature.

Besides these considerations it must be pointed out that the modification worked out by the Dutch school only partly allows for the effects arising from the molecular character of matter. Knowing the forces between two molecules at a given distance apart, the actual value of the intrinsic pressure could only be correctly obtained by summing up the components (normal to the interface at which the pressure is being calculated) of all the forces between every pair of molecules each being calculated for the actual positions in which the molecules instantaneously are. It is true, that with forces that vary so fast with distance it is only the molecules which are fairly near to a point whose individual contributions are important: the contributions of the remainder may be estimated by an approximate method such as that followed by Laplace. Something has been done in this direction (Lennard-Jones, *Faraday Society*, "Discussion on cohesion," 1927) but the fact remains that though the law of force is probably greater than the inverse fifth it may vary up to the inverse seventh so far as present knowledge goes. If we take the higher of these two estimates the force between molecules which are neighbours and those that are next door to neighbours will be as 2^7 to 1, *i.e.*, in the ratio 128 to 1 or that between any layer and the next and next but one contiguous layer as 2^6 to 1, *i.e.*, in the ratio of 64 to 1. Hence all but a small percentage of the intrinsic pressure is due to the molecules in a small volume surrounding the point. This conclusion is important since it signifies that in any material (gas, liquid, solid) the intrinsic pressure will be uniform at all points except for a thin layer of usually negligible volume near its boundary.

Theory of Surface Forces.—This surface layer has theoretically no inner boundary but it may be taken, for most purposes, as being only a few molecules thick (mol. diameter is of the order of 10^{-8} cm.). The most prominent peculiarity is that it possesses more potential energy than the rest of the body per unit volume.

Now increase of free energy at constant temperature is equal to the external work done on a system. If we write $dW=\sigma dA$ σ is called the surface tension. To determine its value theoretically we estimate dW for the formation of a surface of unit area. Now if a body is split by a plane section and the two halves separated, a fresh surface is formed. The attraction per unit area between the halves at any distance x is

$$2\pi\int_x^\infty \psi(y)dy = K(x) \text{ say.}$$

The total work of separation is $\int_s^\infty K(x)\,dx$ and in the process a fresh area of 2 units is formed. Hence expressing the work done in ordinary units

$$2\sigma = 2\pi\Gamma\rho^2\int_s^\infty K(x)dx$$

(In previous editions many theorems were given [some of which date from Laplace] which depend, however, upon the lower limit being zero. It is sufficient to say that these theorems are not applicable to the formulae given here.)

If a power law is taken as the law of force between molecules it follows that

$$\sigma = \frac{\pi\rho^2\Gamma}{(n-1)\,(n-3)\,(n-4)\,(n-5)\,s^{n-5}}.$$

This law may be combined with that for K with the result that

$$\frac{K}{\sigma} = \frac{2\,(n-5)}{s}.$$

For water at ordinary temperature, approximately

$$K = 10{,}000 \text{ Atm.} = 10^{10} \text{ dynes/sq.cm.}$$
$$\sigma = 75 \text{ dynes/cm.}$$
$$s = 4\times 10^{-8} \text{ cm.}$$

Whence, $$n-5 = \frac{10^{10}\times 4\times 10^{-8}}{2\times 75} = \frac{8}{3}$$

and $$n = 7{\cdot}67.$$

It must not be forgotten, however, that K and s are obtained by very approximate methods only.

Interfacial Tensions.—When two liquids are in contact there is in general a surface-tension at the interface which is called interfacial tension. Denoting this by σ_{12} and the tensions of the liquids as σ_1 and σ_2 respectively, and carrying out a separation of the two liquids the value of σ_{12} can be determined. In the above process the interface between 1 and 2 disappears and two fresh surfaces appear at which the tensions are σ_1 and σ_2. Hence

$$\sigma_2+\sigma_1-\sigma_{12} = 2\pi\rho_1\rho_2\int_{\frac{s_1+s_2}{2}}^{\infty} K(x)dx$$

where the lower limit is the sum of the radii of the two kinds of molecules. Hence

$$\sigma_{12} = \pi\rho_2^2F(s_2)+\pi\rho_1^2F(s_1)-2\pi\rho_1\rho_2F\left(\frac{s_1+s_2}{2}\right).$$

Young took the functions F as being identical being all the same function of zero instead of the molecular diameters;

whence $$\sigma_{12} = \pi(\rho_2-\rho_1)^2\,F(0)$$

or $$\sqrt{\sigma_{12}} = \text{const.}\times(\rho_2-\rho_1).$$

Hence for three liquids taken pair by pair

$$\sqrt{\sigma_{12}}+\sqrt{\sigma_{23}}+\sqrt{\sigma_{31}} = 0.$$

These simplified relations are known not to be true. On the other hand if the power law is valid and is the same law for different substances the equations given here lead to

$$\sigma_{12} = \left(\frac{\rho_2^2}{\sigma_2^{n-5}}+\frac{\rho_1^2}{\sigma_1^{n-5}}-\frac{2\rho_1\rho_2}{\left(\frac{s_1+s_2}{2}\right)^{n-5}}\right)\frac{\pi}{(n-1)(n-3)(n-4)\,(n-5)}$$

and the square root law should not be expected to be true excepting in special cases in which the molecular diameters of the three substances were the same.

All surface-tensions with which we have to deal are in reality interfacial tensions since a liquid is always in contact with its own vapour or the gas in which it is immersed. The effect due to the gas is known, however, to be very small.

The normal pressure to be expected from the existence of a superficial tension is best obtained by considering in the first place a cylinder.

Consider an element of surface, $ds\times$unity. The tensions acting at its extreme edges are inclined to one another and have a resultant inwards. Their resultant is a normal force $2\sigma\sin\frac{d\theta}{2}$ or in the limit $\sigma d\theta$. But $\frac{ds}{d\theta}=R$ (the radius of curvature); hence the normal force is $\sigma\frac{ds}{R}\cdot$ Since this acts over an area equal to ds, the normal pressure is σ/R.

If we take a body of any shape and select a square-bounded element of the surface, the tensions in the plane of the diagram are equivalent to a normal force $\sigma ds_1\times\frac{ds_2}{R_1}$ and those acting on the other two edges to $\sigma ds_2\times\frac{ds_1}{R_2}\cdot$ Hence per unit area

$$p = \sigma\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\cdot$$

Here R_1 and R_2 are the radii of curvature in two planes at right angles. Owing to Gauss's theorem of integral curvature the sum of two such curvatures at a point is a constant. The above theorem is therefore true whether the two rectangular planes considered are principal planes or otherwise. In the case of a sphere

$$p = \frac{2\sigma}{R}\cdot$$

Effect of Temperature.—The variation of surface tension with temperature was not taken into account in Laplace's theory. The forces between molecules were taken, like gravitational forces, to be independent of temperature. The rise in a capillary tube was supposed to vary merely because the density varied. Experiment has shown, however, that the tension itself in all cases diminishes with rise in temperature. That it must ultimately diminish to zero can be inferred from the fact that according to the usual conceptions as to the critical state a liquid and its vapour will at that point become identical with one another; the tension at the interface must then be zero. Eotvös introduced the conception of molecular surface tension. By means of somewhat doubtful reasoning he concluded that $\sigma(Mv)^{\frac{2}{3}}$ (where Mv is the molecular volume), plotted against temperature should give

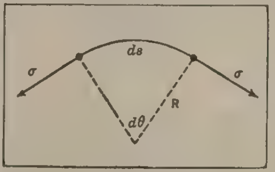

FIG. 4

the same kind of curve for different substances, and he found in fact that it was representable by $K(T_c-T)$ where T_c is the critical temperature and K a constant. According to Ramsay and Shields K should be the same constant for all non-associated substances. In reality K varies betyeen 1·5 and 2·6 and it is necessary also to change T_c-T to $T_c-T-\delta$ where δ is a small constant, so that the law is only a rough one. According to this equation the curve would be a straight line cutting the temperature axis a few degrees below the critical point.

In connection with this, it is important to remember that σ is only the free energy per unit area and not the total energy per unit area (u). Lord Kelvin was the first to prove that the variation of σ with temperature, involves that u must be greater than σ; or in other words, when an expansion of the surface takes place heat must be added to keep the temperature constant. The connection between these quantities he proved thermodynamically to be $u=\sigma-T\dfrac{d\sigma}{dT}$ (*vide* THERMODYNAMICS applied to chemistry). Now, at the critical point, u (which is only the *extra* energy due to the existence of unit surface and not the total energy of the whole body) must also vanish. But if both u and σ are then zero so also must $T\dfrac{d\sigma}{dT}$ be zero.

Hence, if our conceptions of the critical state are correct the curve of σ plotted against T instead of being a straight line must become horizontal at the critical point. In 1894, van der Waals showed that a formula of the type $\sigma=A(T_c-T)^n$ was to be expected and gave the average value of $n=1{\cdot}27$ as deducible from the experimental values. In 1916 A. Ferguson (*Phil. Mag.*, Jan. 1916), examining the data for 14 different organic substances showed that the best values of n ranged from 1·187 to 1·248. The advantageous character of this power equation is that it makes σ, u, and $\dfrac{d\sigma}{dT}$ all equal to zero at the critical point and it thus satisfies all that is required of it theoretically. Liquids, however, which are believed to be associated do not follow the above simple law.

The surface energy, u, also falls to zero at the critical point, but according to a different law. For taking the equation

$$u=\sigma-T\frac{d\sigma}{dT}$$

it follows that $u=A(T_c-T)^{n-1}(T_c+[n-1]T)$. The curves for σ and u are shown in fig. 5 for the case of benzene. The curve shows how nearly a straight line law satisfies the values of σ until the critical point is closely approached. An interesting relation has been given by Prof. E. T. Whittaker between u and the latent heat (internal) of *evaporation*. The internal latent heat (L_i) is obtained by subtracting the external work done from the ordinary latent heat. The relation in question is that $\dfrac{T_c}{T}\cdot\dfrac{u}{L_i}$ is nearly a constant, and that (in C.G.S. units) this constant is about unity for ethyl oxide, methyl formate, benzene and chlorobenzene and about 2 for carbon tetrachloride. The degree of constancy is indicated in the following table for benzene (Crit. temp. = 561.5A)

$T°A$	$\dfrac{T_c u}{T L_i}$	$T°A$	$\dfrac{T_c u}{T L_i}$
353	1·106	493	1·089
403	1·100	503	1·106
453	1·067	513	1·129

The relation is important since it indicates the close connection there is between the surface energy and the volume energy of the substances.

General Properties of Surface Tension.—The notion of surface tension, though it is only a derived one, enables us to deal with all the phenomena which were enumerated at the head of this article without making explicit reference to the more fundamental notion of molecular attractions upon which they in reality depend. It is appropriate to summarize here the leading characteristics of this property.

The tension of a liquid across any straight line drawn on the surface is normal to that line and is the same for all directions of the line and is measured by the force across an element of the line divided by the length of that element.

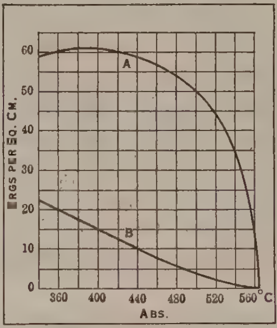

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FIG. 5

For any given homogeneous liquid surface, as the surface which separates water from air or oil from water, the surface tension is the same at every point of the surface and in every direction. In the case of mixtures, however, when circumstances demand it (*e.g.*, when the surface is inclined and the effects of a gravitation field require consideration) the concentration at the surface may adjust itself from point to point of the surface in such a way as to produce a corresponding variation in the value of the surface tension sufficient to satisfy the conditions of equilibrium. This effect is very minute and in nearly every problem may be ignored.

When the surface is curved the effect of the surface tension is to make the pressure on the concave side greater than that on the convex side by the amount $\sigma(C_1+C_2)$ where C_1 and C_2 are the curvatures in mutually perpendicular normal planes.

The tension of the surface separating two liquids cannot be deduced by any reliable method from the tensions of the liquids when separately in contact with air. The experiments of C. G. M. Marangoni, van der Mensbrugghe, and Quincke have led to results which show that the common surface between two liquids has a tension always less than the difference of the tensions of the separate liquids. This is usually referred to as Marangoni's rule.

If three liquids meet along a line the interfaces at the common edge must be parallel to the sides of a triangle proportional to the three tensions σ_{12}, σ_{23}, σ_{31} otherwise equilibrium cannot obtain (Neumann's rule). This triangle cannot exist unless two of the interfacial tensions are greater than the third. Marangoni's experimental rule shows that the triangle is always imaginary. Hence three pure fluids (of which one may be a gas) accordingly cannot remain in contact. If a drop of oil stands in a lenticular form upon a surface of water, it is because the water-surface is already contaminated with a greasy film.

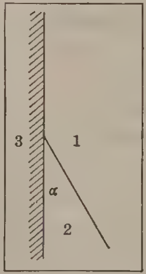

FIG. 6

When a solid body is in contact with two fluids the surface of the solid cannot alter its form but the angle at which the surface of contact of the two fluids meets the surface of the solid must depend on the values of the three surface tensions. For equilibrium

$$\sigma_{31}-\sigma_{32}=\sigma_{21}\cos\alpha.$$

The angle α is known as the angle of contact. For pure substances the angle is definite. It varies from zero (or very nearly so) for liquids that "wet" the solid to 130° or 140° for mercury on glass.

In regard to the experimental behaviour of water on mercury the wealth of papers is equalled by the remarkable lack of uniformity in the results obtained even when elaborate precautions are taken. A drop of water which fails to spread when placed on a mercury surface is often caused to spread by the action of pouring the mercury out of the dish—thus involving the creation of a new surface! Water shows a positive tendency to spread *in vacuo* on a drop *formed in vacuo!* (Burdon, *Faraday Society*, May, 1927).

Form of a Capillary Surface.—The form of the surface of a liquid acted on by gravity is easily determined if we assume that near the part considered the line of contact of the surface of the liquid with that of the solid bounding it is straight and horizontal.

This will be the case, for example, near a flat plate dipped into the liquid. Let A_2P_2 be the vertical plate supposed to be so wide that the edge effects do not count. We will consider the forces per unit depth (perpendicular to the paper) and will consider A_1A_2 as the standard level of the liquid far from the plate. The curvature of the surface at the point x, y, is

$$\frac{d\theta}{ds} = \sin\theta\frac{d\theta}{dy} = -\frac{d(\cos\theta)}{dy}$$

and consequently the pressure in the liquid at that point is less than the pressure outside it by $-\sigma\frac{d(\cos\theta)}{dy}$. But the pressure is less than that at a distant point where the surface is flat by $g\rho y$ or $g(\rho-\rho_0)y$ if allowance is made for the surrounding gas. Hence the differential equation for the surface is

$$-\frac{d(\cos\theta)}{dy} = \frac{g(\rho-\rho_0)}{\sigma}y$$

the integral of which is $1-\cos\theta = 2\sin^2\frac{\theta}{2} = \frac{g(\rho-\rho_0)}{\sigma}\cdot\frac{y^2}{2}$.

The shape of the surface is therefore the *elastica, i.e.*, the form taken by a uniform spring when equal and opposite forces are applied at its ends (*see* Thomson and Tait, *Natural Philosophy*, vol. i. p. 455). The equation might have been found by considering the elementary volume of a strip of liquid, dx, sustained above the normal level of the liquid by the surface forces at its outer and inner edges. The difference of the vertical component of these is $\sigma d(\sin\theta)$ and the weight of the strip is $g\rho y dx$ but since $\frac{d(\sin\theta)}{dx} = -\frac{d(\cos\theta)}{dy}$ the same result is obtained.

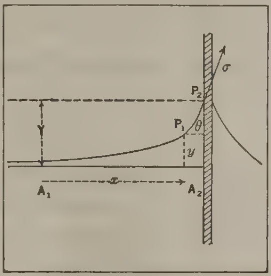

FIG. 7

If the angle of contact is α the value of θ at the plate is $\frac{\pi}{2}-\alpha$;

hence $$1-\sin\alpha = \frac{g(\rho-\rho_0)}{\sigma}\cdot\frac{Y^2}{2}$$

which gives the greatest height through which the liquid is raised. A thin sheet of glass suspended from the arm of a balance and just dipping into a liquid provides a simple way of determining the surface tension. The increase in the apparent weight of the sheet when the liquid has been raised by capillarity is σ multiplied by twice the horizontal length of the sheet. A sensitive form of this apparatus is known as Worthington's multiplier in which the strip is rolled into a vertical cylindrical spiral.

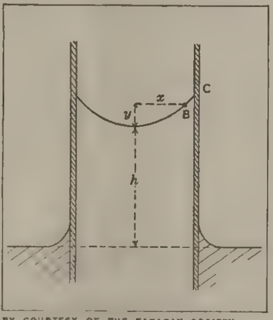

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FIG. 8

Ascent up a Capillary Tube.—A capillary tube dipped in a liquid provides a simple method of determining surface tension. To connect the surface tension with the rise (or descent) of the liquid in the tube measured from the level part of the outside surface we equate the effective weight of the liquid raised to the total force due to the tension. The effective weight (with the symbols shown on diagram) is

$$g(\rho-\rho_0)\int_0^x 2\pi x(h+y)dx$$

for an inner cylinder of radius x where ρ is the density of the liquid and ρ_0 that of the surrounding gas or vapour. The vertical component of the surface force acting all round the edge of the liquid surface of this cylinder is $2\pi x\sigma\sin\theta$ or $2\pi x\sigma\cos\alpha$ where θ is the angle between the surface and the horizontal and α is the "contact-angle" which is measured with respect to the solid surface (in this case the vertical). These two expressions are to be equated to one another.

If we can neglect y altogether compared with h and integrate between the limits 0 and r we obtain $2\pi r\sigma\sin\theta = g(\rho-\rho_0)\pi r^2h$ whence $\sigma\sin\theta = \frac{1}{2}g(\rho-\rho_0)rh$. To seek for a better approximation we first differentiate the two sides of the equation whence

$$\frac{d(x\sin\theta)}{dx} = \frac{g(\rho-\rho_0)}{\sigma}x(h+y) = \frac{x(h+y)}{\beta^2}.$$

We may consider this as the standard exact equation. The left side is

$$\frac{x\,d\sin\theta}{dx} + \sin\theta \quad\text{or}\quad x\left(\frac{\cos\theta d\theta}{dx} + \frac{\sin\theta}{x}\right).$$

But $\cos\theta\frac{d\theta}{dx} = \frac{d\theta}{ds}$ (where ds is an element of the curve AC) and is ∴ the curvature in the plane of the diagram at B; and $\frac{\sin\theta}{x}$ is the curvature of the surface at B in a plane at right angles to the diagram. Hence, calling these curvatures $\frac{1}{R_1}$ and $\frac{1}{R_2}$ we have

$$\sigma\left(\frac{1}{R_1}+\frac{1}{R_2}\right) = g(\rho-\rho_0)(h+y);$$

both of the terms here are expressions for the difference of pressure between the two sides of the surface at the point B.

Narrow Tubes.—The equation shows that the sum of these curvatures increases with the height; but when h is big and y small, as it is for a very narrow tube, the sum is nearly constant. Going back to the differential form of the equation and taking the case where the liquid wets the tube, we may consider the curve as practically circular, of radius r; the corresponding value of $y=r-\sqrt{r^2-x^2}$ and

$$\frac{d(x\sin\theta)}{dx} = \frac{1}{\beta^2}(h+y)x = \frac{x}{\beta^2}(h+r-\sqrt{r^2-x^2})$$ nearly whence, by integration

$$x\sin\theta = \frac{1}{\beta^2}\left[\frac{hx^2}{2}+\frac{rx^2}{2}+\tfrac{1}{3}\{(r^2-x^2)^{\frac{3}{2}}-r^3\}\right].$$

or since $\sin\theta=1$ when $x=r$

$$1 = \frac{r}{2\beta^2}\left(h+\frac{r}{3}\right).$$

By putting the radius of the circle as $R=\frac{r}{\cos\alpha}$ when the angle of contact is α instead of zero this becomes

$$\cos\alpha = \frac{r}{2\beta^2}\left[h+\frac{r}{3\cos^3\alpha}\{1-3\sin^2\alpha-2\sin^3\alpha\}\right].$$

By calculating $\tan\theta$ from $\sin\theta$ and bearing in mind that

$$\tan\theta = dy/dx,$$

we can by subsequent integration obtain a closer value of y in terms of x which can, in turn, be introduced into the differential equation and so on. By such successive approximations Lord Rayleigh has obtained the equation for the case $\alpha=0$ in the form

$$\sigma = \tfrac{1}{2}g(\rho-\rho_0)hr\left[1+\frac{1}{3}\frac{r}{h}-0{\cdot}1288\frac{r^2}{h^2}+0{\cdot}1312\frac{r^3}{h^3}\right]$$

in which the coefficients are claimed to be correct to the approximation given. The equation can only be used in the case when r is small compared with h. It may be mentioned that a very near approach to the equation can be obtained by considering the surface as ellipsoidal with its minor axis vertical. This was first shown by Hagen and Desains. Various methods are employed for determining surface tension experimentally:

(*a*) From the rise in a capillary tube making use of the above equation.

(*b*) *Sentis's Method.*—A capillary tube is partly immersed in the liquid. It is then withdrawn vertically and a drop remains clinging to the lower end; the position A of the vertex of the drop is noticed. The liquid in the vessel is then raised until it touches the vertex (when the column falls) and then raised further till the upper surface is at the same level C as at first. The liquid in the vessel is then at the level B. The vertical distance AB corresponds to h in the ordinary method but in the *correcting terms* h must be put negative. The width of the *drop* is in this case to be small compared with h.

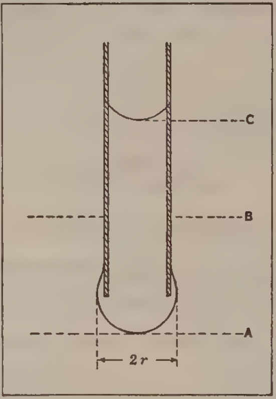

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FIG. 9

(*c*) *Jaeger's Method.*—In this method an orifice (a "tip") is placed just under the surface of the liquid and the pressure of gas is increased until bubbles form. The *maximum* pressure of the gas (which is fairly sharply marked) is observed. The deduction of the applicable equation is a somewhat delicate matter because the problem is really a kinetic, not a static, one. The formula employed is

$$\sigma = \frac{p_{\max} r}{2}\left[1 - \frac{2}{3}\frac{r}{h}\right]$$

where $p_{\max}$ is the maximum difference of pressure between the level of the end of tube inside and outside, and r is the internal radius of the tube. The bubble is assumed to form within the internal circumference. In practice, however, it sometimes forms on the outside circumference. To obviate the uncertainty it is recommended to make the two circumferences as nearly equal as possible, but this is an experimental matter of great difficulty. The final accuracy depends chiefly on the measurement of the radius r. The subject of the formation of bubbles and drops requires much more study than it has received.

(*d*) *Drop Weight Method.*—This method is connected with the preceding one because the drops considered are those issuing from a narrow tube. It was employed by Tate (1864) who gave as the result of his observations:—Other things being the same, the weight of a drop of liquid is proportional to the diameter of the tube in which it is formed. Later, Quincke used it and gave the value $2\pi r\sigma$ as the weight of the suspended drop just before falling provided that the inflow of liquid is sufficiently slow. A portion of the drop is always left behind when the main part falls; but he considered that it might be neglected in the case of very small drops.

Rayleigh has discussed the question from the "dimensional" point of view. (*See* UNITS AND DIMENSIONS.) Assume that the mass M of the drop depends only upon the surface tension, σ, the value of acceleration due to gravity, g, the density of the liquid, ρ, and the inside radius, a, of the tube. Rayleigh shows that $\sigma a/g$ has the same dimensions as a *mass* and that $\sigma/g\rho a^2$ is a pure number. Since quantities that can be equated together must be quantities of the same kind, it follows that $M \propto (\sigma a/g)F(\sigma/g\rho a^2)$ where there is no restriction, imposed by this method of inquiry, upon the function F of the quantity in the second pair of brackets. Rayleigh finds by experiment that $gm/\sigma a$ is fairly constant for wide ranges in the diameter of the tube. For thin-walled tubes in the case of water the following values were obtained:

$\frac{\sigma}{g\rho a^2}$	$\frac{gM}{\sigma a}$	$\frac{\sigma}{g\rho a^2}$	$\frac{gM}{\sigma a}$
2·58	4·13	·277	3·78
1·16	3·97	·220	3·90
·708	3·80	·169	4·06
·441	3·73		

The mean value of the constant is thus about 3·8 instead of 2π which the imperfect theory gave. Further experiments by Harkins and Brown show that the constant approaches Quincke's value as the diameter becomes very small.

As a means for measuring surface tension this method is obviously not satisfactory; but for rough comparative values for liquids of like kind it is a very quick and easy method.

Wide Tubes.—When a is not small the approximations made above for narrow tubes are not suitable.

The question has been fully discussed by the late Lord Rayleigh to whose papers reference should be made (*v.* Rayleigh, *Proc. Roy. Soc.* A, 92, 184, 1915).

Bubbles and Drops.—These can be dealt with by similar methods. Air bubbles in a liquid can be formed of any size, from minute ones which are nearly spherical to large ones shaped like a flat cake. The excess pressure $p - p_0$, which is easily found by experiment, determines the total curvature at the lowest point N; being equal to $\frac{2}{R}$. If y is reckoned upwards as before, then

$$\frac{d(x \sin\theta)}{dx} = \left(\frac{2}{R} + \frac{y}{\beta^2}\right)x:$$

thus $\frac{2}{R}$ replaces h/β^2 in the previous problems. For very large bubbles, as for wide tubes, a good approximation can be obtained by neglecting the second curvature and also $\frac{2}{R}$, so that

$$(1-\cos\theta) = \frac{y^2}{2\beta^2} = 2\sin^2\frac{\theta}{2}.$$

If H is the value of y for which the tangent to the curve becomes vertical we have $H = \sqrt{2}\cdot\beta$. This method has been used by Quincke and others but not always with bubbles large enough to justify the approximation that is made. The bubble is conveniently formed under a slightly concave surface so as to prevent it from escaping. Drops of mercury are easily formed above a concave surface. If y is measured *downwards* from the summit the same formulae hold as for bubbles.

Great attention has been paid to these methods owing to their use in determining surface-tension. The most thorough treatment from the practical point of view is given by Bashforth and Adams (*Capillary Action*, 1883). By means of infinite series calculated for each of the variables each term in the differential equation can be calculated to very high accuracy and tables are drawn up enabling the form to be determined for given weights of material and given surface tensions.

Thin Films.—In this section we consider thin films. The first group of cases consists of those in which the substance forms a thin sheet with gas on both sides, as for example, a soap bubble. Here we have always two surfaces to consider. When the thickness is considerably greater than the value of the range, ϵ of molecular forces the two surfaces are independent of one another; the surface-tension must then have the usual value for each. For very thin films this will not be so. If the thickness is less than the range, ϵ, the tension for each surface will be certainly less than the normal value. When the variation of density at different levels in the film is taken into account it is clear that the reduction in the surface-tension must begin when the thickness is twice ϵ.

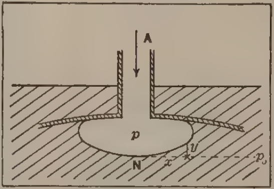

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FIG. 10

A soap film is simply a small quantity of soapsuds spread out so as to present a large surface to the air. The soap solution may with great advantage be specially prepared. The addition of glycerine and resin enables more permanent films to be prepared. Bubbles may easily be blown 20 in. in diameter in the open air using a clay pipe or a small glass funnel. (The method needs no precise description.) Sir James Dewar has obtained bubbles that last almost indefinitely if evaporation be prevented by blowing them in a confined space saturated with water vapour.

The pressure inside a bubble is greater than that outside by

$2\sigma\left(\frac{1}{R}+\frac{1}{R}\right)$, *i.e.*, by $4\sigma/R$ where R is the radius of curvature. The factor 2 arises because both surfaces give rise to normal components of forces. This result is easily obtained by considering the equilibrium of each *half* of the bubble. The force at the cut edge is $2\sigma\cdot 2\pi R$ and this is balanced by the excess pressure acting over the plane area πR^2. Hence the excess pressure is

$$\frac{2\sigma\cdot 2\pi R}{\pi R^2}=\frac{4\sigma}{R}.$$

If the end of the pipe or funnel is opened the bubble will contract because of the escape of high pressure air from inside. As it contracts the pressure rather paradoxically increases. It may be added that (neglecting gravity) the bubble is spherical because this *shape* makes the surface area (and therefore the potential energy) least for a given volume.

If bubbles are blown on the expanded ends of two funnels (the stems being stopped by the fingers) they can be made to coalesce by carefully bringing them into contact. (A slightly electrified rod brought not too near will assist the coalescence.) On drawing the funnels slowly apart a cylindrical bubble is obtained. The excess pressure is now $2\sigma/R$ where R is the radius of the opening of the funnel. Further separation causes the cylinder to contract in the middle; one of the two curvatures is now negative; the surface is an *anticlastic* one. With further extension of length the surface becomes unstable and the film collapses. It has been shown by Clerk Maxwell that a cylindrical film becomes unstable when its length is greater than its circumference.

Films on Liquids.—In the second group of cases a liquid or solid is on one side and a gas on the other. To this group belong all cases of the spreading of oil or other substance on water or other liquid or solid. This old familiar subject has recently acquired very great importance in its bearing upon molecular structures. The first to experiment in detail on such films was F. H. R. Lüdtge (*Pogg. Ann.* cxxxix., p. 620), who showed how a film of high surface tension is replaced by one of lower surface tension. Akin to these are experiments made on the erratic movements that are observed when fragments of camphor are sprinkled on a *clean* water surface. A trace of grease such as may be communicated to the surface by dipping a finger in the water may be sufficient practically to stop this motion. The thickness of oil which is required may be spoken of as the "camphor-point." The first to determine it was (the 3rd) Lord Rayleigh who in 1890 (*Roy. Soc. Proc.*) showed that the thickness of the film of olive oil, calculated as if continuous (*i.e.*, non-molecular) which corresponds to the camphor-point is about 2×10^{-6} mm.; *i.e.*, it is only a moderate multiple of the supposed diameter of a gaseous molecule and perhaps scarcely exceeds at all the diameter to be attributed to a molecule of oil; and he ultimately realized that this phenomenon was therefore entirely outside the scope of a theory of surface action such as Laplace's in which matter is regarded as continuous and that an explanation required a direct consideration of molecules.

In 1891 Miss Pockels (*Nature*, XLIII., 437 [1891]) showed by means of a movable slider on water (the surface tension being measured by means of the attraction on a small disc) that the contaminating material on the surface could be squeezed up and concluded from her experiments that the water-surface can exist in two sharply-contrasted conditions; the normal condition, in which the displacement of the partition makes no impression on (the value of) the tension; and the anomalous condition in which every increase or decrease (of the surface) alters the tension.

The question was taken up again by Lord Rayleigh in 1899 (*Phil. Mag.* XLVIII., 1899) with apparatus designed on the lines of that of Miss Pockels (but employing a different way of measuring the surface tension) and he concluded that the first drop in tension corresponded to a complete layer one molecule thick and that the diameter of a molecule of oil is about $1{\cdot}0\times10^{-6}$ mm.

Later investigations have been made by I. Langmuir (in America: *J. Amer. Chem. Soc.*, 1915 to 1918) and N. K. Adam (in England) and their coworkers. By measuring the surface area that can be completely covered by a weighed quantity of material Langmuir determined both the cross-sectional area and the length of a molecule and proved that the length for organic molecules like those of palmitic, stearic, cerotic acids, etc., was nearly five times the breadth, while in cetyl palmitate it is nearly ten times. Adam has developed the technique and has very much extended the theoretical interpretation (*Roy. Soc. Proc.* A. 1921 to present time). Both Langmuir and he measured the amount of "oil" and measured directly the force required to compress the surface to any given area by means of a floating barrier. The actual force measured is the length of the barrier multiplied into the difference of the surface tension on the two sides of it. On the outside the surface is that of pure water—on the inside that of water on which a thin film has been formed. It is found that when the molecules in the film are so sparse as to be widely separated from one another the force due to the film is an expansive one.

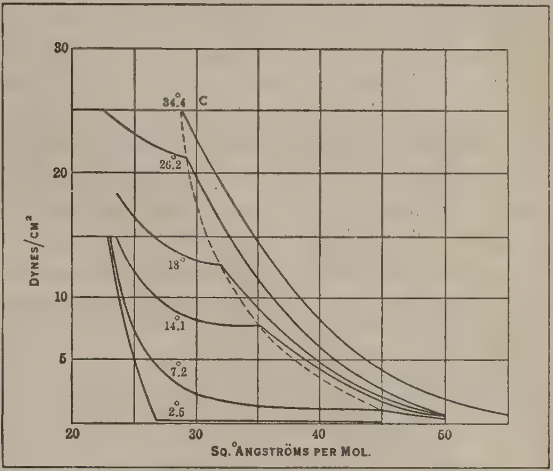

FIG. 11

This cannot be explained on Laplace's theory: it is necessary to modify it by allowing for the effects of thermal motion; the film in such a case is analogous to a two-dimensional gas. If the barrier is now moved so as gradually to compress the film various changes take place successively which are depicted in fig. 11 for the case of a film of myristic acid on weak HCl (N/100). The unit of area adopted is a square each side of which is an Ångström unit (*i.e.*, 10^{-10} metre), and the area specified is that occupied by one molecule of the acid. The ordinates of the curves are the difference of the tensions on the two sides of the barrier. The curves are isothermals extending from 2·5° to 34·4° C. They exhibit some of the characteristics of the p, v, curves for a condensible substance. At high temperatures the curves appear to be approximately rectangular hyperbolas. For small values of the area they approach the form for liquids. At intermediate stages, however, there is no constant pressure isothermal as in the analogous case of the vapour pressure of a liquid below the critical point (the form is more nearly that for the vapour pressure of a *mixture of two liquids;* this fact may indicate that the underlying water takes a part in the changes that occur).

It is not to be expected that there should be complete correspondence between the two classes of phenomena. There is, however, sufficient indication that the effects of thermal motions in the films cannot be neglected. The analogy with liquids and gases can be further illustrated by plotting FA against F, where F is the force applied per unit length; the resemblance to an Amagat diagram for a fluid is very striking (Schofield and Rideal, *Roy. Soc. Proc.* A, 109, p. 67; 110, p. 170). It is clear from the diagram that a film of myristic acid can be squeezed up until a molecule occupies less than 24 A^2. At the opposite end where the behaviour approaches that of a gas it is to be expected that the equation would take the form $FA=RT$ where the value of R (allowing for only two degrees of freedom) should be 1·372 per molecule; at room temperature therefore FA should be about 400. This has been experimentally verified as a limiting value for very low surface pressures. With the long chain fatty acids, esters and nitriles it is approached within 25%, the pressure being below 0·1 dyne per cm. With the dibasic ester $C_2H_5OOC\cdot(CH_2)_{11}COOC_2H_5$ it has been verified within 10%.

The interpretation of the experimental results is still in a somewhat fluent state and it is clear that we must not press any *simple* gas analogy too far. A thin film upon a body of different material cannot be treated as in a similar state to the molecules in the body of a gas. Forces must exist between the film and the liquid beneath. This may account for the fact that at any rate some films do not spread indefinitely as a gas expands into a vacuum. Further, the most compressed state can only give an upper limit to the least cross sectional area of the molecule. The molecules are resting on the rapidly-moving molecules beneath them and must share to some extent in their agitation. Still it must be granted that these new investigations are throwing great light on the nature of films and on the dimensions of molecules. Where corroboration is possible, measurements made by means of X-rays are in good accord with those obtained by this method.

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For certain properties of solutions *see* THERMODYNAMICS (applied to Chemistry). (A. W. Po.)

SURF-BIRD, a wading bird found along the Pacific coast of the Americas, from Alaska to Chile, and believed to nest on the north Alaskan tundra. Grinnell, who observed the surf-bird in the region of Kotzebue Sound, says that he was informed by the Eskimos of the district that the birds nested in the neighbourhood of some small lakes far back on the tundra and not far from the base of the mountains; this confirms the observation of Nelson at St. Michael. The surf-bird (*Aphriza virgata*), which is nowhere abundant, belongs to the family *Charadriidae*, the plover-like birds, and is placed by Knowlton between the turnstones and the oyster-catchers; it is distinguished from the turnstones by its longer tarsus, emarginate tail, and the swollen terminal portion of the bill. The surf-bird is 10 in. long, dusky, with a white rump.

SURGE, in meteorology, a term first used by Abercromby to denote a long period fluctuation of barometric pressure which seems to be superimposed upon the short period changes related to the passing of a low pressure centre.

SURGERY. The treatment of malformations and diseases by manual operation; secondarily, a medical practitioner's consulting room or office. Progress in the surgical art in the past century has in some measure run parallel with the advances made in all branches of science. The full development of methods for producing anaesthesia (*q.v.*) was the base upon which the progress and elaboration of surgery could be worked out. Study and improvement in anaesthetic methods have continued to the present time and the results have brought within the sphere of operation conditions which were previously beyond surgical aid.

Lister's discovery that a preventible bacterial infection was the cause of suppuration formed the next stage and upon it the development of modern surgery has been founded. By the employment of antiseptic and aseptic methods (*q.v.*) in the preparation of instruments, dressings and the patient's skin, it is now taken for granted that every operation will be carried out without the introduction of micro-organisms into the wound from without.

Advances in regard to these two controlling factors, anaesthesia and asepsis, during the past ten years have merely been developments of detail. Certain new substances have been employed as anaesthetics, both general and local, and minor improvements in apparatus and methods of administration have been introduced. As a theoretical basis for surgery the maintenance of asepsis in all procedures has been long accepted, and no material alterations have been brought forward. It must, however, be appreciated that asepsis is a relative term in regard to wounds of the body; micro-organisms in some numbers may be already present in the tissues, or are introduced despite every precaution. A more complete appreciation of this fact has emphasised the importance of avoiding any treatment of the body tissues which will lower their natural resistance to such mild infection as may be present.

General Principles of Operative Treatment.—Surgery has long passed the stage of being a handicraft. Accurate diagnosis and the ability to estimate the risks of different types of operation in relation to the individual are essential to the equipment of a surgeon. The handicraft of surgery can be as rapidly acquired as that of carpentry; surgical judgment is only developed by long clinical experience and by the ability to learn from failure. In every major surgical operation the variable human factor is present. It may affect the issue of medical and surgical procedures both on psychological and physical grounds, and an appreciation of these possibilities and an acceptance of the limitations of the individual's resistance must always be in the mind of the surgeon when planning an operation. The physical condition of the patient in respect of the function of all essential organs can be assessed with some accuracy by modern methods. His psychological reaction is much less certain. In cases of operation for infective conditions the response to them of his natural defensive mechanism remains a factor of uncertainty. A good deal is known about the reaction of the body to bacterial infections (*see* IMMUNITY), but the problem of the artificial immunisation of the patient against them is still in its infancy. A consideration of these several problems on physiological lines has tended of late to divide operations for acute conditions into two or more stages.

Shock (*q.v.*).—A limit is set to any operation by the incidence of shock. This condition of collapse is secondary to several factors. In its most severe form it may prove directly fatal; its milder manifestations may considerably prejudice the patient's normal recovery. With good anaesthesia, careful haemostasis, and the avoidance of loss of body heat during operation, the condition is now seldom seen in the operating theatre.

It is perhaps in place here to mention pulmonary embolism (*see* THROMBOSIS and EMBOLISM), a rare but serious complication of operations. It may follow a week or so after a simple surgical procedure which appears to have run a normal course. The condition is produced by the impaction of a clot of blood in one of the lung arteries. The clot originates in a vein in the operation area. The size of the clot and the corresponding area of the lung deprived of blood determine the severity of the symptoms.

Diagnosis.—Although the well established methods of clinical examination have not been superseded, the chief advances in surgical diagnosis of late years have been due to a more exact use of radiology (*q.v.*). Though shadow pictures are open to misinterpretation and may mislead, these methods as a whole have led to much greater accuracy in the localisation of morbid conditions in various organs, or in establishing the fact that they are normal. Advances in the chemical investigation of the blood and urine have made it possible to estimate the functional ability of the kidneys with considerable accuracy. The importance of this cannot be overestimated in considering the probabilities of survival of a patient after a major operation on the urinary system.

Preventive Surgery.—Though surgery cannot be regarded as a preventive art there are certain conditions in which it may be properly characterised as such. The early recognition and removal of diseased lymphatic organs such as the tonsil and the appendix are undoubtedly reducing the incidence of certain chronic and acute diseases which may follow the retention of a diseased organ in the body. Another example may be cited in the early operation on the common forms of hernia (*q.v.*). This condition is now customarily operated on almost as soon as it is recognised, frequently in childhood; as a result, the gross and disabling ruptures with their concomitant danger to life, commonly met with in the past century are now relatively rare. Preventive medicine on the other hand, is gradually removing, as it should, from the sphere of surgery many conditions hitherto treated by the knife. In most civilised communities, rickets (*q.v.*) has been eradicated or is treated so early that operation is seldom necessary.

Transplantation of Tissues.—Remarkable experimental results in animals have been published from time to time in regard to the transference of organs and tissues from one animal to another. These results in animals can be applied to a limited degree in man. It has not been found possible successfully to transplant organs or tissues of one species to another. Success in this respect can only be claimed if the transplant survives and retains its original cell form and functions. Skin, fascia and bone are the tissues which can be usefully transplanted from one part of the body to another.

Surgical Technique.—Pre-operative management of the patient will concern his general condition, the preparation for the anaesthetic and the cleansing of the skin in the operation area. Before an operation the patient should be in as good a physical state as possible. For one who is reduced or anaemic, infusion of fluid or even transfusion of blood may be required. In the case of a patient suffering from diabetes the proper dose of insulin or glucose is administered. As regards preparation for an anaesthetic, severe purging and prolonged starvation are now avoided. If the anaesthetic to be administered is ether, a small dose of atropine is given half an hour before the operation to limit the excretion of mucus in the air passages during the operation. Morphia is sometimes given beforehand to calm a nervous patient. Preparatory skin preparation need not exceed the dictates of ordinary cleanliness. The most generally employed method of sterilising the skin immediately before operation is after shaving to paint it with a solution of iodine or picric acid in spirit.

Sterilisation of Instruments, Dressings, etc.—This is effected by boiling them from five to fifteen minutes in water. Strong chemical antiseptics or spirit are often employed to sterilise edged instruments which would be blunted by boiling. Ligature materials used within the wound are now usually made of catgut. These are specially prepared (whereby different degrees of durability are obtained) and sterilised by various processes. Silk and thread are sometimes used for special purposes and are sterilised by boiling in water. Sutures for the skin, which are removable, are commonly made of silkworm or salmon gut and are sterilised in the same way. Dressings and wound coverings are most effectively disinfected by exposure in an autoclave to superheated steam at a temperature of about 250° F for 20 minutes. Sterilisation by hot air from its less penetrating power is limited in application to instruments which would be damaged by boiling in water. Formalin vapour is also of use for instruments of this type.

In all operations the surgeon wears a sterile gown, cap and mask, and protects his carefully cleansed hands with sterilised rubber gloves. During operation care to avoid shock to the patient on the lines already indicated is taken. The operating theatre is kept at a temperature above 70° F, and unnecessary exposure of the patient is avoided. When shock is inevitable infusion of saline solution or blood may be carried out during the operation.

After-treatment.—This will be directed to avoid the complications secondary to anaesthesia. The patient is kept warm in a well-ventilated room. Some vomiting is to be expected after ether anaesthesia. Fluid is administered in small quantities by the mouth as soon as the patient regains consciousness. In some conditions fluid administration may be given by the rectum or subcutaneously. Diet is kept to fluids for a few days. A measure of starvation at this stage, so long as plenty of fluid is given, does not prejudice the patient's recovery. A return to normal diet will depend upon the nature of the operation and the idiosyncrasy of the patient.

Treatment of Operative Wounds.—The normal clean surgical wound is dressed with sterile gauze which may be left in place till the stitches are due for removal; this will probably be about a week after operation. In those cases in which suppuration is present either as the result of a pre-existent abscess or from surgical infection, the wound will be drained by a tube or wick, and mild antiseptic dressings are applied at frequent intervals.

The period of time during which the patient is kept in bed necessarily depends on the mechanical state of affairs, especially in regard to abdominal wounds. In general, time will be given for substantial healing of the abdominal incision before the patient gets up—that is to say—two to three weeks.

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REGIONAL SURGERY

The Brain.—Surgery of the brain (*see* BRAIN, SURGERY OF) is directed to the opening of abscesses and the removal of tumours. Considerable advance in the localization of the latter has led to a higher percentage of satisfactory results and a number of dramatic cures. It must, however, be appreciated that some tumours are so closely incorporated with the brain that their removal is impracticable or inconsistent with the survival of the patient. For these cases an operation of decompression is carried out which consists in removing a considerable area of bone from the skull to allow the brain to expand beneath the scalp. Such operations are directed to relieve the patient of headache and to save the sight. Operations on the spinal cord and nerves (*see* SPINAL CORD, SURGERY OF) are mostly carried out for cases of injury; in the case of the former to relieve pressure, and in the latter to suture the cut ends of the nerve. Tumours may form in or about the cord, and their position can now be recognized.

Lungs (*see* HEART AND LUNG, SURGERY OF).—The chest has always been considered a difficult area for the surgeon to work in. The presence of negative pressure in the pleural sac leads to the collapse of the lung when the chest wall is opened, and enterprise in the direction of radical surgery has on this account been limited. With the introduction of anaesthesia by intubating the larynx and pumping air containing ether under positive pressure into the lung, intrathoracic operations are now made with safety.

Thyroid Gland (*see* GOITRE).—Operations on this essential ductless gland are carried out for simple and malignant tumours and also for disorders of secretion. In exophthalmic goitre, the gland becomes hyper-active and though the condition may in some measure be controlled by administration of iodine, the removal of half or even more of the gland has proved the most successful method of treating severe cases. At one time, operations of this character were associated with a high mortality, but with improved methods of pre-operative treatment and of anaesthesia the results have been much more satisfactory. The operations for simple tumour are straightforward and call for little comment; in those instances in which the whole gland is removed for malignant disease the complete loss of thyroid solution thereby entailed must be made up for subsequently by the regular administration of thyroid extract (*cf.* myxoedema).

Breast (*see* MAMMARY GLAND, DISEASES OF).—This organ especially in the female, may develop simple tumours (adenoma), or undergo a change classified as chronic mastitis; it is a relatively common seat of cancer (*q.v.*). The simple tumours appear as a rule before middle age and are easily recognized and removed. Chronic interstitial mastitis is essentially a disease of the middle-aged; though in itself not a very serious condition, there is little question but that its more severe forms predispose towards cancer. On these grounds removal of one or both breasts for the condition is very often carried out. Cancer of the breast is rare before middle age and is most commonly met with between forty-five and sixty-five. Usually it starts as a painless hard nodule in the breast; it causes no signs of inflammation nor does it interfere in any way with the muscular system. On this account an early growth may be missed by an unobservant patient. The surgical treatment of cancer in this organ has proved strikingly successful in cases in which a radical operation is carried out before secondary deposits have appeared elsewhere. The outlook in cases in which operation is undertaken at a later stage is very much less hopeful. The operation current at the present time for cancer is a thorough one, and consists of removing the whole breast with the overlying skin and underlying muscle. The armpit is freely opened up and the lymphatic channels from the breast and the glands into which they drain are cleanly removed. The value of X-rays and radium in the treatment of breast cancer is becoming more clearly defined; there is no doubt that a certain type of X-ray and the gamma rays of radium are able to kill cancer cells locally, and both methods have considerable value in dealing with local recurrent growth and as prophylactic measures (*see* RADIOLOGY; RADIOTHERAPY; RADIUMTHERAPY).

Abdominal Surgery (*see* ABDOMEN, SURGERY OF).—In the case of the stomach and duodenum—the diagnosis of simple ulcers and cancerous growths of the stomach has been greatly advanced by radiological methods. The method does not consist in simply taking a shadow picture of the stomach. Chief reliance is placed on observation of the stomach movements by a trained observer. It must not however be thought that this is the only or the final method of diagnosis. Clinical observation and the chemical examination of test meals are essential and often carry equal weight in forming an opinion as to the exact condition.

Operation is much less frequently undertaken for active gastric and duodenal ulcer (*q.v.*) now than a few years back. It still remains the only radical method of dealing with long-standing ulcers which have led to adhesions of the stomach and surrounding structures or to narrowing of its lumen either in the body of the organ or at its junction with the duodenum. The simplest operation is that of gastro-enterostomy, which consists of short-circuiting the distal part of the stomach and duodenum by anastomosing a loop of adjacent small bowel direct to the stomach. A part of the stomach may be removed for chronic ulcer as it is for cancer; indeed very nearly the whole stomach has been successfully removed for this condition, an anastomosis being subsequently established between the cut upper end and the small bowel. Surgery offers the only satisfactory means known at the present to deal with cancer of the stomach.

Gall Bladder.—The gall bladder forms a reservoir for bile though it has nothing to do with the secretion of this fluid. Gall stones (*see* CALCULI) may be deposited in it and lead to attacks of acute pain if they are forced out of the gall bladder into the bile passages. The presence of stones may also irritate the bladder and lead to abscess formation. The diagnosis is usually made clinically although the shadow of the gall bladder outline can be obtained by injecting a chemical into the blood, and in some instances gall stones show up in radiographs. The operation at the present time most often performed is complete removal of the gall bladder including the stones.

Large Bowel.—Considerable sections of the large bowel can be removed for growths which are usually malignant. Sections of the bowel may also be cut out on account of inflammatory conditions. After resection of part of the bowel the lumen is reconstituted by an anastomosis. This may be effected by stitching the two cut ends of the tube together directly, or by laying them side to side and making a lateral communication after stitching up the ends. Cases of intestinal obstruction due to irremovable causes in the lower part of the bowel are treated by colostomy. This operation consists in bringing up to the surface a section of the bowel and opening it. The artificial anus so formed will drain the bowel effectively, but the condition has the inconvenience that it is not subject to any sphincter control.

Rectum and Anus.—The rectum is subject to similar growths and inflammatory conditions to those met with in the colon. If a cancer of the rectum is recognized early, its radical removal gives a very good proportion of cures. It is inevitable in all such cases for the sphincter mechanism of the bowel to be destroyed by the operation and the patient is therefore left with a colostomy.

An anal fistula (*see* FISTULA) consists of a communication between the lower part of the rectum and the surface. It usually follows the formation of spontaneous evacuation of an abscess in this area. The condition can only be effectively cured by laying open the whole fistulous tract, and leaving it to heal slowly by granulation.

Haemorrhoids (*q.v.*) are due to a varicose condition of the veins in the lower part of the rectum. They may cause prolapse of the mucous lining of the lower end of the rectum or they may become grossly inflamed and painful. Slight damage to them may lead to troublesome haemorrhage. The condition is usually quite a local one and can be dealt with successfully by several means. Injection of the piles with chemical solution will produce clotting or scarring of the vascular area sufficient to cure the slighter cases of internal haemorrhoids. More severe persistent cases are better dealt with by operations of excision and ligature.

Kidneys and Bladder. (*See* UROLOGY; BLADDER AND PROSTATE DISEASES.)—The accurate diagnosis of the diseases of the kidney and bladder have made great advances in the last ten years as the result of the perfection of instruments for inspecting the inside of the bladder and passing catheters up the ureters. The injection of opaque solutions into the cavity of the kidneys enables a radiograph to be taken which assists considerably in diagnosis. Better radiological technique has also increased the accuracy with which the presence of a stone and its position in the kidney can be made out. The estimation of the functional activity of the kidney by mechanical means has been put on a scientific basis and makes it possible for the surgeon to assess the patient's probable reaction to operations in this area.

Stone in the Kidney.—Operations for stone located in the kidneys are straightforward if the stone be small in size and when only one kidney is affected. It is not uncommon for more than one stone to be present, and there is considerable variety in their form and nature, which affect the liability to recurrence. A stone may be passed from the kidney down the ureter into the bladder, and if it is sufficiently small, may even be evacuated naturally. The prolonged presence of a stone in the kidney, especially if it leads to a partial obstruction in the outlet, results in inflammation of the kidney substance, and for this reason early recognition of a stone by X-rays and its radical removal are important.

Tuberculous Kidney and Bladder.—Tuberculosis of the kidney may appear as the main focus of tuberculous infection in the body. In such cases the organism must, however, have been conveyed by the blood system from some previously established focus elsewhere. A tuberculous infection of the kidney may be part of a diffused tuberculous infection or one involving the whole urinary system. In the case of limited and early disease of one kidney, the symptoms may be slight, and the recognition of the presence of the infection will depend upon finding of B. tuberculosis in the urine. In such cases, or in those in which the disease is more advanced but has remained localized, the excision of one kidney is practiced with satisfactory results.

Tuberculosis of the bladder is usually secondary to the presence of this infection in some other part of the genito-urinary tract. It leads to great irritability of the bladder and corresponding discomfort to the patient. Treatment of the condition by direct surgical means is clearly difficult, and is seldom attempted.

Enlargement of the Prostate.—This condition affects males above middle life. The enlarged gland, situated as it is, at the neck of the bladder, tends gradually to interfere with the proper evacuation of this organ. This may produce attacks of complete retention of urine or result in the development of cystitis. The continued existence of the condition produces in time by the effect of back pressure or infection, secondary damage to the kidneys. This will materially sap the patient's resistance to infection or indeed in itself produce a condition inconsistent with life, if the suppression of the function of the kidneys is carried far enough. The relief of prostatic obstruction may be temporarily effected by the passage of a catheter to empty the bladder at regular intervals, but as this process is not a convenient one and in itself is bound to lead to the establishment of chronic cystitis, radical removal of the enlarged prostate is usually carried out.

The operation is usually effected by opening the bladder through an abdominal incision and gaining access to the base of the bladder in this way. In some clinics approach to the enlarged gland is by the perineum. In view of the age of the patients affected by this condition, the operation must be considered a severe one. The mortality has been considerably reduced in the last ten years by modifications in technique and by the carrying out of the procedure in two stages in those instances in which chronic cystitis is present or where there is evidence of disturbed function of the kidneys from back pressure.

Cancer of the prostate occurs and may be associated with similar symptoms to those of simple enlargement of the organ. Operative removal of the cancerous gland is practised, but on account of its anatomical position the probabilities of recurrence are great.

New Growths of the Kidney and Bladder.—The kidney and bladder may be involved in new growths which may be either simple or cancerous. The symptoms are generally evidenced by the passing of blood and disturbance in the regular evacuation of the bladder. In the case of the kidney, complete removal of the growth, if recognized early, is a simple and satisfactory procedure. In the bladder complete removal of malignant growths is difficult, consistent with the maintenance of the normal function of the organ.

Stricture of the Urethra.—Stricture of the urethra is due to contraction of scarred tissue in and around the tube secondary to old-standing inflammation. The closing down of the urethra leads to a gradual difficulty in emptying the bladder and indeed to a group of symptoms similar to those observed in enlargement of the prostate; the condition, however, usually develops much earlier in life and will be associated with a previous history of urethral infection. The condition in the early stages can be treated by regular dilation of the stricture with suitable bougies. If it is allowed to develop to the stage of complete obstruction associated with retention of urine, various operations for the relief of the condition may have to be brought into play.

Testicle.—This may be the seat of new growths which are generally cancerous or tuberculous. The statements made in regard to similar conditions affecting the kidney apply in general to this organ. On account of its accessibility early diagnosis and prompt treatment are relatively easy.

The condition of hydrocele (*q.v.*) is due to the secretion of fluid in the serous sac covering the testicle. The condition may arise apart from injury at almost any period of life. The largest forms are seen in those past middle-age. Radical treatment by excision of the sac is simple and straightforward.

Hernia (*q.v.*).—There are certain areas in the abdominal wall which are naturally weak and through these a protrusion or pouch of the peritoneum is liable to prolapse, producing a hernia. These regions are at the groins and umbilicus. Herniae are also likely to form in weak abdominal scars following operations. Apart from the discomfort caused by the prolapse of bowel into the hernia, there is always a danger of its contents becoming constricted or obstructed (*see* INTESTINAL OBSTRUCTION) by being nipped at the margin of the opening through which the protrusion has occurred. If such a complication arises it leads to strangulation which is an almost inevitably fatal condition unless relieved by prompt operation. The surgery of hernia should clearly be of a prophylactic nature and be undertaken as early as possible after the development of the swelling. Radical operations for herniae undertaken nowadays in good time on healthy individuals are followed by a high proportion of permanent successes. (C. M. P.)

See also BONES, DISEASES OF; FRACTURE; JOINTS, SURGERY OF; ORTHOPAEDIC SURGERY; GYNAECOLOGY; DENTISTRY, etc.

SURGICAL INSTRUMENTS AND APPLIANCES. The chief fact about the surgery of the present day, that it is aseptic or antiseptic, is exemplified in the make of surgical instruments and in all the installation of an operating-theatre. Take, for instance, a scalpel and a saw that are figured in Ambroise Paré's (1510–1590) surgical writings. The scalpel folds into a handle like an ordinary pocket-knife, and the handle is most elegantly adorned with a little winged female figure. The saw, after the same fashion, has a richly chased metal frame, and, at the end of the handle, a lion's head in bold relief, with a ring through its mouth to hang it up by. If one contrasts with these artistic weapons the instruments of 1850, one finds no such adornment, and for general finish Savigny's instruments would be hard to surpass; but the wooden or ivory handles, cut with finely scored lines like the cross-hatching of an engraving, are not more likely to be aseptic, even with prolonged attempts at sterilization, than the handles of Paré's instruments. At the present time, instead of such handles as these, with blades riveted into them, scalpels are forged out of one piece of steel, their handles are nickel-plated and perfectly smooth, that they may afford no crevices, and may be boiled and immersed in carbolic lotion without tarnishing or rusting; the scalpel has become just a single, smooth, plain piece of metal, having this one purpose that it shall make an aseptic wound. In the same way the saw is made in one piece, if this be possible; anyhow, it must be, so far as possible, a simple, smooth, unrusting metal instrument, that can be boiled and laid in lotion.

Or we may take, at different periods of surgery, the ligatures for arrest of bleeding from a divided blood-vessel. In Paré's time the ligature was a double thread, and he employed a forceps to draw forward the cut end of the vessel to be ligatured. From the time of Ambroise Paré to the time of Lister no great improvement was made. Then came Lister's work on the absorbable ligature; and out of this and much other experimental work has come a sterile thread that can be tied, cut short, and left in the depth of the wound, with certainty that the wound may at once be closed from end to end and nothing more will ever be heard of the ligatures left buried in the tissues.

Much the same is true of surgical dressings. When inflammation and suppuration were almost inevitable, dressings were usually such as could be easily and frequently changed—ointment, or wet compresses, to begin with, and poultices when suppuration was established. Now, after passing through a period when they were impregnated with some antiseptic, they are usually non-medicated but rigidly aseptic, and applied dry and are changed as little as possible in every aseptic operation.

The great principle of aseptic surgery combined with discovery of anaesthetics led to a great enlargement of the field in which surgical operations could be undertaken. As a result instruments for special purposes were devised that were without counterpart in olden times while appliances such as the laryngoscope, ophthalmoscope, cystoscope, sigmoidoscope, bronchoscope were invented and facilitated diagnosis. These means of improved diagnosis, in their turn, pointed the way towards yet more specially derived instruments so that the modern instrument maker's catalogue is a bulky and profusely illustrated volume.

SURICATE or **MEERKAT** (*Suricata tetradactyla*), a small South African mammal of the civet family, ranging from Cape Colony to Algoa bay. The head and body are about 14in. long, and the tail half as much; the fur is long and soft, light grizzled grey in colour, and banded with black on the lower part of the back. Meerkats are sociable animals, living in holes in the rocks on the mountains, and burrowing in the sandy soil of the plains. They feed chiefly on succulent bulbs, which they scratch up with long, curved, black claws on their fore-feet. They are often domesticated as pets.

SURIGAO, a municipality (with administration centre and 14 *barrios* or districts), capital and port of the province of Surigao, which is located in north-east Mindanao, and adjacent small islands, Philippine islands, 459 m. from Manila. Pop. (1918), 15,772. Some valuable timber grows in the vicinity, and there is a gold mine nearby. Abacá, corn and copra are among the agricultural products. In 1918, it had three manufacturing establishments and 164 household industry establishments with outputs valued at 45,300 and 40,500 pesos respectively. Of the 16 schools, 14 were public. Many of the inhabitants are Bisayans.

SURINAM: *see* GUIANA, *Dutch.*

SURINAM TOAD (*Pipa americana*), an aglossal (tongueless) tailless Amphibian (*q.v.*). It inhabits S. America east of the Andes and north of the Amazon, and is thoroughly aquatic. It has an extremely flattened head; the snout and the angles of the jaws bear several lappets, the fingers terminate in a star-shaped appendage, and the eyes are minute and without lids.

The eggs are carried on the back by the mother, and the skin thickens and grows round the eggs until each is enclosed in a dermal cell, which is finally covered by a horny lid. The eggs, which may number about 100 and measure 5–7mm. in diameter, develop entirely within these pouches, and the young hop out in the perfect condition. Pairing takes place in the water, the male clasping the female round the waist. During oviposition the cloaca projects from the vent as a bladder-like pouch, which is inverted forwards, between the back of the female and the breast of the male, and by means of this ovipositor the eggs are evenly distributed over the back. *See* A. D. Bartlett, *Proc. Zool. Soc.* (1896).

SURMA or **BARAK,** a river of Assam, India. It is one of the two chief rivers of the province, watering the southern valley as the Brahmaputra waters the northern and larger valley. It rises in the Barail range to the north of Manipur, its sources being among the southern spurs of Japvo. Thence its course is south with a slight westerly bearing, through the Manipur hills to British territory. The name of Barak is given to the upper part of the river, in Manipur and Cachar. A short distance below Badarpur in Cachar it divides into two branches. The northern, which passes Sylhet, is called the Surma. The southern, which is called the Kusiara, subdivides into two branches, one called Bibiana or Kalni, and the other the Barak, both of which rejoin the Surma. At Bhairab Bazar in Mymensingh the Surma unites with the old channel of the Brahmaputra and becomes known as the Meghna until it joins the Ganges between Narayanganj and Chandpur. The river is navigable by steamers as far as Silchar in the rains. Total length about 560 miles.

SURPLICE (Lat. *super,* over, and *pellicia,* furs), a liturgical vestment of the Christian Church. It is a tunic of white linen or cotton material, with wide or moderately wide sleeves, and varying in length. Originally it reached to the feet, but as early as the 13th century it began to be shortened. This process was carried furthest in the Roman use, according to which the surplice (the Italian *cotta*) hardly reaches to the hips. In other churches of the Roman communion it does not come below the knees.

The older history of the surplice is obscure. Its name is derived from the fact that it was formerly put on over the fur garments which used to be worn in church as a protection against the cold. In all probability the surplice is no more than an expansion of the ordinary liturgical alb, due to the necessity for wearing it over thick furs. It is first mentioned in the 11th century, in a canon of the synod of Coyaca in Spain (1050) and in an ordinance of King Edward the Confessor. In Italy it was known at least as early as the 12th century. It probably originated outside Rome, and was imported thence into the Roman use.

Originally only a choir vestment and peculiar to lower clergy, it gradually (certainly no later than the 13th century) replaced the alb as the vestment proper to the administering of the sacraments and other sacerdotal functions.

In the Oriental rites there is no surplice, nor any analogous vestment. Of the non-Roman Catholic churches in the West the surplice has continued in regular use only in the Lutheran churches of Denmark, Norway and Sweden, and in the Church of England.

Church of England.—The surplice was prescribed by the second Prayer-Book of Edward VI. as, with the tippet or the academical hood, the sole vestment of the ministers of the church at "all times of their ministration," the rochet (q.v.) being practically regarded as the episcopal surplice. Its use was furiously assailed by the extremer Reformers but, in spite of their efforts, was retained by Elizabeth's Act of Uniformity, and enforced by the advertisements and injunctions issued under her authority, which ordered the "massing vestments" (chasubles, albs, stoles, and the like) to be destroyed (*see* VESTMENTS). Its use has never been confined to clerks in holy orders, and it has been worn since the Reformation by all the "ministers" (including vicars-choral and choristers) of cathedral and collegiate churches, as well as by the fellows and scholars of colleges in chapel.

The traditional form of the surplice in the Church of England is that which survived from pre-Reformation times; viz., a wide-sleeved, very full, plain, white linen tunic, pleated from the yoke, and reaching almost, or quite, to the feet. Towards the end of the 17th century, when large wigs came into fashion, it began for convenience to be constructed gown-wise, open down the front and buttoned at the neck, a fashion which still partially survives, notably at the universities.

SURRENDER, in law, a mode of alienation of real estate. It is defined by Lord Coke to be "the yielding up of an estate for life or years to him that hath an immediate estate in reversion or remainder" (Coke upon Littleton, 337 b). It is the converse of release, which is a conveyance by the reversioner or remainderman to the tenant of the particular estate. A surrender was the usual means of effecting the alienation of copyholds (*q.v.*). A surrender must, since the Real Property Act 1845, be by deed, except in the case of copyholds and of surrender by operation of law. (*See* REMAINDER.)

In Scots law surrender of a lease is represented by renunciation. The nearest approach to surrender of a copyhold is resignation *in remanentiam* (to the overlord) or resignation *in favorem* (to a purchaser). These modes of conveyance were practically superseded by the Conveyancing Act 1874.

In America surrender divides itself into express surrender and surrender by operation of law. The former is the surrender known to the early common law; the latter takes place when the tenant and the reversioner have performed acts inconsistent with the continued existence of the two former distinct estates, from which acts the law implies that a surrender has been made. Thus where there is an acceptance by the tenant of a new lease to begin at any time during the existence of the previous lease, or the relinquishment of possession by the tenant and the resumption of possession by the landlord, a surrender by operation of law is deemed to have taken place.

SURRENTUM (mod. *Sorrento, q.v.*), an ancient town of Campania, Italy, situated on the north side of the promontory which forms the south-east extremity of the Bay of Naples. The most important temples of Surrentum were those of Athena and of the Sirens (the latter the only one in the Greek world in historic times). The place was famous for its wine, its fish and its red Campanian vases. It was protected by deep gorges, except for a distance of 300 yd. on the south-west where it was defended by walls, the line of which is necessarily followed by those of the modern town. The south gate is indeed ancient. The arrangement of the modern streets preserves that of the ancient town, and the disposition of the walled paths which divide the plain to the east seems to date in like manner from Roman times. On the east of the town the most important ancient ruin is the reservoir of the (subterranean) aqueducts, which had no less than 27 chambers, each about 90 ft. by 20 feet. There are also remains of villas. To the north-west, on the Capo di Sorrento, is another villa, the so-called Bagni della Regina Giovanna, with baths, and in the bay to the south-west was the villa of Pollius Felix, the friend of Statius, of which remains still exist. Some fine reliefs were found here, representing a sacrifice to Diana (A. Levi in *Monumenti dei Lincei,* xxvi., 181–218, 1920).

SURREY, EARLDOM OF. This earldom is of uncertain but unquestionably early origin. A Norman count, William de Warenne (*c.* 1030–1088), is generally regarded as its first holder and is thought to have been made an earl by William II. about 1088. William and his successors were styled earls of Surrey or Earls Warenne indifferently, and the family became extinct when William, the 3rd earl, died in 1148. The second family to hold the earldom of Surrey was descended from Isabel de Warenne (d. 1199), daughter and heiress of Earl William, and her second husband Hamelin Plantagenet (d. 1202), an illegitimate half-brother of King Henry II. Their descendants held the earldom until Earl John died without legitimate issue in 1347.

The earldom and estates of the Warennes now passed to John's nephew, Richard Fitzalan, earl of Arundel (*c.* 1307–1376), being forfeited when Richard's son, Richard, was beheaded for treason in 1397. Then for about two years there was a duke of Surrey, the title being borne by Thomas Holand, earl of Kent (1374–

1400), from 1397 until his degradation in 1399. In 1400 Richard Fitzalan's son, Sir Thomas Fitzalan (1381–1415), was restored to his father's honours and became earl of Arundel and earl of Surrey, but the latter earldom reverted to the Crown when he died. In 1451 John Mowbray (1444–1476), afterwards duke of Norfolk, was created earl of Surrey, but the title died with him.

The long connection of the Howards with the earldom of Surrey began in 1483 when Thomas Howard, afterwards duke of Norfolk, was created earl of Surrey. Since then, with brief exceptions, the title has been borne by the duke of Norfolk.

See the articles Warenne, Earls; and Arundel, Earls of; also G. E. C.(ockayne), *Complete Peerage,* vol. vii. (1896).

SURREY, HENRY HOWARD, Earl of (1518?–1547), English poet, son of Lord Thomas Howard, afterwards 3rd duke of Norfolk, and his wife Elizabeth Stafford, daughter of the duke of Buckingham, was born probably in 1518. He succeeded to the courtesy title of earl of Surrey in 1524, when his father became duke of Norfolk. His early years were spent in the various houses of the Howards, chiefly at Kenninghall, Norfolk; he used also to stay at Windsor with young Henry Fitzroy, duke of Richmond, of whom his father was guardian. Anne Boleyn tried to arrange a marriage between the princess Mary and her kinsman, Surrey. The Spanish ambassador, in the hope of detaching the duke of Norfolk's interest from Anne Boleyn in favour of Catherine of Aragon, seems to have been inclined to favour the project, but Anne changed her mind, and as early as October 1530 arranged a marriage for Surrey with Lady Frances de Vere, daughter of the 15th earl of Oxford. This was concluded at the earliest possible date, in February 1532, but in consequence of the extreme youth of the contracting parties, Frances did not join her husband until 1535. In October Surrey accompanied Henry VIII. to Boulogne to meet Francis I., and, rejoining the duke of Richmond at Calais, he proceeded with him to the French court, where the two Englishmen were lodged with the French royal princes. Surrey created for himself a reputation for wisdom, soberness and good learning. Meanwhile in spite of his marriage with Frances de Vere, the project of a contract between him and the princess Mary was revived in a correspondence between the pope and the emperor, but rejected by the latter. Surrey returned to England in the autumn of 1533, when the duke of Richmond was recalled to marry his friend's sister, Mary Howard. Surrey made his home at his father's house of Kenninghall, and took his father's side in a dispute which led to a separation between the duke and duchess.

In May 1536 he filled his father's functions of earl marshal at the trial of his cousins Anne Boleyn and Lord Rochford. In the autumn of that year he took part with his father in the bloodless campaign against the rebels in Yorkshire and Lincolnshire, in the "Pilgrimage of Grace." Hasty in temper, and by no means friendly to the Seymour faction at court, Surrey struck a man who insinuated that he had secretly favoured the insurgents. For breaking the peace in the king's domain he was arrested (1537), but thanks to Cromwell, he was merely sent to reside for a time at Windsor. During this retirement he had leisure to devote himself to poetry. In 1539 he was again received into favour. In May 1540 he was one of the champions in the jousts celebrated at court.

The fall of Thomas Cromwell a month later increased the power of the Howards, and in August Henry VIII. married Surrey's cousin, Catherine Howard. Surrey was knighted early in 1541, and soon after he received the Garter and was made chancellor of the duchy of Lancaster. In 1542 he was imprisoned again for quarrelling, but was soon liberated. Shortly after his release he joined his father on the Scottish expedition. They laid waste the country, but retreated before the earl of Huntly, taking no part in the victorious operations that led up to Solway Moss.

Surrey's ties with Wyat, who was fifteen years his elder and of opposite politics, seem to have been rather literary than personal. He appears to have entered into closer relations with the younger Wyat, with whom he got into trouble for breaking the windows of the citizens of London on Feb. 2, 1543. In prison for this offence he probably wrote the satire on the city of London, in which he explains his escapade by a desire to rouse Londoners to a sense of their wickedness. In October he joined the English army co-operating with the imperial forces in Flanders, and in the campaign of the next year he served as field marshal under his father, and took part in the unsuccessful siege of Montreuil. In August 1545 he was again serving in France.

Surrey had always been an enemy to the Seymours, whom he regarded as upstarts, and he thwarted the proposed marriage of his sister, the duchess of Richmond, with Sir Thomas Seymour. He thus increased the enmity of the Seymours and added his sister to the already long list of the enemies which he had made by his haughty manner and brutal frankness. He was now accused of quartering with his own the arms of Edward the Confessor. The charge was a pretext covering graver suspicions. Surrey had declared that his father, the duke of Norfolk, as the premier duke in England, had the obvious right of acting as regent to Prince Edward. He also boasted of what he would do when his father had attained that position. This boast was magnified into a plot on the part of his father and himself to murder the king and the prince. The duke of Norfolk and his son were sent to the Tower on Dec. 12, 1546. The duchess of Richmond was one of the witnesses (*see* her depositions in Herbert of Cherbury, *Life and Reign of Henry VIII.*, 1649) against her brother, but her statements added nothing to the formal indictment. On Jan. 13, 1547 Surrey defended himself at the Guildhall on the charge of high treason for having illegally made use of the arms of Edward the Confessor, before hostile judges. He was condemned by a jury, packed for the occasion, to be hanged, drawn and quartered at Tyburn. This sentence was commuted to beheading. Surrey was executed on Tower Hill on the 19th of the month.

Surrey's name has been long connected with the "Fair Geraldine," to whom his love poems were supposed to be addressed. The story is founded on the romantic fiction of Thomas Nashe, *The Unfortunate Traveller, or Life of Jack Wilton* (1594), according to which Surrey saw in a magic glass in the Netherlands the face of Geraldine, and then travelled throughout Europe challenging all comers to deny in full field the charms of the lady. At Florence he held a tournament in her honour, and was to do the same in other Italian cities when he was recalled by order of Henry VIII. The legend, deprived of its more glaring discrepancies with Surrey's life, was revived in Michael Drayton's *England's Heroicall Epistles* (1598). Geraldine was the daughter of the earl of Kildare, Lady Elizabeth Fitzgerald, who was brought up at the English court in company with the princess Elizabeth. (*See* James Graves, a *Brief Memoir of Lady Elizabeth Fitzgerald,* 1874.) She was ten years old when in 1537 Surrey addressed to her the sonnet "From Tuskane came my ladies worthy race," and nothing more than a passing admiration of the child and an imaginative anticipation of her beauty can be attributed to Surrey.

His poems, which were the occupation of the leisure moments of his short and crowded life, were first printed in *Songs and Sonettes written by the ryght honorable Lorde Henry Howard late Earle of Surrey, and other* (apud Richardum Tottel, 1557). A second edition followed in July 1557, and others in 1559, 1565, 1567, 1574, 1585 and 1587. Although Surrey's name, probably because of his rank, stands first on the title-page, Wyat was the earlier in point of time of Henry's "courtly makers." Surrey, indeed, expressly acknowledges Wyat as his master in poetry. His sonnets, his elegy on Wyat and his lyrics served as models to generations of court poets.

As their poems appeared in one volume, long after the death of both, their names will always be closely associated. Surrey's contributions are distinguished by their impetuous eloquence and sweetness, and he introduced new smoothness and fluency into English verse. His chief innovation as a metrician lies outside the *Miscellany.* His translation of the second and fourth books of the *Aeneid* into blank verse—the first attempt at blank verse in English—was published separately by Tottel in the same year *Certain Bokes of Virgiles Aeneis turned into English meter.*

See Professor E. Arber's reprint of *Songs and Sonettes* (*English Reprints,* 1870); the Roxburghe Club reprint of *Certain Bokes of Virgiles Aeneis* (1814); Dr. G. F. Nott, *The Works of Henry Howard, Earl of Surrey* (1815); and *The Poetical Works of Henry Howard, Earl of Surrey* (Aldine edition, 1866). The best account of Surrey's life is in Edmond Bapst's *Deux Gentilhommes-poëtes de la cour de Henry*

VIII. (1891), which rectifies Dr. Nott's memoir in many points. *See* also Brewer and Gairdner, *Letters and State Papers of Henry VIII.*; Lord Herbert of Cherbury, *Life and Raigne of Kinge Henry the Eighth* (1649); J. A. Froude, *History of England* (chs. xxi. and xxii.); W. J. Courthope, *History of English Poetry* (1897), vol. ii. ch. iii., where the extent and value of Surrey's innovations in English poetry are estimated; F. M. Padelford, *The MS. Poems of Henry Howard, Earl of Surrey* (1906); O. Fest, "Über Surreys Virgilübersetzung," in *Palästra,* vol. xxxiv. (Berlin, 1903).

SURREY, a south-eastern county of England, bounded north by the Thames, separating it from Buckinghamshire and Middlesex, east by Kent, south by Sussex, and west by Hampshire and Berkshire. The administrative county of London bounds that of Surrey (south of the Thames) on the north-east. The area is 758 sq. miles. The north of the county is low lying, the eastern part consisting of the London clay, the western of the Bagshot beds. Near the western boundary the land rises into the low Chobham ridges. Across the middle of the county, from east to west, run the North downs, composed of chalk. In the east they form a wide band with an extreme height of 852 ft., but westward they narrow into the Hog's Back. The line of the Downs is broken at two points: by the river Mole between Dorking and Leatherhead, and by the Wey near Guildford. These are the two chief rivers in the county, and they join the Thames at Molesey and Weybridge respectively. The northern slopes of the Downs are flanked by a narrow strip of Lower London Tertiary beds, the southern by narrow bands of Upper Greensand and Gault. These beds, like the chalk, have a wider extent in the east than in the west. To the south of the Gault we find a wide band of Lower Greensand, which narrows eastward. On this greensand is found the highest land in the county, Leith Hill (965 ft.) near the centre, and Devil's Punch Bowl (895 ft.) in the west. The rest of the county, except for a small triangle of Hastings beds in the extreme south-east, is composed of Weald clay.

The chief evidence of the presence of Palaeolithic man in Surrey comes from various gravels near Limpsfield (in the east of the county), near Guildford and Godalming, and near Farnham. The Weald region in early times was very thickly forested, and traces of Neolithic man, indicated by finds of implements, are therefore most numerous on the chalk and greensand, especially in the west, but finds of this age are not rare on the lower lands in the north-east of the county. Bronze weapons have not been found in such great numbers as those of stone, but their distributions are, roughly, coincident except that the metal weapons have been found at several places along the Thames.

Near the chalk ridge of the North downs runs the ancient track of the Pilgrims' way. A track here was used in very early times to connect the cultural centre of Kent with Hants and Wiltshire; in the middle ages the route regained importance as the path of pilgrims from the west to the shrine of St. Thomas at Canterbury. The Romans did not occupy Surrey very closely, but there are traces of their influences in the remains of one or two small settlements and a few villas.

The county was penetrated by the English invaders at a fairly early date, and its position between the Thames and the Weald decided its northern and southern borders. The Kentish boundary probably dates from the battle of Wibbandune, between Ethelbert of Kent and Ceawlin of Wessex, while the western limit in a wild, uncultivated district was not then strictly defined. In the 7th century Surrey was under the overlordship of Wulfhere, king of Mercia, who founded Chertsey abbey, but in 823, when the Mercians were defeated by Egbert of Wessex, it was included in the kingdom of Wessex, as the Anglo-Saxon Chronicle relates.

Surrey was constantly overrun by Danish hordes in the 9th century and until peace was established by the accession of Canute. In 857 a great national victory over the Danes took place at Ockley, near Leith Hill. The Norman army traversed and ravaged the county in their march on London. A large portion of the county having been in the hands of Edward and Harold, fell to the share of William himself; his most important tenants in chief being Odo of Bayeux and Richard de Tonebridge, son of Count Gilbert, afterwards "de Clare." The church also had large possessions in the county, the abbey of Chertsey being the largest monastic house. At the time of the Domesday survey the number of hundreds was 14 as now, but the hundred of Farnham was not so called, the lands of the bishop of Winchester being placed in no hundred, but coinciding with the present hundred of that name. The western boundary of the county was probably definitely fixed about this time. Until quite recently Surrey had never been in any diocese but Winchester, of which it was an archdeaconry in the 12th century. Croydon was a peculiar of Canterbury, in which diocese it was included in 1291. The shire court was almost certainly held at Guildford, the seat of the royal court at times during the reigns of John and Henry III.

From 1290 to 1832 the shire returned two knights to parliament. There have been several adjustments of electoral divisions since 1832.

Architecture.—The only ecclesiastical ruins worthy of special mention are the walls of Newark priory, near Woking, founded for Augustinians in the time of Richard Coeur de Lion; and the Early English crypt and part of the refectory of Waverley abbey, the earliest house of the Cistercians in England, founded in 1128. Among the more interesting churches are Albury (the old church), near Guildford, the tower of which is of Saxon or very early Norman date; Beddington, a fine example of Perpendicular; Chaldon, remarkable for its fresco wall-paintings of the 12th century, discovered during restoration in 1870; Compton, worthy of notice for its two-storeyed chancel and its carved wooden balustrade surmounting the pointed transitional Norman arch which separates the nave from the chancel; Leigh, Perpendicular, possessing some very fine brasses of the 15th century; Lingfield, Perpendicular, containing some fine stalls (the church was formerly collegiate); Ockham, chiefly Decorated, with a lofty embattled tower; Stoke d'Abernon, Early English, with the earliest extant English brass (1277). Of ancient domestic architecture, examples include Beddington Hall, retaining the hall of the Elizabethan building; Crowhurst Place, built in the time of Henry VII.; portions of Croydon palace, an ancient seat of the archbishops of Canterbury; the gate tower of Esher Place, built by a bishop of Winchester, and repaired by Cardinal Wolsey; Archbishop Abbot's hospital, Guildford, in the Tudor style; the Elizabethan house of Loseley near Guildford; Sutton Place near Woking, dating from the time of Henry VIII., possessing curious mouldings and ornaments in terra cotta; and Ham House, of red brick, dating from 1610.

Industries.—Surrey was at first agricultural. The stone quarries of Limpsfield and the chalk of the Downs were early used, the latter chiefly for lime-making. Fuller's earth was obtained from Reigate and Nutfield; and the facilities afforded by many small streams, and the excellent sheep pasture, made it of importance in the manufacture of cloth, of which Guildford was a centre. Glass, at Chiddingfold as early as 1266, and iron were made in the Weald district, whose forests produced the necessary charcoal for smelting. The ironworks of Surrey were of less importance, and much later in development than those of Kent and Sussex, owing to the want of good roads or waterways, but the increasing demand for ordnance in the 16th century led to the spread of the industry northward; the most considerable works being at Haslemere. Chilworth was famous for its powder mills in the 16th century. The earliest Delft ware manufactory in England was at Lambeth, which remains a centre of earthenware manufacture.

The total acreage under crops and grass in 1926 was 458,211, of which 74,788 ac. were arable land. Oats and wheat were the chief grain crops, root crops occupied about one-third the acreage of the corn, while the area under potatoes was just over 4,000 acres. Clover and rotation grasses for hay took up 10,051 ac., and the acreage of the orchards was 1,841. The cattle are chiefly of the dairy type, the milk being sent to London, while sheep are reared on the chalk downs. A considerable area is occupied by market gardens on the alluvial soil along the banks of the Thames.

The county is chiefly residential, for those people who have business interests in London, and manufactures are not of outstanding importance. The more important are chiefly confined to London and its immediate neighbourhood. They include cloth, calicoes, drugs, tobacco, etc. Communications include the navigation of the Thames and Wey, and the Basingstoke canal, communicating with the Wey from Frimley and Woking. The county is served by the Southern railway, whose lines intersect the county from north to south and from east to west. Near Croydon is the London terminal aerodrome.

Population and Administration.—The population in 1801 was 268,233, and in 1851, 683,082. In 1888, part of the county was transferred to the county of London. The area of the administrative county is now 461,833 ac., with a population (1921) of 930,086. The county contains 14 hundreds. Croydon is a county borough, and the other municipal boroughs are Godalming, Guildford, Kingston, Reigate, Richmond, Wimbledon. There are seven parliamentary divisions—Chertsey, Farnham, Mitcham, Epsom, Eastern, Reigate, Guildford; each returning one member. The borough of Croydon returns two members to parliament and the boroughs of Richmond, Kingston and Wimbledon one member each.

Guildford and Kingston are the county-towns, the assizes being held at Guildford and Croydon alternately, while the County Council sits in the County hall at Kingston. The county has one court of quarter sessions; Croydon and Guildford have separate courts of quarter sessions. The county is in the south-eastern circuit, while the central criminal court has jurisdiction over certain parishes adjacent to London. All those civil parishes within the county of Surrey, of which any part is within 12 m. of, or of which no part is more than 15 m. from, Charing Cross, are in the metropolitan police district. The county is mainly in the new diocese of Guildford, recently divided off from that of Winchester.

See Topley's *Geology of the Weald* and Whitaker's *Geology of London Basin*, forming part of the *Memoirs of Geological Survey of United Kingdom* (1875); J. Aubrey, *Natural History and Antiquities of Surrey* (5 vols., 1718–19); D. Lysons, *Environs of London* (5 vols., 1800–11); Baxter, *Domesday Book of Surrey* (1876); O. Manning and W. Bray, *History and Antiquities of Surrey* (3 vols., 1804–14); E. W. Brayley, *Topographical History of Surrey* (5 vols., 1841–48); another edition, revised by E. Walford (1878); *Archaeological Collections* (Surrey Archaeological Society; from 1858); *Victoria County History: Surrey* (4 vols.).

SURROGATE, a deputy of a bishop or an ecclesiastical judge, acting in the absence of his principal and strictly bound by the authority of the latter (Lat. *surrogare,* to substitute for). Canon 128 of the canons of 1603 lays down the qualifications necessary for the office of surrogate, and canon 123 the regulations for the appointment to the office. The office is of some importance in the United States as denoting the judge to whom the jurisdiction of the probate of wills, the grant of administration and of guardianship is confided.

SURTAX. In Great Britain and the United States, a tax imposed in pursuance of the principle of graduating the taxation of income according to the principle of "ability." The British tax originated in the "super-tax," which was first imposed in 1909. Whether named super-tax or surtax, the impost is in reality a supplementary income tax. In the British financial year 1927–8 the name "super-tax" was dropped in favour of "surtax." The surtax is assessed and collected separately from the income tax. For further details about the British and American rates of tax imposed *see* Income Tax: *In Practice* and Super-tax.

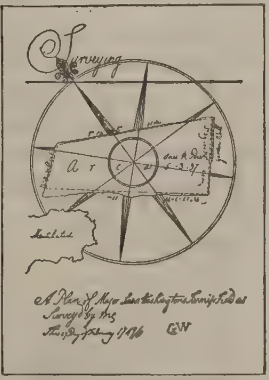
SURTEES, ROBERT SMITH (1803–1864), English novelist and sporting writer, was the second son of Anthony Surtees of Hamsterley Hall, Durham. Educated to be a solicitor, Surtees soon began to contribute to the *Sporting Magazine,* and in 1831 he published a treatise on the law relating to horses and particularly the law of warranty, entitled *The Horseman's Manual.* In the following year he helped to found the *New Sporting Magazine,* of which he was the editor for the next five years. To this periodical he contributed between 1832 and 1834 the papers which were afterwards collected and published in 1838 as *Jorrocks's Jaunts and Jollities.* This humorous narrative of the sporting experiences of a cockney grocer, which suggested the more famous *Pickwick Papers* of Charles Dickens, is the work by which Surtees is chiefly remembered, though his novel *Handley Cross,* published in 1843, in which the character of "Jorrocks" is reintroduced as a master of fox-hounds, also enjoyed a wide popularity. The former of these two books was illustrated by "Phiz" (H. K. Browne), and the latter, as well as most of Surtees's subsequent novels, by John Leech, whose pictures of "Jorrocks" are everywhere familiar and were the chief means of ensuring the lasting popularity of that humorous creation. Surtees wrote other novels, the last of which, *Mr. Facey Romford's Hounds* (1865), appeared after the author's death (March 16, 1864).

See R. S. Surtees, *Jorrocks's Jaunts and Jollities* (London, 1869), containing a biographical memoir of the author; W. P. Frith, *John Leech, His Life and Work* (2 vols., London, 1891); Samuel Halkett and J. Laing, *Dictionary of Anonymous and Pseudonymous Literature of Great Britain* (4 vols., Edinburgh, 1882–1888).

SURVEYING, the technical term for the art of determining the position of objects on the surface of the ground, for the purpose of making therefrom a graphic representation of the area surveyed. The general principles on which surveys are conducted and maps constructed from such data are in all instances the same; certain measures are made on the ground, and corresponding measures are protracted on paper on whatever scale may be a convenient fraction of the natural scale. The method of surveying varies with the magnitude of the survey, which may embrace an empire or represent a small plot of land. All surveys rest primarily on linear measurements for the direct determination of distances; but linear measurement is often supplemented by angular measurement which enables distances to be determined by principles of geometry over areas which cannot be conveniently measured directly.

History.—It is very probable that surveying had its origin in ancient Egypt. But long before the dynastic period in Egypt, we may imagine that neolithic man was able, like the savages of to-day, to make a rough kind of map based on his journeys, or a primitive plan to show tribal or property boundaries. Apart from such speculations, however, we find, in a Theban tomb of the XVIII. dynasty, a plan of the villa of a great Egyptian noble: in the tomb of one Menna at Thebes, there is a representation on the walls of two chainmen surveying a field of corn: and in Ptolemaic and Roman papyri in the same country, measurements of plots of land are described. That the early Egyptians could carry out measurements with a considerable degree of accuracy, is certain from a study of the dimensions of the Great Pyramid.

In Roman times we meet with the groma, which consists of two pairs of plumb-lines suspended from the ends of two horizontal rods, at right angles to each other: the use of the instrument being to lay out lines at right-angles. The metal parts of one of these gromas was found in 1912, in Pompeii. An early groma of the same type, but rougher construction has been found in Egypt. The Romans also used 10 foot rods, and bronze terminal pieces of such rods have been found at Enns in Austria, the foot in this case being 13·2 inches. The Romans certainly made use of an instrument not unlike the plane-table for determining the alignment of their roads. The Greeks used a form of log line for recording the distances run from point to point along the coast whilst making their slow voyage from the Indus to the Persian gulf three centuries B.C. Still earlier (as early as 1600 B.C.) it is said that the Chinese knew the value of the loadstone and possessed some form of magnetic compass. The earliest maps of which we have any record were based on inaccurate astronomical determinations; not till mediaeval times, when the Arabs made use of the astrolabe (*q.v.*), could nautical surveying really be said to begin. In 1450 the Arabs were acquainted with the use of the compass, and could make charts of the coast-line of those countries which they visited. In 1498 Vasco da Gama saw



BY COURTESY OF THE U.S. BUREAU OF RECLAMATION

A PLAN MADE BY GEORGE WASHINGTON IN 1746, INSCRIBED IN HIS OWN HANDWRITING a chart of the coast-line of India, which was shown him by a Gujarati. Plane-tables were in use in Europe in the 16th century and the principle of graphic triangulation and intersection was practised by surveyors in England and elsewhere. In 1615, Willebrord Snell, the Dutch mathematician, measured an arc of meridian, by instrumental triangulation.

The Different Kinds of Surveys.—Surveys may be classed in a variety of different ways. We may describe them by their scales, as *large-scale* or *small-scale;* the large-scale surveys would be those on a scale larger than, let us say, 1:25,000. On the other hand small-scale surveys would be those on scales of 1:25,000, and smaller. Or we may describe surveys by the technical method employed. Thus we sometimes find the expressions, trigonometrical survey, compass survey, chain survey. Or surveys may be described by the purpose for which they are carried out. There are for instance, geodetic surveys, of which one of the chief objects will be the furtherance of the study of the figure of the earth and allied matters; cadastral surveys, whose purpose is to facilitate the collection of land revenue; hydrographic surveys, the purpose of which is the production of charts of the sea, for use in navigation; railway surveys, which are carried out to enable a line of railway to be economically located; and so on. Or we may describe a survey by the character of the resulting map. A topographical survey is intended to determine and depict the relative positions of the surface features of the earth, such features being either natural or artificial. A topographical map differs from a cadastral map in that the latter does not show any natural surface features which do not affect property boundaries.

Methods of Survey.—The simplest and most ancient method of making a plan or map is by means of direct measurement on the ground, with a rope, a chain, or a tape, of known length, suitably divided. As a simple illustration let us take the case of a level field of which a plan is wanted.

Suppose the field is as represented in fig. 1, the boundaries of the field being the irregular lines ABCD. Then, to survey this field with a chain or tape, put pickets at the points ABCD, somewhere near the corners of the field, these four points being intervisible and the lines between them being free from obstruction. Then measure, with the chain or tape, the direct straight-line distances, AB, BC, CA, AD, DC, BD. This will provide the necessary frame-work. It will be seen that for the plotting of the frame-work, only one diagonal, that is, either AC, or BD, is required. The measurement of both gives a check on the work and shows the surveyor how much reliance he can place on his measurements; it also enables gross errors to be detected. This principle of providing checks, and of never depending upon one measurement, is of great importance. To survey the irregular boundaries, all that is necessary is to measure "offsets" from the main chain lines, at known distances along the lines, and to note these in the field book. The offsets are measured with an offset rod or a tape at right-angles to the chain line. With all this information in the field book there is no difficulty in plotting the plan on paper to any scale that may be required. It is usual to lay down some limit for the offsets.

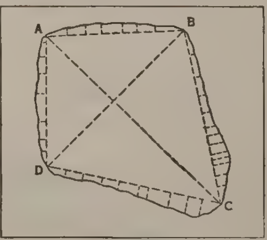


FIG. 1

An elaboration of this simple method is the scheme which was adopted by the Ordnance Survey of Great Britain and Ireland, when large-scale surveys were first commenced officially in 1825. The country was covered with a triangulation, of which the sides averaged, for the original six-inch map, some 5 miles. Each of the sides of these triangles was chained, and notes were made in the field book of points where the chain lines crossed detail, such as edges of roads, banks of streams, hedges, walls, and so on. The great triangles were broken up by other chain lines into smaller triangles, and lines tying on to these at their extremities were run along the detail to be surveyed, offsets being measured as usually.

Modern Methods.—We may now consider the system which would be adopted in a perfectly up-to-date, modern state. In such a case, there would be a geodetic survey covering the whole country with a system of triangulation of the first order; that is to say, the country would be reconnoitred beforehand, and mutually intervisible stations would be selected, some ten to thirty or forty miles apart, covering the country with a net-work, or series of chains, of triangles. At the apices of these triangles horizontal and vertical angles would be observed with a theodolite; one of the triangles would be connected with a measured side, called the base or base-line. From the known length of this side the lengths of all the other sides would be calculated. The latitude and longitude of one point in the triangulation would be determined by astronomical means, and also the true bearing of one line is obtained; it is then clearly possible to determine the latitude and longitude of every other point. The meaning of the term "first order," used above, is that the average triangular error of the net-work, or system of chains, of triangles, that is, the error of the sum of the 3 angles of a triangle, should not exceed one second.

Now we have to hang all other surveys upon this frame-work. A frame-work of the kind described has the fixed points too widely separated to be of much use for the detail survey, so the first thing to be done is to provide a closer frame-work; and this would usually be done by executing another triangulation, of less accuracy than the first, but depending upon it. There would be more points in this secondary triangulation, and the points would be distant from each other some 5 to 10 miles. The triangular error would not exceed 5 seconds. If now it were required to make a map on a scale of, say, 1:100,000 the frame-work would be sufficiently close, and the detail could, in suitable country, be carried out by plane-tabling which would be based upon the points so provided.

But, if it were required to construct a map on a large, cadastral scale, more fixed points still would be needed, and a tertiary triangulation would be carried out, depending upon the secondary work. This tertiary triangulation would have its points only a mile or two apart, and its triangular error would not exceed 15 seconds. It is now customary to classify a triangulation according to its accuracy, thus, a triangulation of the 1st order has a triangular error not exceeding 1 second; a triangulation of the 2nd order has a triangular error not exceeding 5 seconds; a triangulation of the third order has a triangular error not exceeding 15 seconds; and one of the 4th order has a triangular error greater than 15 seconds.

But it will easily be imagined that certain areas do not readily lend themselves to triangulating, and in such areas, occasionally, *traversing* is resorted to for the frame-work. This will be described later. Also, in the rapid exploration of a new country it may be necessary that the frame-work be astronomical. But this is an inaccurate make-shift, and should always be avoided whenever possible.

It should be emphasized that whatever may be the extent of the area to be surveyed, whether it be a backyard or a continent, the area should be dealt with as a whole, and the frame-work should be designed to stiffen the whole area. Anyone who is charged with the execution of a survey should, therefore, carefully consider how he can best design the control or frame-work.

Bases.—The length of every side in a triangulation depends upon the length of the measured side, called the base, or base-line. Bases for geodetic work are measured with very great refinement, and the probable error of such a base would be of the order of one in one-million. Such bases in times past have been measured with glass rods, wooden rods, steel bars, and compound bars of brass and steel. But now almost every accurate base, whether for geodetic purposes, or for secondary work, or for very good topographical work, would be measured with metallic (usually invar) wires or tapes supported in catenary, *i.e.*, allowed to hang free in a natural curve, being slung over trestles. Invar is an alloy of steel and nickel, containing 36% of the latter, and this alloy is used because it has the smallest known expansion of any metal or alloy. Invar wires and tapes require, however, careful handling, and testing, and on this account are not freely used for rapid topographical bases. It is possible to get quite good results from the use of ordinary steel (not invar) tapes laid along the surface of the ground.

Let us then, take the case of the measurement of a topographical base with steel tapes laid along the ground. The first thing to do is to select the site and the positions of the terminal points. These must be so chosen that well-conditioned triangles can be built up on the base, connecting it with the main points of the triangulation. (*See* fig. 2.)

Then the site must be cleared of obstructions, and small undulations levelled. Then the base terminals must be marked, and a theodolite set up over one of them and directed to a pole put up over the other. Intermediate marks, in the form of pickets driven in flush with the ground, should be fixed. The actual measurement is made with a steel tape, kept at a fixed tension with a spring balance, and marks are made on the tops of the pickets, which are at tape-lengths from centre to centre; the tops of the pickets may be conveniently covered with strips of zinc, on these strips the positions of the ends of the tape are marked when measuring. A convenient length of tape is 300 ft., with a width of $\frac{3}{8}$ inch. A convenient tension is 20 pounds. A base so measured requires corrections for standard, temperature, slope if any, and height above sea. The chief difficulty in this sort of measurement is to ascertain the temperature of the tape.

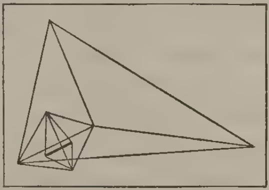


FIG. 2

A base of this kind might be some two or three miles long; but it should be remembered that it is more important to be able to extend the base by well-conditioned triangles than to measure a long base. The base having been measured, it is now necessary to proceed with the execution of the triangulation. Fig. 2 shows the base extension, and in the case shown, the longest side reached is more than 8 times the length of the base, so that if the base were 2 miles long, the side of the main triangulation would be more than 16 m. long.

The process of triangulating consists of observing the angles at the apices of the triangles and at the two ends of the base. The apices and the ends of the base must be marked. The permanence of the marks will depend upon the character of the triangulation. Thus, in first-order work, a mark-stone would be buried deep in the soil, and isolated from the platform surrounding it. Vertically over the mark, when the observations were finished, a stone pillar would be built. In such work the signals would be luminous, either lamps or heliographs. But in work of a lower order the marks would usually be opaque; various different patterns have been used, poles, baskets, quadripods and so on. In very rapid work the tops of spires, pagodas, temples, or solitary trees are observed too; in some cases it has been found to be useful to clear a hill of all trees but one. In very rough work sometimes the tops of prominent hills are used, without any mark.

The angles at these trigonometrical points of whatever order, are invariably observed with a theodolite, and as this is without doubt the most important of all surveying instruments, it is desirable to give a description of it.

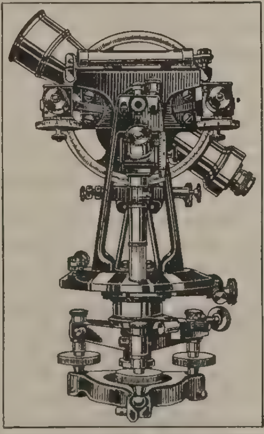


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FIG. 3.—FIVE-INCH MICROMETER THEODOLITE

The Theodolite.—The theodolite is a surveying instrument consisting of two graduated circles placed at right angles to each other, for the measurement of horizontal and vertical angles, a telescope, which turns on axes mounted centrically to the circles, and an alidade for each circle, which carries two or more verniers or micrometer microscopes. The whole is supported by a pedestal resting on footscrews, which are also employed to level the instrument. The size has varied from a minimum with circles $2\frac{1}{2}$ in. in diameter to a maximum with a 36-in. horizontal and an 18-in. vertical circle, but these very large circles are now obsolete owing to improvements in dividing machines. The largest now in use is 12 in. in diameter.

As an example of a modern theodolite suitable for use in topographical or exploratory surveying, we may take a 5-inch transit theodolite, fitted with micrometer microscopes. The accompanying fig. (3) shows such an instrument by Messrs. Cooke, Troughton and Simms. The instrument rests on a tripod stand, which is not shown in the figure. The levelling base has three screws. The horizontal and vertical reading circles are 5 in. in diameter, and are each read, by two microscopes, by estimation to single seconds. The telescope, which can be completely rotated in its horizontal bearings, has a magnification of 25. The instrument packs up in two boxes for transport. Excellent work has been done with such a theodolite all over the world. It does not appear desirable to give a more elaborate description, for the use of such an instrument can only be acquired by practice.

Triangulation.—This may be carried out either in the form of chain or of a net-work (fig. 4). In a small country even the first-order triangulation might cover the land with a net-work, with sides about 30 miles long; and this was done in the case of the British Isles. But in large countries such as India or the United States a very considerable saving of time and money is effected by running chains of triangles, generally north and south, or east and west. Second order work may also be either in the form of chains or of a net-work; it would be dependent on the first order work, if that existed. Third order work, which is required by the detail surveyors, would usually cover the ground completely.

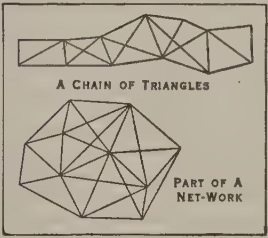


FIG. 4

At each station of the triangulation the theodolite is centred over the station mark and one of the distant stations is taken as the Referring Object and the other stations are also observed in turn. The first station should read about 0°, the base plate being so set, and then the other stations would be observed in order and the round of angles would close again on the first station. If this round were taken with the telescope to the right, the next round would be taken with the telescope to the left. The number of rounds taken will depend on the order of the work, the zero being shifted at each round, or at each alternate round. For rapid work a good system would be First zero, 0°0′, telescope right; Second zero 225° 1′ left. Telescope right is sometimes called "Face Right," and telescope left, "Face Left."

The angles having been all booked, the means are taken, and if each angle of a triangle has been observed, it is clear that the sum of the three angles should add up to 180°, plus the spherical excess, an excess which is due to the fact that the earth's surface is not plane, but is curved. Spherical excess varies directly as the area of the triangle, and may be taken to amount to 1·32 seconds for every hundred square miles, and other areas in proportion. It is generally neglected in rough work, and the excess or defect of the sum of the three angles of a triangle is, in such work, distributed equally amongst the three angles. Thus, if the sum of the three observed angles amounted to 180° 1′ 30″, each observed angle would be diminished by 30″ for use in the computations.

Computations.—Over large areas, and in work which is likely to be extended to great distances, or in which, for some special reason, the geographical positions are required, it is necessary to calculate for each trigonometrical station its latitude and longitude, starting from some station for which these elements are known. But, in the case of small or isolated surveys, such elaboration is unnecessary, and we can proceed as follows:—Take any one station as the origin, and the meridian through that station as the initial meridian; then, having observed an azimuth, or true bearing, at the origin, we shall know the azimuth of each line which radiates from the origin. Then if l_1 is the length of one of these lines, and if α is the angle which it makes with the initial meridian, then $l_1 \cos\alpha$ is the north-south co-ordinate, and $l_1 \sin\alpha$ is the east-west co-ordinate of the end of that line. For lines radiating from the end of the line in question, if β be the angle that one of them makes with a line parallel to the initial meridian, then if l_2 be the length of this second line, the co-ordinates of the end of it with reference to the beginning will be $l_2 \cos\beta$ and $l_2 \sin\beta$, so that the co-ordinates of any point in the triangulation, with reference to the origin, will be $l_1 \cos\alpha + l_2 \cos\beta + l_3 \cos\gamma + \ldots$, and $l_1 \sin\alpha + l_2 \sin\beta + l_3 \sin\gamma + \ldots$. Each point in the triangulation can now be plotted with reference to the origin and the initial meridian, due regard being paid to the signs of the trigonometrical functions. With these co-ordinates available it is, of course, easy to compute the distance of any one point in the triangulation from any other point.

In using this simple method, we have assumed that the earth's surface is plane; actually it is a spheroidal surface. The errors involved are chiefly in a north-south direction. At sixty miles' distance from the origin the error amounts to $\frac{1}{8,800}$, and the error increases as the square of the distance, so that at 100 miles the error is $\frac{1}{8,100}$ and if we were content with this error as a maximum, we could survey 200 miles on this system.

Heights.—Points fixed as above described, and plotted on paper at intervals of, say, four or five inches, give a sufficient control for the horizontal work of the detail surveyor; but he will also require a frame-work of heights if he is to contour, or approximately contour, the terrain. Heights may be determined in a variety of ways and with several degrees of accuracy; the most accurate method, and at the same time, the slowest and most expensive, is levelling, which will be dealt with later. The next method in order of accuracy is trigonometrical determination by vertical angles, taken with a theodolite, and this will now be briefly described. On the same day that the horizontal angles are observed at a trigonometrical station, vertical angles are observed to all the distant marks, and are read on the vertical circle of the theodolite. It has been found by experience that vertical refraction is least during the middle of the day, and vertical angles would, therefore, be taken between noon and three. It is best to eliminate refraction as far as possible by observing vertical angles at each of the two stations of which the difference of height is required. Then it is easily shown that, if one angle is an elevation, E_a and the angle at the other station is a depression, D_b, then the difference of height is $c \tan \frac{E_a + D_b}{2}$; or if both are depressions,—which may often happen with long rays,—the difference of height is $c \tan \frac{D_b - D_a}{2}$, c being the distance between the two stations. If only one angle has been observed, it will be necessary to correct this for refraction and curvature; the average amount of this correction may be taken as roughly about 4½ seconds for every thousand feet of horizontal distance between the stations, and for other distances in proportion. Barometers are best used for determining differences of height, and not absolute heights. All heights should, when possible, be based on some determination of mean sea-level, which is now the universally accepted datum.

Levelling.—A "Level" is an optical surveying instrument, which, when in adjustment, has its line of collimation horizontal; that is, the intersection of the cross-wires will cut an object, seen through the telescope, on the same horizontal plane as the optical axis. In using a level there is no need to consider the curvature of the earth, because the distances between the level and the forward and back level-staves are always kept short; in good work such a distance should not exceed 50 yards. If the distances in question are always kept approximately equal, any error due to faulty collimation will tend to disappear. Excellent modern levels are now made which enable the observer to read the bubble without moving from the object end of the telescope, and the instrument is finally levelled before the reading is taken. Readings are taken on two staves, usually some ten feet long; each staff graduated in feet and tenths of feet, and hundredths may be estimated.

TOPOGRAPHICAL SURVEYS

The British empire affords examples of all possible methods of the survey for, and preparation of, topographical maps.

Great Britain itself is one of the few countries in which all mapping is combined under one department and in which the expense of duplicating surveys for different purposes is avoided. The six-inch plans are used in the field for a special revision, arranged to secure the correct information for small scale maps. The small scale maps are then drawn for reproduction by heliozincography, each scale serving as a basis for the next in order.

Canada supplies excellent examples of topographical mapping and particularly so in photographic method. The one inch maps of areas in the Rocky mountains are made by ground photographic methods. A control of triangulated points is first established. The photographic party is equipped with theodolites and cameras which fit upon the same stands. The cameras are so used that each portion of the ground to be mapped is photographed from two points of view on plates held in the vertical plane. The position of the camera is resected with the theodolite. The plotting is carried out during the winter recess, each photographic view being used as a record of angular measurement both horizontal and vertical. Positions are established by the intersections of rays.

The survey of the Orange Free State in the Dominion of South Africa is an example of a plane table survey in country admirably suited to its use. The total area of over 50,000 square miles was mapped in 6 years by a Colonial Survey Section of 2 officers and 4 non-commissioned officers, R.E. There already existed, in parts of the area, chains of the Geodetic Survey of South Africa. Based on this triangulation, the officers of the party extended a ruling triangulation of a secondary nature (mean triangular error of less than 3 seconds). The sides of this triangulation varied from 10 to 45 miles. A tertiary triangulation, completed with a free use of intersection and interpolation, resulted in a fixed position and height every 4 or 5 miles. Plane tabling was carried out at the scale of $\frac{1}{125,000}$ each field sheet including 15 minutes of latitude and longitude. Progress averaged six or seven square miles per man per diem.

An example of a different class of survey in much more difficult country is to be found in the forest regions of the Gold Coast and Sierra Leone. There is little triangulation available, nor would it be possible without heavy expense. The control, mainly astronomical and widely spaced, is provided by a special party equipped with theodolite and wireless receiving set. The detail party traverses along cleared paths with chain and compass between control points. The triangles are then cut up by a number of rope and sound traverses. Along the main traverses lines of rough levelling are run, and aneroid barometers are carried on the minor traverses. Field work is at the two-inch scale and each traverse is adjusted and compiled on a final compilation.

Plane Tabling.—The plane table is merely a flat board which can be attached to a tripod. The board varies in dimensions from 40 in. to 18 in. a side, a convenient size being 24×18 inches. The board itself is generally made of wood, sometimes fitted with aluminium corners and fittings. Underneath, the board is strapped with metal, and has in the centre a ring with arrangements for attachment to the tripod. The tripod, of three girder pattern legs of light wood, can be clamped to the board or left friction tight to allow of rotation. Plane tables designed for large scale surveying often include a ball and socket joint for levelling, and an instrumental slow motion in azimuth. For topographical survey the board and legs are left as simple and light as possible. On the table is mounted drawing paper or some form of celluloid.

The principal accessory to the plane table is the sight vane or alidade, which is merely a ruler with sighting vanes which can be raised or lowered at will. For engineering surveys at a largish scale a telescope with stadia hairs and vertical circle is added to the alidade. A box compass and some form of clinometer for measuring slopes or vertical angles complete the outfit.

The first step in the field is to set the board. To do so it is only necessary to set a line a.b. on the board parallel to A.B. on the ground. The alidade is laid on the line a.b. and—standing at A.—the planetabler revolves his board until he sees B. through the sight vanes. Lines can then be drawn from a. towards any other points on the landscape. Similar lines from b. intersecting those from a. will then fix the positions. This intersection is an important factor in plane tabling. Even though the topographer may be given many control points fixed by the theodolite, he must amplify that control for the detail surveying he has to do. As a general rule then intersection is used today in providing the minor control for tomorrow. The actual mapping is based mainly on the process known as interpolation, resection, or "making the point." This is simply to find, from the positions of three or more control points, the position at which the table is set up. There are several methods of resection, the simplest of which will be described briefly:

> The board is roughly set and rays are drawn backwards from three control points towards the observer; the alidade being aligned on each in turn, so that it touches its plotted position. If the board has been truly set these rays will all pass through a point. If not, the true position of the observer will be nearest to the ray from the nearest point, furthest from the ray from the most distant. Again if the three control points lie round and outside the observer his position will be within the triangle of error. If the observer is outside his points his position is outside the triangle of error.

At each point so fixed the topographer sketches in the detail immediately around him, on directions drawn along the alidade, and at distances which are measured tachymetrically or by pacing or estimation. Heights are fixed by observing angles of elevation or depression and multiplying their tangents by the distances.

In average country a topographer will survey a square mile or so per diem on the one inch scale, but his rate will depend greatly upon his transport. Even at such scales as 3 inches to the mile, where the amount of detail to be shown demands intensive surveying rather than fast movement, a bicycle or some other transport is advisable.

The scales suitable for plane tabling lie between a quarter inch and three inches to the mile. At larger scales the plane table may still be and often is used, but more as a record of instrumental measurement and less purely graphically.

Traversing.—A traverse consists of measured lengths connected by measured angles. A traverse may end upon itself forming a complete figure, in which case it is called a closed traverse. More commonly it starts from one point of the triangulation and ends upon another. In cities, forests, or other areas of little visibility, the whole control may consist of a net-work of traverses.

The lengths or "legs" of the traverse may be measured in many ways. In control traversing invar or steel tapes are used in catenary (as in base measurement) or laid flat; in both cases under tension. For topographical surveying legs are measured with tapes or chains, ropes or rattans, by cyclometer or by pacing. They may also be measured optically with rangefinder, telemeter, subtense bar, or tachymeter. In geographical surveying, distances may be determined by observed differences of latitude on observed azimuths, or estimated from the time taken to travel over them on foot, horse, camel or motor car. Any class of precision may in fact be obtained, varying in fractional error from $\frac{1}{200,000}$ to $\frac{1}{50}$.

The angles of a traverse may be measured with theodolite or compass, may be obtained graphically on the plane table, or estimated from the direction of a sound, generally in the form of a prearranged call or whistle from a forward observer.

In the topographical survey of a new country various classes of traversing may occur. In the Federated Malay States and in West African Colonies, precise traverses with a linear error of about $\frac{1}{50,000}$ have been used as a framework or control. In the actual detail survey of forest regions minor traverses fill up the gaps between more precise and costly control traverses and afford opportunity of plotting detail. Examples of Topographical Traverses which will explain the procedure are given below.

In a recent three inch to one mile survey in Johore, the trigonometrical control consisted of a number of points assumed as errorless. Between them were run traverses with the compass and chain. The course of the traverse was cut as straight as possible. The observer plotted his bearings and lengths on squared paper at 6 inches to the mile, including the mapping of detail and contours. On reaching the closing point the traverse was adjusted graphically to its correct length, reduced to 3 inches to the mile and plotted on the plane table. Errors were, in general, of the order of $\frac{1}{500}$. The triangle of traverses was then cut up by minor traverses running straight and parallel at 200 feet intervals. These traverses were compass and "rattan" (a long creeper, marked to length, and compared each day with a standard chain). The detail and contours were mapped during the course of the traverse which was plotted direct on the plane table and seldom showed need of adjustment.

As explained above traverses which are graphic in principle are adjusted graphically and proportionally. In adjusting instrumental (or booked) traverses the normal rule is to adjust as follows:—

> As the arithmetical sum of all x's (or y's) is to any one x (or y), so is the whole error in x's (or y's) to the correction to the corresponding x (or y).

An adjustment on these lines gives equal weight to angular and linear measurement and admits the fact that there is, in general, no evidence on which to give preference among (*i.e.*, to *weight*) the measurements.

OPTICAL METHODS OF MEASURING DISTANCES

The optical methods of distance measurement which are here dealt with are those which depend upon the measurement of a length from a small base at one end and the angle subtended by that base at the other. They include a number of alternatives. For example the base may be fixed or variable, the subtended angle variable or fixed. The base may be at the observer's end or the far end, may be vertical or horizontal, whilst the angle may be measured by hairs or lines in the focal plane, by a micrometer scale in the focal plane, by repetition measurement on the horizontal arc, or by optical devices actually included in the base apparatus. The earliest form development took was in the use of fixed stadia hairs in the focal plane, reading, according to distance, a variable length on a vertical graduated staff. This method was later called tachymetry, or tacheometry (quick measurement) by the Italian Porro.

Tacheometry or tachymetry was first outlined and applied by the English astronomer Gascoigne in 1639. Montanari, a Venetian doctor, constructed and used an instrument of similar principle in 1674. James Watt used it for surveying in the West of Scotland from 1771 onwards, and William Green, a London optician, did much to develop the method by the publication of a description in 1778. (*Description and use of an improved Reflecting and Refracting Telescope and Scales for Surveying.*) The unequal effect of refraction on the top and bottom lines of sight was understood by Green who called attention to the advantage of a horizontal, as opposed to a vertical, angular measurement. Nevertheless the practical convenience of the vertical staff has made it the most popular. Methods in which the base is variable but horizontal, that is a horizontal tachymetry, are sometimes known by the term telemetry. Methods in which the base is fixed (and generally horizontal) and angles read on the theodolite arcs are known as subtense, whilst the fixed base which includes its own system of angular measurement is commonly called rangefinding. The use of the various terms is, however, and must be, elastic.

Tachymetry.—A tachymeter (or tacheometer), in its simplest form, is only a theodolite, or telescopic alidade, provided with two horizontal wires fixed in the diaphragm at equal distances from the axis. These wires, read against a vertical graduated staff at the distant point, measure an intercept "a." The distance between the wires is so arranged that the required length "s" is some fixed multiple "k" of "a" (k usually = 100) although certain corrections may have to be applied.

The theodolite still most commonly used has a biconvex object glass and an eyepiece, and it can be shown that the point at which the subtended angle is constant lies not on the vertical axis but at a distance in front equal to f+c, where f is the focal length at stellar focus, and c is the distance of the centre of the object glass to the diaphragm,

$$\text{then } s = k.\, a + (f + c).$$

(k if not known must be determined by experiment.)

Used in this general form for many years, the inconvenience of the constant computation of $(f+c)$ has led to the use of an "anallatic," or converging, lens between the object glass and the diaphragm. Due to the Italian Porro the introduction of this lens makes it possible to measure lengths directly from the station as defined by the vertical axis of the instrument. To an increasing extent the internal focussing telescope, translating for focussing, is now replacing the older style, and in it the point of measurement is so close to the vertical axis as to result in consequent errors of an order inferior to many others which are unavoidable. (*See* bibliography—Henrici.)

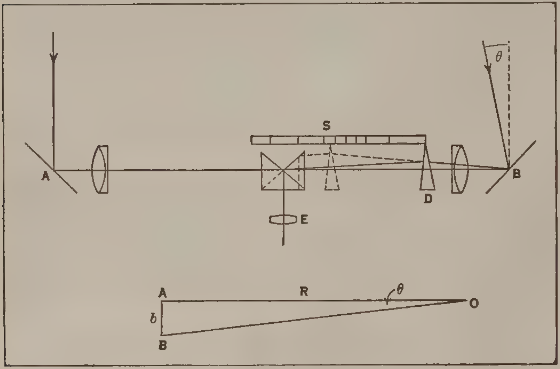


FIG. 5

The general equation thus becomes $s = k{\cdot}a$.

The length "s" is however the actual distance between instrument and staff, whereas surveying demands the horizontal and vertical components, and the computation of these will depend on the way in which the staff is held. Normally the staff is held vertical. Let θ be the angle of elevation, or depression, to the centre of the intercept a. Let d be the horizontal component and h the vertical component. Now the image of a will be reduced, obviously, to equal $a\cos\theta$, and

$$s = ka\cos\theta \text{—}$$
$$\text{but } d = s\cos\theta.$$
$$\text{Therefore } d = ka\cos^2\theta$$
$$\text{and } h = \pm d\tan\theta, \text{ or } \tfrac{1}{2}\, ka\sin 2\theta.$$

The rod may however be held perpendicular to the optical axis. Where this is intended the staff is equipped with a device which allows the rodman to sight on the instrument. In this case if l be the length from the foot of the stave to its intersection with the produced optical axis—(the sighting point)

$$\text{then } s = ka\cos\theta \pm \sin\theta$$
$$\text{and } d = \pm Ra\sin\theta \mp l\cos\theta.$$

In the course of a normal tachymetric survey a very large number of points are generally fixed and the trigonometrical computation becomes irksome. There are numerous tables designed to facilitate this computation, and there are also special instrumental fittings for the same purpose. Some continental forms of tachymeter solve the triangle by scaled bars which actually form the triangle whose sides are s, d and h. The Beaman arc is a fitting used often in America. This arc is fitted against the vertical arc of the tachymeter but is independent of it and can be set to any zero. It has two scales which help in the solution of $\cos\theta$ and of $\frac{1}{2}\sin 2\theta$. Some recent models give a direct reading of the horizontal and vertical components. It may be said, generally, that the tachymeter should not be used for distances of over 600 feet, that errors increase proportionally to the distance (except in the case of refraction which acts as the square of the distance) and that they may be expected to reach at least one part in four hundred.

Tachymetry is a medium scale method and is particularly suitable to engineering surveys, above or below ground. It is used perhaps more than any other for continental topographical surveys at scales of $\frac{1}{20,000}$ or $\frac{1}{25,000}$ but is unsuitable alike for the 25 inch mapping of the United Kingdom or the small scale mapping of the Empire overseas. Used on the plane table the tachymeter is useful for traversing in difficult enclosed country or, where the control points can be seen, for measuring distances and heights to points that are immediately round the point of resection.

Telemetry.—The very marked effect of refraction upon the precision of tachymetry has led to the use of staves in the horizontal position. The need for greater precision seems to have been felt particularly desirable for the distance between the cameras used in ground photo surveying.

Subtense methods are much used in topographical and military surveys. In such cases a theodolite is usually available and a subtense bar or base can be rapidly improvised. The bar or base is arranged horizontal so that the line between stations is perpendicular to it either at its centre point or at one end. The angle is measured by "repetition" on the slow motion screws of upper and lower plates. Thus, sighting on the left hand mark, the telescope is revolved with the top plate slow motion screw to point at the right hand mark. The bottom plate screw is then used to repoint on the left hand mark and the process continued until some 10 to 20 readings have been made. The whole angle is then read and divided by the number of times the measurement has been made. The general equation is

$$d = \frac{b}{2}\cot\frac{a}{2} \text{ if the perpendicular is to centre point}$$

or

$$d = b\ \cot a \text{ if the perpendicular is to end point.}$$

Where d is the horizontal distance, b is the length of bar or base, and a the subtended angle.

The subtense base may be of any convenient size. Sometimes signals have been erected as ends of a subtense base of as much as a quarter of a mile in length the distance between being taped. But subtense bars of special design, 10–20 ft. long, are the commonest form of base. The end marks are often discs with black lines on a white ground. For distances up to 500 yards using a 10-foot subtense bar, with disc terminals, errors of the order of $\frac{1}{500}$ may be expected, but with proper precaution, good end marks, and sufficient repetition, a much higher order of precision may be obtained. The advantages of these subtense methods over tachymetry lie in their greater range and precision, in the ease with which the base can be improvised, in the freedom from either a special instrument or a special staff of rodmen, and in the direct measurement of the horizontal distance.

Rangefinders.—Some rangefinders are stereoscopic in principle and resemble, in that respect, the stereoscopic plotting machines with their "floating mark." Coincidence methods have the great advantage over stereoscopic that almost everyone can use them. Moreover for this particular purpose a general plastic image is not required. Errors involved in the use of the rangefinder, for any given base and magnification, are proportional to the square of the distance and an error of $\frac{1}{500}$ may be taken as normal at a range of reach 100 feet in base length and 28 in magnification. With a 1 250 yards with a 31·5 inch (8 cm.) magnification 8 model. Models metre base and magnification 20 the fractional error is less than $\frac{1}{500}$ at 500 yards. An increasing survey use is being made of this rangefinder. In Canada, Egypt and elsewhere surveyors are finding its advantage over the tachymeter in the independence of rodmen and the increased speed. In Canada it has been, and is, used in the control of river and lake traverses on which the surveys, nowadays mainly air photo-surveys, of the northern territories are based. Obviously the rangefinder would prove useful in medium scale plane tabling for the measurement round each resected point.

Contouring.—The first step in contouring is to measure or choose the datum to which the height of all points shall be referred. It is now common to accept mean sea-level, as measured and meaned over a long period of time at same tide gauge. With reference to this datum a control of heights is distributed over the country by spirit levelling or by vertical angles measured with the theodolite.

Geodetic levelling would not be available, normally, as a backbone or control for a topographical survey. For this latter purpose secondary levelling with errors not exceeding about 0·03 foot per mile would suffice. These secondary chains, spaced fifty to a hundred miles apart in a grid or net, are generally confined to railways or roads. The intervals would then be filled up with subsidiary orders of levels reaching eventually such errors as 0·1 foot per mile over short lengths. Levels of a topographical class are often run with the tachymeter in conjunction with plane tabling.

In topographical surveys of new countries it is usual to base contouring on a control of heights determined trigonometrically (by vertical angles with a theodolite). The operations of triangulation and determination of heights are thus combined. Truly simultaneous observation between two points will tend to eliminate refraction. In all other cases there is bound to be uncertainty. Observation of vertical angles should be confined to the times of minimum refraction (early in the afternoon), and heights should be carried forward through the shortest sides—since the correction for refraction varies as the square of the distance. Trigonometrical heights show errors of the order of two or three feet in 100 miles.

In plane-table surveys minor heights are obtained with the Indian pattern clinometer, a small instrument which reads slopes, vertical angles, and natural tangents of the vertical angles. The clinometer (nine inches long) has two vanes. In the rear vane is a sight hole which can be levelled in relation to the zero point of the front vane. If confined to a radius of two miles this clinometer gives excellent results, but at longer ranges errors rapidly increase.

The increasing use of the aneroid barometer is due to the convenience of measuring height directly instead of deducing it from distance and slope. A barometer measures the pressure of the air however and before it can be used to measure either absolute or relative heights corrections must be applied to eliminate the effect of (a) Weather, diurnal, and area variations, (b) Temperature, (c) Index or other instrumental errors.

The first correction is usually applied by comparing the record of a barometer retained in camp with that of the field instrument. The second can be applied directly if the shade temperature is measured at the time of each reading, but thermometer readings must also be taken for the stationary or camp instrument. Under particularly stable conditions it is possible to record the movement due to average diurnal variations and to dispense with the camp instrument, the recording of which is often difficult to arrange. In these cases the record graphs should be either corrected for variation in temperature or amplified by a statement of the mean temperature at definite time intervals. There is much to be done still in designing survey barometers with an eye to reducing instrumental errors such as lag, friction of pivots, etc.

The hypsometer (or boiling point apparatus) is of more value to the explorer than the surveyor.

In topographical surveying contours are not generally followed out in detail, but are sketched in upon the control. Strict accuracy in contouring is not perhaps a very important feature of a topographical map. Topographical scales will not show, in any case, enough information for engineering enterprise, whereas a relatively good and reliable picture of the accidents of the ground is of the first order of importance in the development of a new country. The sketching in of the contours is helped by measuring gradients, by noting all points in the observer's level and by spacing contours properly on rivers and streams. There is little difficulty in attaining sensible accuracy in the position of contours in hilly country, but errors of four or five feet in altitude are normal and may be appreciable in flat country.

The vertical interval between contours depends principally upon the scale of the map although it is also conditioned by the type of country. Thus the same vertical interval could hardly be applied to Switzerland and to Flanders. A good idea as to the proper interval in feet for average country will be obtained by dividing 50 by the scale in inches to the mile. Thus a map on the scale of ½ inch to one mile would have contours at 100 feet intervals.

Field Sheets.—As explained in the article on plane tabling the board is covered with paper, canvas backed, or mounted previously on a thin sheet of aluminium. Some form of celluloid is also used on occasion. This covering is called the Field Sheet. On it are plotted the control and the boundary lines of the individual task, and on it the plane tabler subsequently maps. A plane tabler should be "within his points." The area of his work should then be substantially less than that of the board itself in order to allow of plotting control points in the margins, which are also wanted for notes and lists of names. On the other hand, a plane tabler starts a new field sheet slowly and gathers pace as he gets to know his control and his country. A good mean figure for the area of work on a board of 18×24 in. is from 60 to 80 sq. inches.

The plane tabler's area should be bounded by definite, ruled-in lines. It sometimes happens that a river or other topographical obstacle makes it imperative for neighbouring topographers on either side to work to this natural and therefore irregular line, but the accuracy of subsequent adjustment suffers. The dividing line should be one across which roads, rivers and other details pass naturally. An overlap between well trained plane tablers is neither necessary nor advisable, nor is it necessary for them to meet at any stage of their work. The correct conventional signs and colours will have been laid down in advance and each plane tabler will ink in his work as and when he considers it final. No colour which is not photographically opaque should be used. It is not generally advisable to map at scales larger than the final map. The plane tabler judges more accurately the amount of generalisation necessary if his field sheet is plotted at the map scale and as names are generally written in the margin, there is ample space available in which to show all the required detail.

On conclusion of the survey, the field sheet will be available for checking. Every party should have some proportion of its strength earmarked for revision. After, or during, revision the edges common to the finished field sheets should be compared. Differences on the edges should be small, but occasional errors in orientation ("swing") may arise if there has been difficulty in seeing the control points. Differences should be traced backwards to the nearest resections and for this reason resected points and their heights should be left in pencil on the field sheet until comparisons are finished.

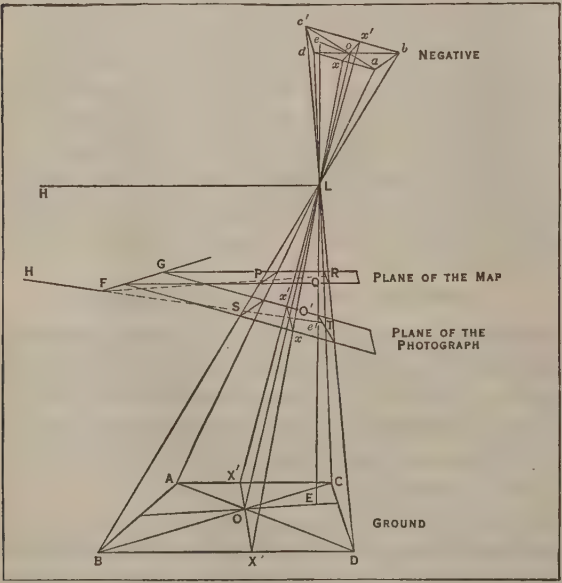
SURVEYING FROM AIR PHOTOGRAPHS

A photograph is a perspective view of the ground it represents. In certain cases, though rarely, the ground surface is truly parallel to the plane of the photographic plate. In this case the photograph is a correct plan. Any other relationship of ground (or map) and photographic plane results in a true perspective plan so long as the surface to be mapped is flat, the angle between the two planes being known as the tilt. In this case the map can be wholly reconstructed on perspective lines.

The general case differs from either of the above in that the surface to be mapped is rarely flat, presenting the three ordinary dimensions of nature, whilst, as in the second case, the photographic plane is inclined or tilted to the map plane. There are then two difficulties to surmount, the perspective effect and that of difference of altitude. These two effects act from different points on the plane of the photograph. It is one of the hardest problems of surveying from air photographs to disentangle these two effects and to correct them in the proper way. The photograph is a central perspective of the ground mapped, which is true in so far as lens, shutter, photographic material, temperature changes and rigidity of the camera allow. The perspective centre is the point on, or with reference to, the plate from which directions to points on the ground correspond to those from the camera. Height, however, introduces in the perspective view distortions which radiate from a point in the plane of the photograph vertically below the front nodal point of the lens. This point is commonly known as the Photo Plumb Point. The perspective centre and photo plumb point coincide with each other, and with the optical centre, when the two planes (ground and photo) are parallel. In all other cases these three points are distinct from each other and lie on a line perpendicular to the axis of tilt at distances which are functions of the tilt.

As nearly all photographic surveying demands a knowledge of the position of these points the first step is so to calibrate and to adjust the camera that the optical centre corresponds to the principal point (the point at which a perpendicular from the front nodal point meets the plane of the photo). Fiducial marks photographed on the four edges of the plate can then be joined up to give the correct position. It is with reference to this position that the perspective centre and photo plumb point can be found. The principal distance (between the lens and the principal point) must also be measured. In the remainder of this article it will be assumed that the camera has been properly calibrated and adjusted.

The Single Photograph in Perspective. (a) *Where the Ground is Flat.*—If S is the representative fraction of the scale, L be a distance on the ground, and l the corresponding distance on the photograph, then for any given small area $S=\frac{l}{L}$. But l is conditioned by the tilt and the scale varies accordingly. Where photographs are taken as nearly as possible with a vertical axis then $S=\frac{f}{H}$ where f is the principal distance (not quite the same thing as the focal length), and H is the height of flight. Whether or not photographs are nearly vertical the problem is the same because it has not been found possible hitherto to maintain the axis truly vertical, to record such deviations from the vertical as may occur, or to keep a constant height. In every case then the photograph is a perspective view at an unknown tilt and from an unknown height. The effect of tilt can be eliminated by perspective treatment founded on the corresponding positions (on ground and photograph) of four points. Such treatment may be either graphic or photographic and is generally called rectification.



BY COURTESY OF COL. M. N. MACLEOD, FROM TRANS. OPT. SOCY., BY PERMISSION OF SECY.

FIG. 6

Graphic methods are seldom applied to the whole photograph. In practice it is easy to find straight lines through points clear on the photograph, and already mapped, which will intersect on, or sufficiently close to, the new point which is to be added. Perspective figures may also be used. If the lines or subdivisions of the perspective figures are sufficiently close, detail may be copied by eye, correcting both for tilt and for scale in the process.

Photographic rectification is more suitable for larger areas if these are really flat. It must be remembered however that a sharp image is essential to good plotting and that the ordinary projecting lantern, though it offers freedom of movement for the screen, does not do so for the photograph. This latter movement is, however, necessary to secure a sharp image. Space forbids a further analysis of the perspective and optical principles involved. (*See* bibliography.) For small scale or exploratory mapping it may be convenient to assume that photography has been vertical and the height has been constant. Mosaics (composite pictures made up of "vertical" photographs) are made on this assumption, although where good maps already exist, mosaics are usually built up on positions taken from them.

Examples of Surveys on the Above Lines: i. The Topographical Survey of Canada has made excellent quarter inch maps of the lake and river areas of the Laurentian Plateau from highly tilted oblique photographs in which the horizon appears, and serves the purpose of two of the four necessary control points.

ii. The swamps and forests of the Irrawaddy Delta were mapped by the Survey of India from "verticals" controlled by triangulation and traverse. Individual photographs were not rectified but strips of photographs were prepared and rephotographed to the correct scale as given by the control.

iii. The Air Survey of Flanders and Picardy in 1916–17 was based on a fresh triangulation, on which an old but fairly reliable cadastral survey was assembled. Fresh detail, inclusive of trenches and other military works, was added from vertical air photographs, each of which was treated as a perspective view within the narrow limits of the cadastral control.

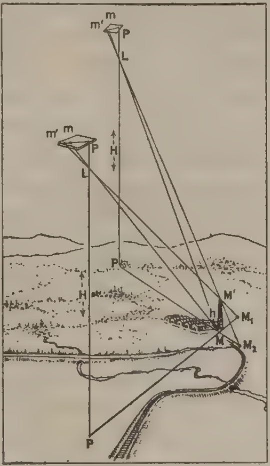
(b) *In Ordinary Country and for Contoured Maps.*—In the bundle of rays which converge to the camera that from the top of a high chimney or hill (unless it be vertically under the camera) will make a larger angle with the vertical than will the ray from the point directly under that chimney or hill top. Heights are thus displaced outwards from the plumb point, depressions inwards. The only perspective effect which holds good is that of direction from the perspective centre.

In ground photo topography the position, height and tilt of the camera are known. In air photo topography none of these are known, but they can be found from the corresponding positions on ground and photograph of four points properly surveyed in plan and in height.

The reconstruction may be graphical, mathematical or mechanical. Graphical methods are not sufficiently precise, whilst a mathematical solution, possible in several ways, is excessively lengthy. The mechanical solution is that adopted in the machines for stereoscopic measurement which will be mentioned later. All three suffer from the difficulty of securing suitable well defined and sharp images on the plate. Precision of measurement on the plate is therefore difficult to attain whilst the comparatively small area of the base (the area included by the four control points), and the comparatively sharp angles at the apex, are difficulties.

Pairs of Photographs.—A pair exposed from different air stations and covering a common portion of ground gives two directions to each point in the area common to the two photographs. The positions and heights of the points can therefore be completely determined so long as the constants of exposure are known.

The stereoscopic machines for surveying from ground stations act on this general principle but the problem they solve is comparatively easy because the positions of the ground stations can be surveyed directly and the photographs can be taken at measured angles of tilt and in a definite angular relationship to each other. Air stations cannot be surveyed directly. Reference must be made from the images on the plates to the points of a ground control, which those images portray, before the stereoscopic image can be plotted on the plane of the map (*e.g.*, mean sea-level), properly oriented, and reduced or enlarged to the appropriate scale. This reference to ground control can be carried out in two ways. Firstly, as in those stereoscopic machines which follow the general lines of their predecessors designed for ground stereo plotting, each photograph is set, singly, upon a control of four points surveyed on the ground, thus reconstructing the position and tilt of the plate in space. When both plates of the pair have been thus placed a final joint setting ensures proper correspondence. The process of setting may take several hours. There is however another way which is to set the pair in correspondence, in space, before referring to the ground control. The pair is said to be in correspondence when corresponding directions in space intersect, each pair of points being in correspondence when the rays to them intersect. A perfect correspondence between plates is secured when five points are in correspondence and the plates are then set in their correct relative positions to each other and to the base line between the two air stations. This is the principle of the Fourcade stereogoniometer. The strip so set or plotted is, however, not on the required plane nor is it necessarily correct in scale and orientation. To secure correct plan the whole must be referred to a ground control which, however, may be comparatively open. We must know—



BY COURTESY OF THE CONTROLLER, H. M. STATIONERY OFFICE

FIG. 7.—DISPLACEMENT OF PHOTOGRAPH DUE TO HEIGHT OF FEATURE

(a) Scale—This is determined from a measured base on the ground by comparison with the corresponding length in the stereoscopic image.

(b) The position of a horizontal plane in the stereoscopic image which can be determined from a comparison of two vertical angles measured on the ground with the corresponding angles on the stereoscopic image measured in relation to an approximate position of the horizontal which can afterwards be corrected.

The data so obtained set the machine for

(a) The length of the air base.

(b) The angle through which both photographs must be rotated about the air base, in order to re-establish the vertical plane containing the air base.

(c) The inclination of the air base to the horizontal.

However the plates of a pair have been set, detail on the relief or stereoscopic image from a pair of set photographs is plotted by the superimposition of the image formed by a pair of artificial "floating marks" which combine stereoscopically to produce that image at a known position in space. The movement of the image relative to the landscape enables the latter to be measured and surveyed in detail. For convenience however in mechanical and optical construction it is usual for the "floating mark" to be fixed and the stereoscopic image of the landscape to be moved. Maps so produced have been mainly cadastral and engineering plans at a large scale. Meanwhile for topographical work at smaller scales methods have been evolved which depend upon the elimination, by good and consistent flying, of any excessive tilt. For all classes of air survey it is most important that navigation in the aeroplane should aim at maintaining an undeviating course both as to direction and height.

Methods for securing straight flight and constant height have not yet been standardised. As a rule each pilot has evolved his own methods for himself. Great skill is often displayed but variations of wind may well cause displacements of track of half a mile in a ten-mile strip. Deviations of 80 to 100 ft. in height are common. This problem, which can only be solved by a judicious mixture of instrumental control and training, remains one of the most important to surmount. If the tilt is small the perspective centre and the photo plumb point approach each other and the principal point. It is possible then to assume that directions from the principal point may hold good both as regards tilt distortion and height distortion. Methods based on this assumption are known as radial methods. The first assumption made is that the air base of any pair is defined in direction by the line joining the photographic images of the two principal points. It would not be possible however to accept as relatively correct on the ground the successive distances measured on the photographs between principal points. It is usual in these methods to allow for an overlap large enough to include the two air bases (forwards and backwards) from the centre of each individual photograph. The positions of the fore and back stations can thus be found by a comparison of detail, but such tilt and height distortion as may occur on the lines between them are sufficient to introduce serious errors of length.

The scale of the plot is, therefore, obtained by accepting an arbitrary length on the first photograph and by continually fixing points in the overlaps and refixing the principal points from them thus:—The base 1–2 on the first photograph is set along any line which will be convenient for subsequent plotting. A line 1a is now drawn to a (on the photograph, image of A on ground) and is accepted as an arbitrary length on the "plot." The second photograph is now set on line 2–1 and moved along it till the direction from 2 to A cuts the position a on photograph 1. Thus the distance 1a is made the base for all subsequent work. From 1 and 2 directions are drawn to b and c (images of B and C) which appear on both photographs. As these also appear on the third photograph which is set on the direction 2–3 (between principal points 2 and 3) the position of 3 (principal point of the 3rd photograph) can be resected.

Naturally the construction lines must be drawn on tracing paper, linen or celluloid (the latter is most convenient), the photographs being placed separately and successively under it. Once the positions of the principal points have been plotted all other points of detail may be fixed by the intersection of the photographic directions. A particular development of the radial method, commonly known as the Arundel method, employs a small "topographical" stereoscope in these first stages of plotting. The particular feature is the addition over each photograph of glass plates on which are etched diamond shaped grids. These grids fuze stereoscopically into a plane which may be moved vertically in relation to the landscape, for contouring, and which are also used to show when the pair is properly in correspondence. By this method the orientation of the air base can be established and marked on each photograph. Contouring in the Arundel method is carried out on alternate photographs. Each pair is set and examined in the topographical stereoscope on the assumption that they are untilted and exposed from the same altitude. The resulting stereoscopic image is naturally subject to errors in apparent slopes, the effect of which must be held in check by a fairly close height control. The plane formed by the diamond grids may be made to touch the ground at any place, the extent of movement being recorded on scales. Other heights may then be interpolated and when a sufficient control has been secured contours can be drawn in by eye on the actual photograph. They are subsequently traced in correct position on the celluloid plot.

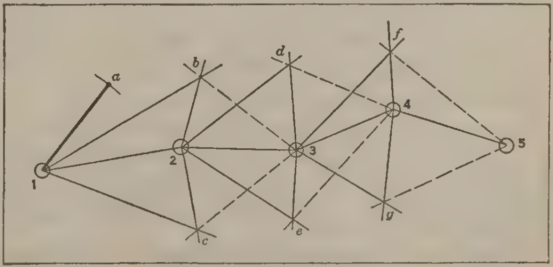


FIG. 8

MAP REPRODUCTION

The general heading of reproduction covers the various processes of drawing, photography and printing, which come between the survey on the ground and the completed map. There is a stage generally carried out by draughtsmen called compilation, which, however, antedates fair drawing and is equivalent to survey. Small scale maps of the less well known parts of the world are made up from material of various sorts and generally of unequal value.

The next stage is fair drawing. The draughtsman's first task is to plot the graticule and margin of his sheet on the chosen projection. He then plots the control points in proper position and begins to incorporate his material. Whether the latter is compilation, or field sheet, it is probable that the photographer will be called upon to provide bromides at the required scale. The next point to decide is the number of colours to employ. If the whole map is drawn on one sheet of paper the photographer will have to divide colour from colour during his preparation of the zinc plates. If each colour is drawn separately then subsequent photography and zincography is made easier, but the fit of one colour upon another, commonly known as the register, will suffer; for, once embarked upon, the various different drawings may expand or contract unequally. The procedure chosen is often a mixture of these two principles.

Sometimes the field sheets are assembled and photographed to be printed in blue and to act as a direct key to the drawing of various colours. Blue is chosen because, in the subsequent photography of the completely drawn colour sheet or plate, blue will not appear on the negative, which will record nothing which has not been inked in. This system is handy, and guards against bad register. The use of a complete key of this sort implies that the whole of the material can be collected and photographed into position at one and the same time. In other cases each main colour is drawn on its own tracing paper, the various plates being compared and examined, over each other, at frequent intervals, to prevent the clash or overprinting of the different colours. In all such drawing the colours used must be photographically opaque. Where main colours are treated separately each is drawn in black. Where all the colours are drawn together a difference must be made as a guide to subsequent separation but the colours employed need not be those of the final map.

The main photographic process of preparing the printed record from the finished drawing is heliozincography. In this process the original drawing is photographed, and the glass negative is then laid over a sensitized zinc plate. The negative and zinc are held in close contact in a frame from which the air can be pumped. Light penetrates the lines and names left clear on the negative and hardens the surface below. The remainder of the sensitized surface, protected by the negative, remains soft and can be washed away.

In the heliozincographic process each plate is photographed to the proper dimensions. The great advantage of heliozincography lies, however, in the possibilities of touching up or adding fresh detail actually on the negative. A special staff is employed in large map establishments for this purpose. If all the colours of the final map have been drawn together it is at this stage that separation occurs. As many negatives are made as there are to be main colours. On each negative everything irrelevant to the particular colour in view is duffed out. The glass negatives then become the final records, from which any number of printing plates may be made.

The zinc plates are now given over to the printers. (*See* LITHOGRAPHY.)

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"SURVILLE, CLOTILDE DE," the supposed author of the *Poésies de Clotilde.* The generally accepted legend gave the following account of her. Marguerite Éléonore Clotilde de Vallon Challis, dame de Surville, was born in the early years of the 15th century at Vallon. In 1421 she married Bérenger de Surville, who was killed at the siege of Orleans in 1428. Her husband's absence at the war inspired her heroic verses and his death her elegiac poems. The last of her poems is a *chant royal* addressed to Charles VIII. In 1803 Charles Vanderbourg published as the *Poésies de Clotilde* some forty poems dealing with love and war. Research showed that the documents, communicated by the marquis de Surville to Vanderbourg were not genuine, and the account of Clotilde herself was proved to be inaccurate.

See A. Macé, *Un procès d'histoire littéraire* (1870); A. Mazon, *Marguerite Chalis et la légende de Clotilde de Surville* (1875); articles by Gaston Paris in the *Revue critique d'histoire et de littérature* (March 1, 1873 and May 30, 1874), by Paul Cottin in the *Bulletin du bibliophile* (1894); E. K. Chambers, *Literary Forgeries* (1891); and further references in the *Bibliographie des femmes célèbres* (Turin and Paris, 1892, etc.).

SURVIVAL: *see* PSYCHICAL RESEARCH.

SUS, a province of southern Morocco. It is an east-to-west valley, 200 km. long, bounded by the Atlantic ocean, High Atlas, Siroua and Anti-Atlas. The area is about 20,000 sq. kilometres. Sus has a Saharan climate slightly mitigated by its nearness to the Atlantic. The arganier (*Argania sideroxylon*) is the characteristic tree; it has the appearance of a spiny olive, and forms sparse forest-steppes. The waters of the Wad Sus and its affluents allow of some cultivation, helped by irrigation, but one must not exaggerate the agricultural wealth of the region; it is reputed to be rich in mines, especially of copper. The population is about 400,000, grouped at the foot of the mountains and along the Wad; it is Berber in race and speech, and belongs to the Chleuh group. The Susis emigrate willingly and are excellent workmen. The port of Sus is Agadir, the Santa-Cruz of Cape Aguer of the Portuguese; situated on the Atlantic to the north of the mouth of the Wad Sus, it includes a citadel and a fishing village; a harbour is being built. Tarudant, capital of Sus, is a native town of 6,000 inhabitants, of whom 1,000 are Jews.

SUSA (Shúshan, Sús), capital of Susiana (Elam) and chief residence of Darius I. and his successors. It lay under the Zagros range at about lat. 32°, near the bank of the Karkha (Choaspes) river and close to the Kárún. (For early history *see* ELAM.)

The site, identified (1850) by W. K. Loftus, has on it four mounds. One, rising about 38 metres, holds the citadel. A second to the east represents the palace of Darius I. and was excavated by M. Dieulafoy. The enamelled bricks taken from its walls are in the Louvre. A third mound to the south contains the royal Elamite city, while the fourth mound consists of the poorer houses. Excavation of the citadel was begun by J. de Morgan in 1897. It yielded the obelisk of Manistusu (*see* BABYLONIA), the stele of Naram-Sin, and the Code of Hammurabi (the latter in the winter of 1901–02).

The finest pottery came in the lowest strata, 25 metres below the surface, and belongs to two different civilizations both in the Neolithic period. The earlier is characterized by vases of fine red clay, wheel-made, in a few well-defined shapes, but all with very thin, polished sides. The decorations applied in black paint or red-brown ferruginous earth consist of bold geometrical patterns, often combined with spirited studies from nature. The pottery of the second period shows a retrogression, being coarser and porous.

Above the early strata come remains of Elamite and early Babylonian civilization, inscribed objects from the latter bearing pictorial characters from which the cuneiform was evolved. The upper portions of the mounds disclosed inscribed Achaemenian monuments, Greek pottery and inscriptions of the 4th century B.C., coins of the kings of Elymais, and Parthian and Sassanian relics. Muslim tradition says that the tomb of the prophet Daniel lay in the bed of the Karkha river and a mosque was built on the bank opposite the supposed spot. Until after the 14th century the city was a flourishing centre of a district famous for silk, sugar-cane and oranges. It is now deserted.

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SUSA (Fr. *Sousse*), a city of Tunisia, on the Gulf of Hammamet, in 35° 49′ N., 10° 39′ E., 36m. by rail E. by N. of Kairawan, of which it is the port, and 93m. S. by E. by rail of Tunis. Susa is built on the side of a hill sloping seawards, and is surrounded by a crenellated wall, strengthened by towers. The kasbah, or citadel, built on the highest point within the town, was thoroughly restored by the French after their occupation of the country in 1881, and serves as military headquarters for the district. The native town has been little changed since the French occupation, but north of the port a European quarter has been created. The museum contains many archaeological treasures, notable mosaics and sculptures. The most interesting buildings in the old town are the Kasr-er-Ribat and the Kahwat-el-Kubba. The Kasr-er-Ribat is a square fortress with a high tower and seven bastions. The Kahwat-el-Kubba (Café of the Dome) is a curious house, square at the base, then cylindrical, and surmounted by a fluted dome. The grand mosque is in the north-east part of the town. To the south-west of the town there are vast Christian catacombs, excavated by the Abbé Leynaud in 1904, which contained some 10,000 burials. The ancient harbours are silted up, but vestiges of the Roman breakwaters may be seen. The modern port, completed in 1901, enables steamers drawing 21ft. to lie at the quays. Exports are chiefly phosphates and other minerals, olive oil, esparto and cereals; imports: cotton goods, building material, etc. The population, less than 10,000 at the time of the French occupation, now reaches 21,298, of which 10,714 are Muslim, 3,728 Jews, 6,856 Europeans (3,664 French, 2,437 Italians, 563 Maltese).

SUSARION, Greek comic poet, a native of Tripodiscus in Megaris. About 580 B.C. he transplanted the Megarian comedy into the Attic deme of Icaria, the cradle also of Greek tragedy and the oldest seat of the worship of Dionysus. According to the Parian Chronicle, there appears to have been a competition on this occasion, in which the prize was a basket of figs and an amphora of wine.

See V. von Wilamowitz-Möllendorf (*Hermes*, ix.), who doubts the whole story; the lines *s.n.* Susarion in Meineke, *Comic Fragments*, are probably spurious.

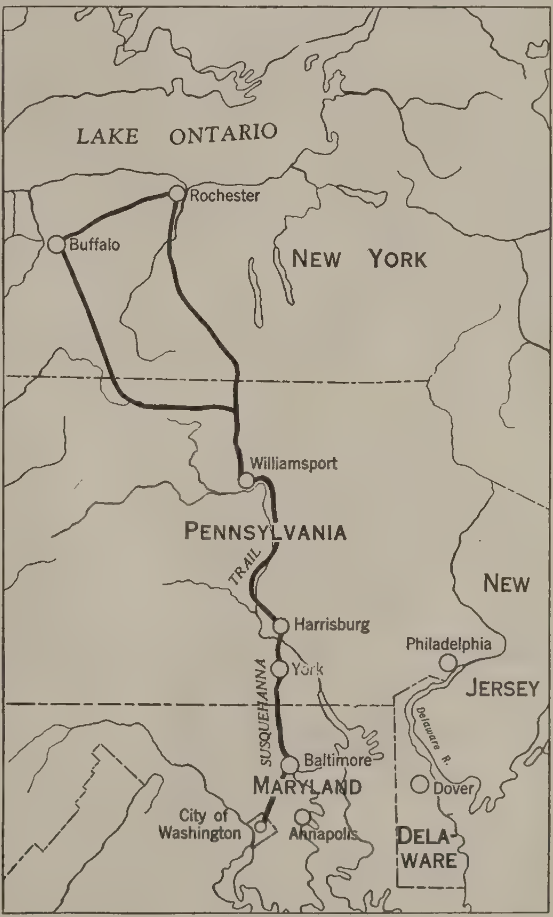
SUSO [SEUSE], **HEINRICH** (*c.* 1300–1366), German mystic, was born at Überlingen on Lake Constance; he assumed the name of his mother, his father being a Herr von Berg. He was educated for the Church, first at Constance, then at Cologne, where he came under the influence of the greatest of the German mystics, Meister Eckart. He subsequently entered a monastery in Constance, where he subjected himself to the severest ordeals of asceticism. In 1335 he wandered through Swabia as a preacher, and won all hearts by his gentle, persuasive eloquence; the effusive lyricism of his language made him an especial favourite among the nuns. About 1348 he seems to have settled in Ulm, where he died on Jan. 25, 1366. Suso's first work, *Das Büchlein der Wahrheit*, was written in Cologne about 1329; setting out from Eckart's doctrines, he presents the mystic faith from its speculative or theoretical side; whereas in *Das Büchlein der ewigen Weisheit*, written some years later in Constance, he discusses the practical aspects of mysticism. The latter work, which Suso also translated into Latin under the title of *Horologium sapientiae*, has been called the finest fruit of German mysticism.

Suso's works were collected as early as 1482 and again in 1512; recent editions: *Heinrich Suso's Leben und Schriften*, ed. by M. Diepenbrock (1829; 4th ed., 1884); *Suso's Deutsche Schriften*, by F. H. S. Denifle (1878–1880, not completed), and *Deutsche Schriften*, by K. Bihlmeyer (2 vols., 1907). *See* also W. Preger, *Die Briefe Heinrich Susos* (1867); W. Preger, *Geschichte der deutschen Mystik* (1882), vol. ii.; J. Jäger, *Heinrich Seuse aus Schwaben* (1894); and *The Life of Blessed H. Suso, by Himself* (1913), trans. by T. F. Knox, with introd. by W. R. Inge.

SUSPENSION BRIDGE: *see* BRIDGES.

SUSPENSURA, the architectural term given by Vitruvius (v. 10) to the hollow space under the floor of a Roman bath, in which the smoke from the furnace passed to the vertical flues in the wall. (*See* HYPOCAUST.)

SUSQUEHANNA TRAIL, an American highway from Williamsport, Pa., to Harrisburg, Pa. It connects at either terminal with paved or hard surfaced roads and furnishes a picturesque route connecting Buffalo and Rochester, N.Y. with Baltimore, Frederick, Md. and Washington, D.C. It passes through farming districts in New York and Pennsylvania, crosses the Appalachian mountains and traverses the Gettysburg battle-field.



SUSSEX, EARLS OF. G. E. Cokayne (*Complete Peerage*, i. 138, 139) holds that Roger de Montgomery, who received grants from William the Conqueror of a large part of the county of Sussex, including the city of Chichester and the castle and honour of Arundel, besides lands in Shropshire with the castles of Shrewsbury and Montgomery, may be regarded as the first earl of Sussex. Whatever Roger's titles may have been, they were forfeited to the Crown when his son Robert was attainted in 1102, and the forfeited estates were conferred by Henry I. on his second wife Adelicia, who after Henry's death married William de Albini, or d'Aubigny. The latter was created earl of Sussex by King Stephen, and "the third penny" of that county was confirmed to him by an instrument of the reign of Henry II., in which, however, he is styled earl of Arundel, a designation by which he was more generally known. His grandson William, 3rd earl of Sussex, was one of King John's sureties for the observance of Magna Carta; and in 1243, the earldom reverted to the Crown on the death of Hugh de Albini, 5th earl of the line. (*See* ARUNDEL, EARLS OF.)

Ratclyffe Earls.—For nearly two hundred years, from 1347 to 1529, the title of earl of Sussex did not exist in the English peerage. In 1529, however, it was conferred on Robert Radcliffe, Radclyffe or Ratclyffe (*c.* 1483–1542), who had been made Viscount Fitzwalter in 1525. In 1540 Ratclyffe was appointed great chamberlain of England. With Edward, the 6th earl (*c.* 1552–1641), the title became extinct.

Savile Earls.—In 1644 Thomas Savile (*c.* 1590–*c.* 1659), son of John Savile, 1st Baron Savile of Pontefract (1566–1630), was created earl of Sussex. Savile opposed Wentworth, afterwards earl of Strafford, the rivalry between the Saviles and the Wentworths being of long standing in the history of Yorkshire. During the Great Rebellion he played a double game, and was imprisoned at different times by both parties. His later years were spent in retirement at Howley Hall, where he died about 1659. He was succeeded in the earldom of Sussex by his son James, on whose death without issue in 1671 the title became extinct.

It was revived in 1684 in favour of Thomas Lennard, 15th Baron Dacre, whose wife Ann (d. 1722) was a daughter of the famous duchess of Cleveland by King Charles II., and again became extinct at this nobleman's death in 1715. The title was next conferred in 1717 on Talbot Yelverton, 2nd Viscount de Longueville and 16th Baron Grey de Ruthyn (*c.* 1692–1731), from whom it descended to his two sons successively, becoming once more extinct on the death of the younger of these, Henry, 3rd earl of Sussex of this creation, in 1799.

Royal Earls.—In 1801 Prince Augustus Frederick (1773–1843), the sixth son of George III., was created duke of Sussex. Spending his early years abroad, the prince was married in Rome in 1793 to Lady Augusta (d. 1830) daughter of John Murray, 4th earl of Dunmore. The ceremony was repeated in London and two children were born, but under the Royal Marriage Act of 1772 the Court of Arches declared the union illegal. The children took the name of d'Este. Sussex was a man of liberal ideas; he favoured the abolition of the slave trade, the repeal of the corn laws and the removal of the civil disabilities of Roman Catholics, Dissenters and Jews. His second wife, Cecilia, widow of Sir George Buggin, was created duchess of Inverness in 1840. He died at Kensington Palace on April 21, 1843. The older title of earl of Sussex was conferred in 1874 upon Prince Albert, the third son of Queen Victoria, who at the same time was created duke of Connaught and Strathearn.

See G. E. C., *Complete Peerage, s.v.* "Sussex," "Surrey," "Arundel," vols. i. and vii. (London, 1887–96); Sir William Dugdale, *The Baronage of England* (1675). For the earls of the Radcliffe family *see* also John Strype, *Memorials of Thomas Cranmer* (1694), *Annals of the Reformation* (1725) and *Ecclesiastical Memorials* (3 vols., 1721); P.F. Tytler, *England under the Reigns of Edward VI. and Mary* (2 vols., 1839); *Calendars of State Papers: Letters and Papers of the Reign of Henry VIII.* For the 1st earl of the Savile line *see* S. R. Gardiner, *Hist. of England, 1603–1642* (10 vols., 1883–84) and *Hist. of the Great Civil War* (3 vols., 1886–91); and John Rushworth, *Historical Collections* (8 vols., 1659–1701).

SUSSEX, THOMAS RADCLYFFE [or RATCLYFFE], 3RD EARL OF (*c.* 1525–1583), lord-lieutenant of Ireland, eldest son of Henry, 2nd earl of Sussex (*see* SUSSEX, EARLS OF), by his first wife, Elizabeth, daughter of Thomas Howard, 2nd duke of Norfolk, was born about 1525, and after his father's succession to the earldom in 1542 was styled Viscount Fitzwalter. After serving in the army abroad, he was employed in 1551 in negotiating a marriage between Edward VI. and a daughter of Henry II., king of France. His prominence in the kingdom was shown by his inclusion among the signatories to the letters patent of June 16, 1553, settling the crown on Lady Jane Grey; but he nevertheless won favour with Queen Mary, who employed him in arranging her marriage with Philip of Spain, and who raised him to the peerage as Baron Fitzwalter in August 1553. In April 1556, Fitzwalter was appointed lord deputy of Ireland. The measures enjoined upon Fitzwalter by the government in London comprised the reversal of the partial attempts that had been made during the short reign of Edward VI. to promote Protestantism in Ireland, and the "plantation" by English settlers of that part of the country then known as Offaly and Leix. But Fitzwalter first of all found it necessary to make an expedition into Ulster. Having defeated O'Neill and his allies the MacDonnells, the lord deputy, who by the death of his father in February 1557 became earl of Sussex, returned to Dublin, where he summoned a parliament in June of that year. Sussex then took the field against Donough O'Conor, whom he failed to capture, and afterwards against Shane O'Neill, whose lands in Tyrone he ravaged, restoring to their nominal rights the earl of Tyrone and his reputed son Matthew O'Neill, baron of Dungannon. (*See* O'NEILL.) In June of the following year Sussex turned his attention to the west, where the head of the O'Briens had ousted his nephew Conor O'Brien, earl of Thomond, from his possessions, and refused to pay allegiance to the Crown; he forced Limerick to open its gates to him, restored Thomond, and proclaimed The O'Brien a traitor. He took part in the ceremonial of Queen Elizabeth's coronation in January 1559; and in the following July he returned to Ireland with a fresh commission, now as lord lieutenant, from the new queen, whose policy required him to come to terms if possible with the troublesome leaders of the O'Neills and the MacDonnells. Sussex was recalled, at his own request, in 1564. His government of Ireland had not, however, been without fruit. Sussex was the first representative of the English Crown who enforced authority to any considerable extent beyond the limits of the Pale.

On his return to England, Sussex immediately threw himself into opposition to the earl of Leicester. In 1566 and the following year Elizabeth employed him in negotiations for a marriage with the archduke Charles. When this project fell to the ground Sussex returned from Vienna to London in March 1568, and in July he was appointed lord president of the north, in which office he had to deal with the rebellion of the earls of Northumberland and Westmorland in 1569. In 1570 he laid waste the border, invaded Scotland, and raided the country round Dumfries, reducing the rebel leaders to complete submission. In July 1572 Sussex became lord chamberlain, and he was henceforth in frequent attendance on Queen Elizabeth, both in her progresses through the country and at court, until his death on June 9, 1583.

The earl of Sussex was a patron of literature and of the drama. He was twice married: first to Elizabeth, daughter of Thomas Wriothesley, earl of Southampton; and secondly to Frances, daughter of Sir William Sidney. His second wife was the foundress of Sidney Sussex College at Cambridge, which she endowed by her will. The earl left no children, and at his death his titles passed to his brother Henry.

See P. F. Tytler, *England under the Reigns of Edward VI. and Mary* (2 vols., 1839); Richard Bagwell, *Ireland under the Tudors* (3 vols., 1885–90); *Calendar of the Carew MSS.*; John Stow, *Annales* (1631); Charles Henry Cooper, *Athenae cantabrigienses*, vol. i. (Cambridge, 1858), containing a biography of the earl of Sussex; John Strype, *Ecclesiastical Memorials* (Oxford, 1822); Sir Cuthbert Sharpe, *Memorials of the Rebellion of 1569* (1840); John Nichols, *Progresses and Public Processions of Queen Elizabeth* (3 vols., 1823); Sir William Dugdale, *The Baronage of England* (1675).

SUSSEX, a southern county of England, bounded north by Surrey, north-east by Kent, south by the English Channel, and west by Hampshire. The area is 1,459·2 sq. miles. The county consists of the central and southern portion of the broad east to west dome of the Wealden anticline, and is very long (78 m.) in proportion to its breadth (28 m. at broadest). The dominant feature is the chalk of the South Downs (average height 500 ft., Ditchling Beacon 800 ft.) which cross the county in a west-north-west to east-south-east direction, ending in bold cliffs at Beachy Head. Westward from this point the chalk forms the south coast, except that at Seaford there are outliers of Reading beds and from South Lancing onwards the same beds extend as a thin belt into Hampshire, there to form the Hampshire basin. This belt lies a few miles from the coast, except south of Chichester, where it broadens out and forms the low flat headland of Selsey Bill. East from Beachy Head, Wealden clay and Hastings beds form the coast, but recent deposits round Winchelsea and Rye (members of the Cinque Ports and prominent in mediaeval trade) and Pevensey have cut these towns off from the sea. The South Downs dip gently southward, but form a steep escarpment to the north, where the upper formations of the anticline have been denuded, exposing in succession from south to north, gault and upper greensand, lower greensand, Wealden clay and Hastings beds, with small patches of Purbeck shale, and limestone with beds of gypsum lying west of Battle. The gault and upper greensand form a plain at the foot of the escarpment, bounded north by the elevated ridge of the lower greensand, beyond which the Wealden clay and Hastings beds give rise to hill country known as the Forest Ridges (800 ft. near Crowborough), where rise many Sussex rivers. Of these, the Rother forms part of the Kent boundary and enters the sea below Rye; the Cuckmere rises near Heathfield (where also natural gas is found in the Lower, Wealden and Purbeck beds); the Ouse, the Adur and the Arun rise in the district of St. Leonard's forest, flow south and breach the chalk, having respectively as gap towns, Lewes, Steyning and Arundel, and as ports, Newhaven, Shoreham and Littlehampton.

The country north of the Downs was formerly covered with forest, but much wood was cut for export to the Low Countries as early as the 14th century, and for the Wealden iron industry, especially in the 17th and 18th centuries. The coast line of Sussex is long and exceedingly varied, and encroachment and erosion have taken place as well as accumulation. Old Winchelsea was submerged in the 13th century; the site of the ancient cathedral of Selsey is a mile out at sea; 5,500 ac. were submerged between 1292 and 1340; early in the 14th century, Pagham harbour was formed by the sudden flooding of 2,700 ac., since reclaimed. The latest movement of the coast is probably one of slight elevation. The following changes have taken place at river mouths:—Prior to a great storm on Oct. 12, 1250, the Rother entered the sea 12 m. to the east; until 1570, the outlet of the Ouse was at Seaford; the Adur has frequently shifted its mouth. Submerged forests occur offshore. The sheltered coast has given rise to many watering-places:—Brighton, Hastings, Eastbourne, Bexhill, Seaford, Shoreham, Worthing, Littlehampton, Bognor.

History.—Sussex, with its long southern shore, supplying fish and salt, and dissected by mouths of clear rivers, with gravel-lined valleys leading to sunny chalk slopes, was admirably suited to the needs of primitive man, and we have definite traces of him in Palaeolithic times, on the coast, *e.g.*, near Worthing, Eastbourne, Brighton and Chichester, and in the valleys, especially of the Arun and western Rother. In Neolithic times these and similar sites were very important, as kitchen middens, tools, bones of animals, etc., abundantly prove. The Downs were also used. The flint mines of Cissbury are now generally ascribed to a late Neolithic date, though some students have dated them back to earlier times. The Bronze age finds (pottery, celts, etc.) show that the coastal regions (Worthing, Wilmington, Eastbourne, where gold bracelets, bronze swords, copper, etc., were found) were again used. The importance of Sussex continued, and the Iron age finds, though less numerous, show a high degree of culture, the gold ornaments from Mountfield being especially important. Objects of Sussex iron (hammer, plough-share, bill-hook, etc.) found at Mount Caburn, point to an iron industry in pre-Roman times. The Long Man of Wilmington cut in the chalk is probably also of this period. That agriculture was practised by prehistoric man is also proved by the presence of numerous lynchets and rectangular fields still traceable on the chalk slopes. Mr. Toms, of Brighton, has gathered evidence to show that the great earthwork at Cissbury is probably of British workmanship in the Roman period, and there are numerous other earthworks in Sussex of early Iron age or Romano-British date. Cissbury and Chanctonbury are in a "Worthing" group, while the Devil's Dyke and many others are in a Brighton group. Mount Caburn and several others are also well known.

In 447 the Saxons, under Ella and his three sons, built up the kingdom of the South Saxons. (*See* SUSSEX, KINGDOM OF.) They took the Roman city of Regnum (Chichester) and drove the British westward, into the forest of Andred. The Roman fortress of Anderida (Pevensey), also fell to the Saxons. According to Bede, Ella was the first Bretwalda. After his time the kingdom of Sussex gradually declined and fell under the dominion of Wessex in 823. Saxon remains are found in numerous cemeteries, and scattered burial places along the south slopes of the Downs. The cemetery on High Down hill, where weapons, ornaments and vessels of various kinds were found, and the Chanctonbury hoard of coins, are noteworthy. A coin of Offa of Mercia, found at Beddingham, recalls the charter of Archbishop Wilfred in 825, in which Offa's connection with the monastery in that place is recorded. From 895 Sussex suffered from constant raids by the Danes, till the accession of Canute, after which arose the two great forces of the house of Godwine and of the Normans. Godwine was probably a native of Sussex, and by the end of the Confessor's reign a third part of the county was in the hands of his family. Norman influence was strong in Sussex before the Conquest; the harbours of Hastings, Rye, Winchelsea and Steyning being in the power of the Norman abbey of Fécamp.

Hastings and Pevensey were important under the Normans, being on the most direct route for Normandy. William secured communication with London by placing the lands in the hands of such men as his half-brother, the count of Mortain, who held Pevensey, and his son-in-law, William de Warenne, who held Lewes. With the exception of lands held by the Church and the Crown, the five rapes of Sussex were held by these and three other Norman tenants-in-chief: William de Braose, the count of Eu, and Roger, earl of Montgomery, who held respectively Bramber, Hastings and Arundel. The honour of Battle was afterwards made into a rape by the Conqueror, and provides one of the arguments in favour of the theory of the Norman origin of these unique divisions of the county. The county was divided into five (afterwards six) strips, running north and south, and having each a town of military, commercial and maritime importance. These were the rapes, and each had its sheriff, in addition to the sheriff of the whole county. Whether the origin of the rapes, as districts, is to be found in the Icelandic territorial division *hreppr* (rejected in the *New English Dictionary*), or in the Saxon *rap*, a rope, or is of Norman origin, as lordships they owed their existence to the Normans. The holdings—which had been scattered under the Saxons, so that one man's holding might be in more than one rape—were now determined, not by the manors in which they lay, but by the borders of the rape. Another peculiarity of the division of land in Sussex is that, apparently, each hide of land had eight instead of the usual four virgates.

The county boundary was long and somewhat indeterminate on the north, owing to the dense forest of Andredsweald, which was uninhabited till the 11th century. Evidence of this is seen in Domesday Book by the survey of Worth and Lodsworth under Surrey, and also by the fact that as late as 1834 the present parishes of North and South Amersham in Sussex were part of Hampshire. At the time of Domesday Sussex contained 60 hundreds, since become 73. These courts were in the hands, either of the Church, or of great lords. The county court was held at Lewes and Shoreham until the Great Inquest, when it was moved to Chichester. After several changes the act of 1504 arranged for it to be held alternately at Lewes and Chichester.

The chief ecclesiastical franchises were those of the archbishop of Canterbury, of the bishop of Chichester, of the Saxon foundation of Bosham, and of the votive abbey of Battle, founded by the Conqueror. This abbey possessed, besides land in many other counties, the "Lowy of Battle," a district extending for 3 m. round the abbey. The see of Chichester was co-extensive with the county, and has altered little. It is one of the oldest bishoprics, having been founded by Wilfred at Selsey; the seat was removed to Chichester by William I.

Sussex was constantly the scene of invasions and rebellions, Pevensey and Arundel playing a great part in the latter under the early Norman kings. In the barons' wars the county was a centre for the king's forces, Lewes being in the hands of the king's brother-in-law, John de Warenne, earl of Surrey, Pevensey and Hastings in those of his uncle, Peter of Savoy. The forces of the king and of De Montfort met at Lewes, where the famous battle and "Mise of Lewes" took place. Corrupt administration during the 13th and 14th centuries, constant passage of troops for the French wars and the devastating plagues of the 14th century, were the causes of such rebellions as the Peasants' Rising (1381) and Jack Cade's Rebellion (1450). During Elizabeth's reign there was constant levying of troops for Flanders and the Low Countries, and preparations for defence against Spain. The sympathies of the county were divided during the Civil War, Arundel and Chichester being held for the king, Lewes and the Cinque Ports for the parliament. Chichester and Arundel were besieged by Waller, and the Roundheads gained a strong hold on the county, in spite of the loyalty of Sir Edward Ford, sheriff of Sussex. A Royalist gathering in the west of the county in 1645 caused preparations for resistance at Chichester. In the same year the "Clubmen" rose and tried to force terms. During the French Revolution, Sussex produced many volunteers. At the outbreak of war with France (1793) a camp was formed at Brighton and at Eastbourne (1803) when the famous Martello towers were erected.

In 1290 we have the first extant return of knights of the shire. Drastic reformation was effected by the Redistribution Act of 1832, when Bramber, East Grinstead, Seaford, Steyning and Winchelsea were disfranchised after returning two members each, the first being classed among the worst of the "rotten" boroughs. Before 1832 two members each had been returned also by Arundel, Chichester, Hastings, Horsham, Lewes, Midhurst, New Shoreham (with the rape of Bramber) and Rye. Arundel, Horsham, Midhurst and Rye were each deprived of a member in 1832, Chichester and Lewes in 1867, and Hastings in 1885. Arundel was disfranchised in 1868, and Chichester, Horsham, Midhurst, New Shoreham and Rye in 1885. In the 18th century the duke of Newcastle was all-powerful in the county, where the Pelham family had been settled from the time of Edward I., the earl of Chichester being the present representative of the family.

Architecture.—Sussex is rich in ancient castles. Lewes and Bramber are in ruins, but Arundel is still the seat of the dukes of Norfolk. More famous than these are the massive remains (part Norman, mainly 13th century), of Pevensey, within the walls of Roman Anderida. Other ruins are those of the finely situated Hastings Castle; the Norman remains at Knepp near West Grinstead; the remarkably perfect moated fortress of Bodiam (14th century); and Hurstmonceaux Castle (15th-century brick).

Monastic remains are few. The ruins of Bayham Abbey near Tunbridge Wells, and of Battle Abbey, may be noticed. There are numerous churches of great interest and beauty. Of these may be mentioned the cathedral of Chichester, the churches of Shoreham and Rye, and the mother church of Worthing at Broadwater. Construction of pre-Norman date is seen in the churches of Bosham, Sompting and, most notably, Worth. There is very rich Norman work of various dates in the church of St. Nicholas, Steyning. Several perfect specimens of small Early English churches are found, as at West Tarring, and at Climping, near Littlehampton. Perhaps the most interesting church in the county is the magnificent Decorated fragment at Winchelsea; another noteworthy church of this period is at Etchingham, near the eastern border. The church of St. Denis, Midhurst, is mainly Perpendicular; the large church at Fletching contains the tomb of Gibbon the historian. At Cowfold, south-east of Horsham, is a great Carthusian monastery, founded in 1877.

Dialect.—A large number of Saxon words are retained and pronounced in the old style; thus *gate* becomes *ge-at*. The letter *a* is very broad in all words, as if followed by *u*, and in fact converts words of one syllable into words of two, as *faüs* (face), *taüst* (taste), etc. Again, *a* before double *d* becomes *ar*, as *arder* and *larder* for *adder* and *ladder; oi* is like a long *i*, as *spile* (spoil), *intment* (ointment); an *e* is substituted for *a* in such words as *rag, flag,* etc. The French refugees in the 16th and 17th centuries introduced many words which are still in use.

Climate and Agriculture.—The climate is mild and equable. The average annual rainfall varies from 22·5 in. (Pevensey levels) to over 40 in. (west end of the Downs). The temperature varies from 61°–63° F, July, to 39°–40° F, January. The soil is fertile and a large proportion is under cultivation. Sussex is still one of the best wooded counties in England; oaks are typical of the Weald and the beech of the lighter chalk lands. The Weald, the Downs and the salt marshes provide different types of pasture. Weald farms often possess marsh pastures, and transhumance takes place between the two. Many cattle are raised, especially in east Sussex, and are sent from the Weald to fatten on the marshes in April and May. Sheep (Southdown and Kent) are very important, and lambs raised on the eastern marshes are often sent to the Weald to winter. The south slopes of the Downs and the coastal plain at their feet, west of Shoreham, form an early region for lambs, with good arable on which both sheep and lambs can be fattened, the latter for early markets. Sheep-rearing has given rise to important fairs:—St. John's and Findon (early July); the Bat and Ball fair at Chiddingly (end of July); Lindfield, near Hayward's Heath (early August); Findon, 2nd fair (early September); Lewes, the most important fair of the year (Sept. 21). Large sales are also held, notably at Chichester, in August. Dairying is becoming increasingly important. Shorthorns and Jerseys (for butter) are the chief breeds. Fruit and hops are important crops on the heavy lands of East Sussex; root-crops (including sugar beet, the output of which has much increased) and grain (wheat and oats) are grown in both, but especially in West Sussex. Milk, poultry, early fruit and flowers are increasingly supplied to London and other markets.

Industries.—The industries, though now mostly limited to minor ones connected with agriculture (brewing, tanning, etc.), were formerly very varied. The furnaces for the Wealden iron industry, which dates back probably to pre-Roman times, were chiefly in Sussex. Clay gave rise to pottery and brick-making. Glass-making (with fine Hastings sand) flourished at Chiddingfold (Surrey), and at Westborough Green, Loxwood and Petworth in Sussex. Weaving and fulling were also carried on, Chichester being noted for its cloth. The shores abound in shellfish, and both fresh-water and sea fishing are very important; the herring-fisheries and the salt-pans on the coast are noted in Domesday.

Communications.—The Southern railway runs from London to Hastings, St. Leonards, Bexhill, Eastbourne, to Lewes and Newhaven, to Brighton, to Shoreham, and to Arundel, Chichester and Selsey, with numerous branches and a connecting line along the coast. There are no good harbours, and none of the ports is of first importance. From Newhaven, however, a large trade is carried on with France, and daily passenger steamers ply to Dieppe.

Population and Administration.—The area of the ancient county is 932,471 ac., with a population (1921) of 727,997. The earliest statement as to the population is made by Bede, who describes the county as containing in the year 681 land of 7,000 families; allowing ten to a family (not an unreasonable estimate at that date), the total population would be 70,000. In 1693 the county is stated to have contained 21,537 houses. If seven were allowed to a house at that date, the total population would be 150,759. It is curious, therefore, to observe that in 1801 the population was only 159,311. The decline of the Sussex iron works probably accounts for the small increase of population during several centuries, although after the massacre of St. Bartholomew upwards of 1,500 Huguenots landed at Rye, and in 1685, after the revocation of the Edict of Nantes, other refugees arrived.

An act of Henry VII. (1504) directed that for convenience the county court should be held at Lewes as well as at Chichester, and this apparently gave rise to the division of Sussex into east and west parts, each of which is an administrative county. East Sussex has an area of 530,555 ac., and West Sussex 401,916 acres. Sussex includes the parliamentary borough of Brighton and the county boroughs of Hastings and Eastbourne. East Sussex contains the municipal boroughs of Bexhill, Lewes and Rye. In West Sussex the municipal boroughs are Arundel, Chichester (a city), and Worthing. The ancient county, which is almost entirely in the diocese of Chichester, contains 377 ecclesiastical parishes or districts, wholly or in part. The total number of civil parishes is 338. Sussex is divided into the following parliamentary divisions: northern or East Grinstead, eastern or Rye, southern or Eastbourne, mid or Lewes, south-western or Chichester, north-western or Horsham and Worthing each returning one member; and contains the parliamentary boroughs of Brighton, returning two members, and Hastings, returning one.

Bibliography.—*See* T. W. Horsfield, *History, Antiquities and Topography of Sussex* (Lewes, 1835); J. Dallaway, *History of the Western Division of Sussex* (London, 1815–32); M. A. Lower, *History of Sussex* (Lewes, 1870), *Churches of Sussex* (Brighton, 1872) and *Worthies of Sussex* (Lewes, 1865); *Sussex Archaeological Society's Collections;* W. E. Baxter, *Domesday Book for . . . Sussex* (Lewes, 1876); Sawyer, *Sussex Natural History and Folklore* (Brighton, 1883), *Sussex Dialect* (Brighton, 1884) and *Sussex Songs and Music* (Brighton, 1885); A. J. C. Hare, *Sussex* (London, 1894); A. Hadrian Allcroft, *Earthwork of England* (1908); *Victoria County History* ii. (1905).

SUSSEX, KINGDOM OF (*Súð Seaxe, i.e.,* the South Saxons), one of the kingdoms of Anglo-Saxon Britain, the boundaries of which coincided in general with those of the modern county of Sussex. According to the tradition given in the Anglo-Saxon Chronicle, it was in 477 that a certain Ella (Aelle) led the invaders ashore at a place called Cymenes ora and defeated the inhabitants. A further battle at a place called Mearcredesburne is recorded for 485, and in the annal for 491 we read that Ella and Cissa his son sacked Anderida (Pevensey) and slew the inhabitants. Ella is the first king of the invading race whom Bede describes as exercising supremacy over the southern English.

The history of Sussex now becomes a blank until 607 when Ceolwulf of Wessex is found fighting against the South Saxons. In 681 Wilfrid of York, on his expulsion from Northumbria by Ecgfrith, retired into Sussex, where he remained until 686 converting its pagan inhabitants. According to Bede, Aethelwald, king of Sussex, had been previously baptized in Mercia at the suggestion of Wulfhere, who presented him with the Isle of Wight and the district about the river Meon in Hampshire. After Wilfrid's exertions in relieving a famine which occurred in Sussex the king granted to him eighty-seven hides in and near the peninsula of Selsey which, with a lapse until 709 after Wilfrid's retirement, remained the seat of the South Saxon bishopric until the Norman Conquest. Shortly afterwards, however, Aethelwald was slain and his kingdom ravaged by the exiled West Saxon prince Ceadwalla. The latter was eventually expelled by two princes Berhthun and Andhun, who assumed the government of the kingdom. In 686 the South Saxons attacked Hlothhere, king of Kent, in support of his nephew Eadric, but soon afterwards Berhthun was killed and the kingdom subjugated for a time by Ceadwalla, who had now become king of Wessex.

Of the later South Saxon kings we have little knowledge. In 692 a grant is made by a king called Nothelm to his sister, which is witnessed by two other kings called Nunna and "Uuattus." Nunna is probably to be identified with Nun, described in the Chronicle as the kinsman of Ine of Wessex who fought with him against Gerent, king of the West Welsh, in 710. According to Bede, Sussex was subject to Ine for many years. A grant, dated by Birch about 725, is made by Nunna to Eadberht, bishop of Selsey, and to this too "Uuattus" appears as a witness. In 722 we find Ine of Wessex at war with the South Saxons, apparently because they were supporting a certain Aldbryht, probably an exile from Wessex. An undated grant is made by Nunna about this time, which is witnessed by a King Aethelberht. After this we hear nothing more until shortly before 765, when a grant of land is made by a king named Aldwulf with two other kings, Aelfwald and Oslac, as witnesses. In 765 and 770 grants are made by a King Osmund, the latter of which is witnessed by Offa of Mercia. Offa also appears as witness to two charters of an Aethelberht, king of the South Saxons, and in 772 he grants land himself in Sussex, with Oswald, *dux* of the South Saxons, as a witness. It is probable that about this time Offa definitely annexed the kingdom of Sussex, as several persons, Osmund, Aelfwald and Oslac, who had previously used the royal title, now sign with that of *dux*. In 825 the South Saxons submitted to Ecgberht, and from this time they remained subject to the West Saxon dynasty.

Authorities.—*Anglo-Saxon Chronicle*, pp. 449, 477, 485, 491, 607, 722, 725, 823, 827 (ed. Earle and Plummer, Oxford, 1899); Bede, *Historia Ecclesiastica*, i. 15, ii. 5, iv. 13, 15, 16, 26, v. 18, 19, 23 (ed. C. Plummer, Oxford, 1896); W. de G. Birch, *Cartularium Saxonicum*, Nos. 78, 144, 145, 197, 198, 206, 208, 211, 212, 1334 (1885–93). (F. G. M. B.)

SUSU, a tall people of French Guinea and Sierra Leone, with pleasant countenances, oval in shape, who tattoo three lines on the breast and beneath the eye. They live in confederate villages under a paramount chief, the houses of one family grouped together. Their material culture is fairly advanced. Marriage is usual between cross cousins and between the husband's brother and widow. Polygamy, with headship of the first wife, is common. Inheritance is patrilineal. The Susu have politico-religious confraternities, known as *Simo,* including as a rule three degrees for men. Their religion is animist but influenced by Islam. Susu is also the name of the fresh-water dolphin of the Ganges; it is blind, fish-eating and pale in colour. (*See* Cetacea.)

See Arcin, *La Guinée Française* (1907); N. W. Thomas, *Report on the Timne-speaking Peoples* (1916).

SUTHERLAND, EARLS AND DUKES OF. The first earl of Sutherland was a certain William (d. 1284), whose father, Hugh Freskin (d. 1204), acquired the district of Sutherland about 1197. Probably about 1230 William was created earl of Sutherland. His descendant William, the 4th earl (d. 1370), was a person of some importance in the history of Scotland; he married Margaret (d. 1358), daughter of King Robert Bruce. His descendant John, the 9th earl, died unmarried in 1514.

John's sister Elizabeth (d. 1535) married Adam Gordon (d. 1537), a younger son of George Gordon, 2nd earl of Huntly, and a grandson of King James I., and before 1516 Gordon became earl of Sutherland by right of his wife. He was succeeded by his grandson John (*c.* 1526–1567), the 2nd earl of his line, who was poisoned at the instigation of George Sinclair, 4th earl of Caithness. His great-grandson John, the 5th earl (1609–1663), was a strong Covenanter, being called by his associates "the good Earl John"; he fought against Montrose at Auldearn, but afterwards he rendered good service to Charles II. John Gordon (*c.* 1660–1733), who became the seventh earl in 1703, supported the revolution of 1688 and was a commissioner for the union of England and Scotland. He was a Scottish representative peer in four parliaments, president of the board of trade and manufactures, and lord-lieutenant of the eight northern counties of Scotland. He was active in putting down the rising of 1715. This earl, who took the name of Sutherland instead of that of Gordon, was succeeded by his grandson William (*c.* 1708–1750), a representative peer, who helped to suppress the rebellion of 1745. William, the next earl, died without male issue in 1766, his daughter Elizabeth (1765–1839) claiming the peerage. Her title thereto was confirmed by the House of Lords in 1771.

Established in the possession of the title and estates of the earldom, the countess of Sutherland was married in 1785 to George Granville Leveson-Gower (1758–1833), who succeeded his father as 2nd marquess of Stafford in 1803. In addition to the estates of the marquessate of Stafford, Leveson-Gower inherited the Bridgewater Canal and estates from his maternal uncle, Francis Egerton, 2nd duke of Bridgewater, and these properties, together with his wife's estates, which included almost the whole of the county of Sutherland, made him a "leviathan of wealth," as he is called by Charles Greville. In 1833 he was created duke of Sutherland. Leveson-Gower was a member of parliament from 1778 to 1784, and again from 1787 to 1798 and was British ambassador in Paris from 1790 to 1792. From 1799 to 1810 he was joint postmaster-general. He was a collector of paintings, and purchased Stafford House, London. He was responsible for the construction of about 450 m. of road and of many bridges, but his policy of removing a large number of his tenants from the interior to the coast aroused bitterness and criticism. However, he reduced rents and brought thousands of acres into cultivation. He died at Dunrobin Castle on July 5, 1833.

See Sir Robert Gordon and George Gordon, *Genealogical History of the Earldom of Sutherland* (Edinburgh, 1813); and also the article Stafford, Earls and Marquesses of.

SUTHERLANDSHIRE, county, northern Scotland, bounded north and west by the Atlantic, east by Caithness, southeast by the North Sea and south by the shire of Ross and Cromarty. Area, 1,297,914 acres (excluding water). The western and northern shores are indented with beautiful bays and sea-lochs, and terminate at many points in precipices and rugged headlands. Almost the whole county is mountainous; the summits are often of finer outline than those of the Grampian heights to the south, and the surface generally consists of wild desolate moorland. The highest point is Ben More in Assynt (3,273 ft.).

An irregular line from Loch Eriboll on the north coast to the neighbourhood of Cromalt near the southern boundary separates the two rock groups that form the foundation of the major portion of the county. On the western side of this line are ancient gneisses and schists (the Lewisian gneiss); these are penetrated by innumerable basic and acid dikes which generally have a north-west to south-east trend. On the eastern side of the line, occupying the whole of the remaining area except the eastern fringe of the county, is a younger series of metamorphic rocks, the Moine schists. In the north-west Torridonian breccias and sandstones rest unconformably on this gneiss, and Cambrian rocks upon the Torridonian; the white Cambrian quartzite capping the dark Torridonian rocks on some of the hills forms a striking scenic feature. Granite masses appear in the eastern schists, and patches of Old Red Sandstone form high land near the south-east coast. Evidence of glacial action is widespread.

The chief river is the Oykell, which, rising in Coniveall (3,234), a peak of Ben More, flows south and then south-east for 33 m. to Dornoch Firth. Other rivers flowing to Dornoch Firth are the Helmsdale (22 m.), the Brora (28 m.), preserving in its name (bridge river) the fact that its bridge was once the only important one in the county; and the Fleet (17), the estuary of which was embanked for 1,000 yd. in 1813 by Thomas Telford, whereby rich alluvial land was reclaimed. The Halladale (22), rising in Knockfin on the borders of Caithness enters the sea to the east of Portskerry. The shire is honeycombed with lakes and tarns, but the only large lake is Loch Assynt, 6⅓ m. long, 215 ft. above the sea, with a greatest depth of 282 ft., emptying by the Inver. The ratio of the area of islands to the loch is greater than in any other British lake. There are many waterfalls; those of Escuallin, near the head of Glencoul, are among the finest in Great Britain.

Agriculture and Industry.—Only one-fortieth of the total area is under cultivation, the shire ranking lowest in Scotland in this respect. The great mass of the surface is grazing ground and deer forest. The best land adjoins Dornoch Firth, where farming is in an advanced condition, but there are fertile patches along the river valleys. At the beginning of the 19th century the first duke of Sutherland (then marquis of Stafford) adopted a policy of wholesale clearance of the crowded crofters of the interior to the coast. The duke incurred great obloquy, but persisted in his policy, which included reduction of rent, reclamation of land, and abolition of the tacksman or middleman. He also did much to open up the shire generally by the construction of roads and bridges. Attempts have been made to repeople some of the glens (Strathnaver, for example) depopulated by the clearances. Crofters still largely predominate, nearly half the holdings being under 5 acres. The average size of the holdings, 12½ acres, is the smallest in Scotland with the exception of the Shetland islands. Oats, barley and potatoes are grown. The raising of sheep, mostly Cheviot, is the staple business of the county, and cattle are also kept. Horses—principally ponies, though Clydesdales are used on the bigger farms—are kept almost wholly for agricultural purposes, and pigs are also reared. Deer forests belonging to the duke of Sutherland cover a large area.

Next to agriculture, the deep-sea fisheries and the salmon fisheries in the rivers are the most important interest. Helmsdale and Golspie are fishing villages. Herrings are the principal catch, but cod, ling and other fishes are also taken. Whisky is distilled at Brora; some woollens are manufactured at Brora and Rogart; coal is mined at Brora, and limestone and sandstone quarried. The exceptional facilities offered by the deer forests, moors and the many lochs and rivers attract large numbers of sportsmen; and Dornoch and Lochinver are in repute as holiday resorts. The L.M.S. railway enters the county at Invershin, goes northward to Lairg, then east to Brora and north-east to Helmsdale, whence it runs north-west to Kildonan, and north to Forsinard, where it shortly afterwards leaves the shire. The Glasgow steamers call at Lochinver about every ten days.

Population and Administration.—In 1921 the population was 17,802, the least densely populated of Scottish counties. Several islands lie off the west and north coast, but only Roan, at the entrance to Kyle of Tongue, is inhabited (41). In 1921 there were 68 persons speaking Gaelic only, 8,831 who spoke Gaelic and English. The county returns one member to parliament with Caithness, and forms a joint sheriffdom with Ross and Cromarty, with a sheriff-substitute resident at Dornoch. The county is under school-board jurisdiction.

History and Antiquities.—Of the prehistoric inhabitants, there are considerable remains in the form of many *brochs* (or round towers), Picts' houses, tumuli, cairns and hut circles. Dun Dornadilla, in the parish of Durness, 4 m. south of Loch Hope, is a tower, 150 ft. in circumference, still in good preservation. The Norse jarl Thorfinn overran the country in 1034 and the Scandinavian colonists called it, in relation to their settlements in the Orkneys and Shetlands, *Sudrland,* the "southern land," or Sutherland. After the conquest of the district by the Scottish kings, Sutherland was conferred on Hugh Freskin (a descendant of Freskin of Moravia or Moray), whose son William was created earl of Sutherland in 1228 by Alexander II. On the south shore of Helmsdale creek stand the ruins of the castle in which the 11th earl of Sutherland and his wife were poisoned by his uncle's widow in 1567, with a view to securing the title for her only child who was next of kin to the earl and his son. Ardvreck Castle, now in ruins, at the east end of Loch Assynt, was the prison of the marquis of Montrose after his defeat at Invercarron (1650), whence he was delivered up by Neil Macleod of Assynt for execution at Edinburgh. In the graveyard of the old church of Durness is a monument to Robert Mackay, called Rob Donn (the brown), the Gaelic poet (1714–1778).

SUTLEJ, river, India, one of the "Five Rivers" of the Punjab. It rises E.S.E. of the Manasarowar lakes in Tibet, at an elevation of about 15,200 ft., threads its way through the gorges of the Himalayas with heights of 20,000 ft. on either side, crosses Bashahr and the Simla hill states, and enters the British district of Hoshiarpur. Thence it flows through the plains of the Punjab, receives the Beas in Kapurthala state, and joins the Chenab near Madwala. From that point the whole river bears the name of Panjnad ("five rivers") until it falls into the Indus near Mithankot after a course of 900 m.

The Sutlej supplies the Sirhind canal, which draws off its waters at Rupar, 100 m. above the junction with the Beas; and the Upper and Lower Sutlej systems, which come below the junction. These irrigate altogether some 1,600,000 acres. Extensions, now undertaken, include 3 new weirs on the Sutlej and 1 on the Chenab, irrigating over 5,000,000 acres. A large dam on the Sutlej where it leaves the hills was under consideration in 1927.

SUTRI (anc. *Sutrium*), an episcopal town of Italy, 4 m. from the railway station of Capranica, which is 36 m. from Rome; 955 ft. above sea-level. Pop. (1921), 2,880. The town is situated on a hill surrounded by ravines, a narrow neck alone connecting it with the surrounding country. There are some remains of the ancient city walls. The crypt of the cathedral, with twenty columns, is Romanesque, and the campanile dates from 1207. In the cliffs to the south is the rock-cut church of the Madonna del Parto, formerly a Mithraeum; and close by is a rock-hewn amphitheatre, with axes of 55 and 44 yd., now most picturesque. Sutri, commanding the Via Cassia, is spoken of by Livy as one of the keys of Etruria, Nepet being the other. It came into the hands of Rome after the fall of Veii. Its importance explains, according to Festus, the proverb *Sutrium ire,* of one who goes on important business, as it occurs in Plautus. (T. A.)

SUTTEE, the Indian practice of concremation of a widow on the pyre of her deceased husband (Sanskr. *satī,* "true" wife). Whether the usage existed in Vedic India has been hotly debated. World-wide primitive usage compelled a widow to be the wife of her husband's brother or near kinsman or, if he had been of princely standing, to be immolated with his concubines, slaves, steeds, etc., at his tomb, to maintain his dignity in the next world. This usage eventually found priestly support in the Hindu conception of matrimony as a bond eternally renewed when the married pair were reborn in succeeding lives—a concept hard to reconcile with polygyny. In late Hindu myth Satī was Siva's spouse who, resenting a slight put upon her lord by her father, destroyed herself but was reincarnated as Umā, the beauteous wife of Siva. Here Satī's act is prompted by a very different motive, and the tale supports the view that the text of the *Rig-Veda* was tampered with, to support the Brahmanical ideal.

According to Diodorus Siculus, Strabo and St. Jerome, Suttee existed in the 4th century B.C. In mediaeval India the practice flourished among the Rajputs—and where Brahman influences were strong. The Satī too began to be worshiped as a Maha Satī or "great and true" wife, commemorated by a stone. Yet reformers denounced the usage, as in Malabar. Even the Brahmanical jurists sometimes deprecated *satī*, allowing the widow the option of living an ascetic life, with rights of inheritance. The Jains do not practice *satī*. Buddhism probably discouraged it. Sikhism expressly forbade it, yet on Ranjīt Singh's death in 1839, several of his widows were burnt. Outside British jurisdiction, *satī* continued in families of high rank until late in the 19th century. In British territory, it was not till 1829 that Lord William Bentinck, with some support from Indian opinion (*see* BRAHMA SAMĀJ) was able, despite strong protests, to make it a statutory offence.

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SUTTER, JOHN AUGUSTUS (1803–1880), American pioneer, was born of Swiss parents at Kandern in the Grand Duchy of Baden on Feb. 15, 1803. He came to America in 1834 and purchased land in Missouri, but in 1838 went overland to California by way of the Oregon trail. Here he was given a grant of 49,000 ac. of land on the Sacramento river by the Mexican governor on condition that he would fortify and develop it into a strong Mexican outpost. Sutter became a citizen of Mexico and was appointed "Commissioner of Justice and Representative of the Government on the Frontier of the Rio del Sacramento." He built not only a strong fort and other buildings but a mill, tannery, distillery, blanket factory, blacksmith and other shops, for which he hired skilled workers. He imported Hawaiians and hired Indians to cultivate the land. He traded with the Indians for furs and purchased a schooner and other boats which plied on the Sacramento. More land was acquired and he rapidly became wealthy. His settlement, "New Helvetia," became a rendezvous for adventurers, sailors, trappers and hunters and for an increasing number of Americans. His growing strength and independence and, above all, his hospitality to the Americans, made him the object of increasing hostility on the part of the Mexican authorities. In 1846 when the Bear Flag revolt took place and Frémont (*q.v.*) arrived with American troops, Sutter at first maintained an appearance of fidelity to the Mexican Government. However, he made but little objection when Frémont took control of his fort and made use of his property. After California was acquired by the United States and settlement became more rapid Sutter felt the need of a new mill. It was while digging the mill race that the famous discovery of gold in California (1848) was made. Sutter tried to keep the strike a secret, but in vain, and his property was soon overrun by gold seekers from whom he could not protect himself. What was worse, the U.S. Supreme Court found the title to 98,000 ac. of his land invalid. Much of what was left him was used to reimburse those to whom he had granted subtitles which he was forced to make good. Soon he was bankrupt. From 1871 to the year of his death he petitioned Congress annually for some reimbursement for his services. He died at Washington, D.C., on June 18, 1880, the evening after Congress had again adjourned without recognition of his claims.

See B. Cendrars, *Sutter's Gold* (1926); T. J. Schoonover, *Life and Times of General J. A. Sutter* (1907); "John A. Sutter" in *Society of California Pioneers' Quarterly*, vol. v., pp. 39–53, 85–102 (1928).

SUTTNER, BERTHA, BARONESS VON (1843–1914), Austrian writer, was born at Prague on July 9, 1843, the daughter of Count Franz Kinsky, Austrian field marshal. Through her mother she was related to the German poet, Theodor Körner. She spent much time in Paris and in Italy. In 1876 she married the novelist, Freiherr Arthur Gundaccar von Suttner (1850–1902), and for nine years lived at Tiflis in the Caucasus. After 1885 she resided at Schloss Harmansdorf in Lower Austria. A fertile writer, her most famous tales and tracts denounce war, for instance, *Die Waffen nieder* (1889), *Krieg und Frieden* (1896), *Das Maschinen-Zeitalter, Zukunfts-Vorlesungen über unsere Zeit* (1899) and *Die Haager Friedenskonferenz* (1900). She founded the Austrian Society of Peace-lovers in 1891, and edited the monthly organ of the peace-movement, *Die Waffen Nieder*, established in Dresden in 1892. In 1905 she was awarded a Nobel prize of £5,000 for her peace propaganda. She died at Vienna on June 21, 1914.

Her *Memoiren* were published at Stuttgart in 1908. *See* also H. v. der Mandere, *Bertha Suttner* (1909).

SUTTON, SIR RICHARD (d. *c.* 1524), the founder, with William Smyth, bishop of Lincoln, of Brasenose college, Oxford, and the first lay founder of any college, was a barrister by profession, and in 1497 became a member of the privy council. In 1513 he became steward of the monastery of Sion, a house of Brigittine nuns at Isleworth. In 1508 Sutton obtained a 92 year lease of Brasenose Hall and Little University Hall for £3 per annum, and from that time until the end of his life was occupied in purchasing estates with which he might endow the new college.

SUTTON, THOMAS (*c.* 1532–1611), founder of Charterhouse school and hospital, obtained great wealth by the ownership of coal mines in Durham and also by his marriage in 1582 with Elizabeth (d. 1602), widow of John Dudley of Stoke Newington. His wish to devote some of his money to charitable purposes led him in 1611 to purchase for £13,000 the Charterhouse (*q.v.*) from Thomas Howard, earl of Suffolk. On this spot Sutton erected the hospital and school which he had originally intended to build at Hallingbury in Essex. Sutton died at Hackney on Dec. 12, 1611, and was buried in the chapel in the Charterhouse. His wealth was left for charitable uses, but in 1613 James I. diverted an allowance to his natural son, Roger Sutton.

SUTTON, an urban district of Surrey, England, 11 m. S. of London by the S. railway. Pop. (1921) 21,063. It adjoins the Banstead downs. The manor, according to Domesday, belonged to the abbey of Chertsey and continued so until the dissolution of the monasteries by Henry VIII.

SUTTON COLDFIELD, municipal borough in Warwickshire, England, 7 m. N.E. from Birmingham on the L.M.S.R. Pop. (1921) 23,020. The town is the centre of a residential district for Birmingham, Walsall and other towns. The church of the Holy Trinity, Early English and Late Perpendicular, enlarged in 1879, contains a Norman font. On the park (2,400 ac.), the inhabitants have the right of grazing horses and cattle at a small fee. This, with the Crystal Palace gardens, forms a public recreation ground. In the vicinity are New Hall (13th century), with a hall of the 16th, used as a boys' school.

Sutton Coldfield is mentioned in the Domesday Survey as a possession of the Conqueror and as having been held by Edwin, earl of Mercia. Henry I. exchanged it with the earl of Warwick. By the time of Henry VIII. the town had fallen into ruin. It received a charter of incorporation in 1529, owing to the interest of John Vesey, bishop of Exeter, a native of the place, and received a further charter in 1664. Fairs were granted in 1300, 1353 and 1529, to be held at the feasts of Trinity, Michaelmas and St. Simon and St. Jude, and are now held on Trinity Monday, March 14, Sept. 19 and Nov. 8.

SUTTON-IN-ASHFIELD, market town, Nottinghamshire, England, on the border of Sherwood Forest, on the L.M.S. and L.N.E.R., 13 m. N. of Nottingham. Pop. (1921) 23,855. The church of St Mary Magdalene of the 12th and 14th centuries was restored in 1868. There are collieries and limeworks in the vicinity. Cotton hosiery and thread are the principal manufactures.

SUVÁROV, ALEXANDER VASILIEVICH, COUNT SUVÁROV RIMNIKSKY, PRINCE ITALYSKY (1729–1800), Russian field marshal, was born at Moscow on Nov. 24, 1729, the descendant of a Swede named Suvor who emigrated to Russia in 1622. He entered the army as a boy, served against the Swedes in Finland and against the Prussians during the Seven Years' War. After repeatedly distinguishing himself in battle he was made a colonel in 1762. He next served in Poland, dispersed the Polish forces under Pulawski, stormed Cracow (1768) and was made a major-general. In his first campaigns against the Turks in 1773–74, and particularly in the battle of Kosludscki in the latter year, he laid the foundations of his reputation.

From 1787 to 1791 he was again fighting the Turks and won many victories; he was wounded at Kinburn (1787), took part in the siege of Ochakov, and in 1788 won two great victories at Focsani and on the Rimnik. For the latter victory, in which an Austrian corps under Prince Josias of Saxe-Coburg participated, Catherine II. made him a count with the name Rimniksky in addition to his own name, and the emperor Joseph II. created him a count of the Holy Roman Empire.

On Dec. 22, 1790, Suvárov stormed Ismail in Bessarabia, and the sack and the massacre that followed the capture equals in horror such events as the "Spanish Fury" and the fall of Magdeburg. He was next placed at the head of the army which subdued the Poles, and repeated the triumph, and some of the cruelties, of Ismail at Warsaw. He was now made a field marshal, and was retained in Poland till 1795, when he returned to St. Petersburg.

His sovereign and friend Catherine II. died in 1796, and her successor Paul dismissed the veteran in disgrace. But in February 1799 he was summoned by the tsar to take the field again, this time against the French Revolutionary armies in Italy.

The campaign (*see* French Revolutionary Wars) opened with a series of victories (Cassano, Trebbia, Novi) which reduced the French government to desperate straits and drove every French soldier from Italy, save for the handful under Moreau, which maintained a foothold in the Maritime Alps and around Genoa. Suvárov himself was made a prince. But the later events of the eventful year went uniformly against the allies. Suvárov's lieutenant Korsákov was defeated by Masséna at Zürich, and the old field marshal, seeking to make his way over the Swiss passes to the Upper Rhine, had to retreat to the Vorarlberg, where the army, much shattered and almost destitute of horses and artillery, went into winter quarters. Early in 1800 Suvárov returned to St. Petersburg in disgrace. Paul refused to give him an audience, and, worn out and ill, he died a few days afterwards, on May 18, 1800. But within a year of his death the tsar Alexander I. erected a statue to his memory in the Field of Mars, St. Petersburg.

Suvárov is specially the great captain of the Russian nation for his leadership responded to the character of the Russian soldier. In an age when war was mere diplomacy he restored its true significance as an act of force. He spared his own soldiers as little as he showed mercy to the population of a fallen city. He was a man of great simplicity of manners, and while on a campaign lived as a private soldier. But he had himself passed through all the gradations of military service; moreover, his education had been of the rudest kind. His gibes procured him many enemies. He had all the contempt of a man of ability and action for ignorant favourites and ornamental carpet-knights. Dragomirov (*q.v.*) avowed that his teaching was based on Suvárov's practice.

See Anthing, *Versuch einer Kriegsgeschichte des Grafen Suworow* (Gotha, 1796–1799); F. von Smitt, *Suworows Leben und Heerzüge* (Vilna, 1833–1834) and *Suworow und Polens Untergang* (Leipzig, 1858); Von Reding-Biberegg, *Der Zug Suworows durch die Schweiz* (Zürich, 1896); Lieut.-Colonel Spalding, *Suvórof* (London, 1890); G. von Fuchs, *Suworows Korrespondenz, 1799* (Glogau, 1835); *Souvorov en Italie,* by Gachot, Masséna's biographer (Paris, 1903); and the standard Russian biographies of Polevoi (1853; Ger. trans., Mitau, 1853); Rybkin (Moscow, 1874) and Vasiliev (Vilna, 1899).

SUVLA BAY, LANDING AT AND BATTLE OF, 1915: *see* Dardanelles Campaign.

SUWALKI, a town of Poland, in the province of Bialystok, 65 m. by rail N.W. of Grodno. Pop. 24,000. The town grew up in the wild borderland between the settlements of the Teutonic Order and the Lithuanians, after the termination of the internecine wars between the two. Polish colonists from Masovia penetrated into the forests and it is now a Polish town, though near the frontier of Lithuania. Its trade includes timber and grain.

SUWARRO (*Carnegiea gigantea*), a remarkable tree cactus, 15 to 70 ft. high, called also saguaro, giant cactus and monument cactus, native to arid districts in southern Arizona, south-eastern California and Sonora, Mexico. It has a stout, woody, vertically ribbed stem, 1 to 2 ft. in diameter, sometimes rising unbranched, like a green, fluted column, whence the name monument cactus; more frequently it bears a few large, stout, widely diverging candelabra-like branches, but occasionally it bears numerous branches which rise vertically from near the base like a group of organ pipes. Close to the top of the stem or branches it bears white flowers which are followed by crimson edible fruits. In Arizona, of which it is the floral emblem or State flower, a desert tract containing numerous fine living specimens of the tree was set apart in 1914 as the Papago Saguaro National Monument. (*See* Cactus: *Cereus.*)

SUYŪTĪ [Abū-l Fadhl'Abd ur-Rahmān ibn Abī Bakr Jalāl ud-Dīn us-Suyūtī] (1445–1505), Arabian encyclopaedic writer, was the son of a Turkish slave woman. His father had been cadi in Suyūṭ (Upper Egypt) and professor in Cairo. The boy's training was taken in hand by a Sufi friend of the father. He was precocious, and in 1462 was already a teacher; in 1464 he made the pilgrimage to Mecca, and in 1486 was promoted to a chair in the mosque of Bibars. From 1501 he worked in seclusion at Rauḍa, an island of the Nile, and there died in 1505. He was one of the most prolific writers of the East.

A list of his works is given in C. Brockelmann's *Gesch. der Arabischen Literatur,* ii. 144–158 (Berlin, 1902). They deal with almost every branch of Moslem science and literature. Among the best known are the *Itqān fi 'Ulūm ul-Qurān* (on the exegetic sciences of the Koran), published with an analysis by A. Sprenger (Calcutta, 1852–1854) and often in Cairo; the commentary on the Koran, known as the *Tafsīr ul-Jalalain,* begun by Jalāl ud-Dīn ul-Maḥalli (1389–1459) and finished by Suyūṭī, published often in the East; and the history of the caliphs, published at Calcutta (1858) and elsewhere.

SUZERAINTY. "Suzerain," a term of feudal law, is now used to describe persons or States in positions of superiority to others. Suzerain has been defined as "Qui possède un fief dont d'autres fiefs relèvent" (*Littré* and *Dictionnaire de l'académie française*). The term was rare in feudal times in England. But it was used in France to describe a feudal lord, the supreme suzerain being the king.

In modern times the term has come to be used as descriptive of relations, ill-defined and vague, which exist between powerful and dependent States; its very indefiniteness being its recommendation. According to feudal law the vassal owed certain duties to the lord; he promised fidelity and service; and the lord was bound to perform reciprocal duties, not very clearly defined, to the vassal —*Dominus vassallo conjux et amicus dicitur*. The relation between a lord and his vassals, implied in the oath of fealty, has been extended to States of unequal power; it has been found convenient to designate certain States as vassal States, and their superiors as suzerains. Originally and properly applicable to a status recognized by feudalism, the term vassal State has been used to describe the subordinate position of certain States once parts of the Ottoman empire. Such were Egypt and Bulgaria.

M. Gairal (*Le Protectorat international*) distinguishes suzerainty from protectorate in these respects: (*a*) suzerainty proceeds from a concession on the part of the suzerain (p. 112); (*b*) the vassal State is bound to perform specific services; and (*c*) the vassal State has larger powers of action than those belonging to a protected State; (*d*) there is reciprocity of obligation. According to M. F. Despagnet the term suzerain is applicable to a case in which a State concedes a fief, in virtue of its sovereignty (*Essai sur le protectorat international*, p. 46), reserving to itself certain rights as the author of this concession.

W. E. Hall thus defines vassal States: "States under the suzerainty of others are portions of the latter which during a process of gradual disruption or by the grace of the sovereign have acquired certain of the powers of an independent community, such as that of making commercial conventions, or of conferring their exequatur on foreign consuls. Their position differs from that of the foregoing varieties of States (protectorates, etc.), in that a presumption exists against the possession by them of any given international capacity" (*International Law,* 4th ed., p. 31).

On the whole, usage seems to favour this distinction: while a protectorate flows from, or is a reduction of, the sovereignty of the protected State, suzerainty is conceived as derived from, and a reduction of, the sovereignty of the dominant State.

As to the power of making treaties, a vassal State cannot, as a rule, conclude them; such power does not exist unless it is specially given. On the other hand, a protected State, unless the contrary is stipulated, retains the power of concluding treaties.

Definitions of suzerainty are of little use. Each instrument in which the word is used must be studied in order to ascertain its significance. Even in feudal times suzerainty might be merely nominal, an instance in point being the suzerainty or over-lordship of the papacy over Naples. In some cases it may be said that suzerainty brings no practical advantages and implies no serious obligations. Among the instances in which the term is actually used in treaties are these: the General Treaty, Peace of Paris, 1856 (arts. 21 and 22), recognized the suzerainty of Turkey over the Danubian principalities Moldavia and Wallachia, modifying the "sovereignty" of Turkey recognized by the Treaty of Adrianople. The convention of Aug. 19, 1858 (Hertslet x. 1052) organized the then principalities "under the suzerainty of the sultan." The internal government was to be exercised by a hospodar, who received his investiture from the sultan, the sign of vassalship. The autonomy of these vassal States was fully recognized by the Treaty of Berlin of 1878. In the Interpretation Act 1889, s. 18 (5), "suzerainty" is used to describe the authority of the sovereign over native princes.

The word suzerain is used in the Pretoria convention of 1881 between the British Government and the late South African republic. The convention (by its preamble) granted to the inhabitants complete self-government, "subject to the suzerainty of her Majesty," and this suzerainty was reaffirmed in the articles. Even when the convention was being negotiated doubts arose as to its meaning, and legal authorities were divided as to its effect. It was doubtful whether territory could be ceded by the Crown of its own authority; and if the power existed the cession could, it was said, be made only by virtue of clear words. From the articles substituted in the London convention of 1884 for those of 1881, the word "suzerainty" was omitted. Fresh doubts arose as to the effect of this omission; before the outbreak of hostilities in South Africa, the British Government maintained that the preamble of 1881, by which alone any self-government was granted, was still in force, and therefore that the suzerainty—whatever it involved—remained; the Transvaal Government, on the other hand, contended that the suzerainty had been abolished by the substitution of the 1884 convention for that of 1881. (*See* MANDATE, PROTECTORATE, SOVEREIGNTY, SPHERES OF INFLUENCE, STATE.)

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ŠVABINSKÝ, MAX (1873–   ), Czech painter, was born at Kroměříž in Moravia. He studied at the Academy of Fine Arts in Prague, where he became a professor; and in Paris, Germany, Holland and Belgium. His first works were made to suit the poetical and symbolic mood prevalent at the time, but he soon turned his attention to realistic subjects, from which he derived the sources of an art intoxicated with the manifestations of life and nature. His large-sized canvases, "The Sun Bath" (1908), "Summer" (1909) and "The Family in the Mountains," provide typical examples. Švabinský has painted many portraits, for instance, of Mánes, Smetana and President Masaryk and of Maeterlinck. Also, there are his etchings and the woodcuts entitled "The Sonata of Paradise" (1918–20).

SVANE [or SVANING], **HANS** (1606–1668), Danish statesman and ecclesiastic, was born on March 27, 1606, at Horsens, where his father, Hans Riber, was burgomaster. His mother Anne was a daughter of the historian Hans Svaning, whose name, subsequently altered to Svane, he adopted. After seven years' residence abroad Svane became professor of Oriental languages at the university of Copenhagen. In 1646, he turned to theology. He became bishop of Sjaelland in 1655. As a theologian he belonged to the severely orthodox Lutheran school. At the *rigsdag* of 1660 he played an important political rôle. He proposed that only members of the council of state should be entitled to fiefs and that all other estates should be leased to the highest bidder whatever his social station. At a hint from the king he tried to get the royal charter abolished and the elective monarchy transformed into an hereditary monarchy. The clerical deputies followed him in a serried band, as the burgesses followed Nansen, and the bishop's palace was one of the meeting-places for the camarilla which abetted absolutist designs of Frederick III.

It was on Svane's motion (Oct. 8) that the Commons agreed "to offer his majesty the crown as an hereditary crown." Svane quashed the timid attempt of the more liberal minded of the deputies to obtain from the king some sort of a constitution. He proposed the erection of a consistorial college for managing all the temporal affairs of the church, including education and poor relief, anticipating to some extent the modern ministries of education and public worship, which unfortunately was not adopted. The privileges which he obtained for the clergy increased the independence of the Danish Church in difficult times. Svane died on July 26, 1668, in his 62nd year.

See Detlev Gotthard Zwergius, *Siellandske clerisie* (Copenhagen, 1754). (R. N. B.; X.)

SVANETIA, a mountainous district on the south slopes of the Caucasus. (*See* GEORGIA.)

SVEHLA, ANTONIN (1873–   ), Czech statesman, was born at Hostivar, near Prague. He was a founder and (1909) chairman of the Czech Agrarian party. Contact with Masaryk enabled him to complete the preparations for the final coup against Austria on Oct. 28, 1918, when in his capacity as vice-president of the Prague National Committee, together with Dr. Soukup and J. Stríbrný, he took over the Government of the Czechoslovak State on behalf of the Czechoslovak National Council, which in the summer of 1918 had been recognized as the Czechoslovak Provisional Government. He became a member of the first National Assembly and was minister for the interior until Oct. 1922, when he formed a new Coalition, reconstituted after the Oct. 1925 elections, so as to include the "Big Business Party." But on March 16, 1926, Svehla resigned. He formed his third administration on Oct. 28, 1926, two German Bohemians being included in his cabinet. The German bourgeois group in the Chamber supported him in a reversion to the four main provinces into which Czechoslovakia was divided before 1920, in preference to the county system then established. His health failed in the autumn of 1927, and in Jan. 1929 he resigned. (*See* also CZECHOSLOVAKIA: *History.*)

SVENDBORG, a seaport of Denmark, capital of the *amt* (county) of its name, on the island of Fünen. Pop. (1928), 14,419. The narrow Svendborg Sund separates Fünen from the lesser islands of Taasinge (245 ft.) and Turø. Inland there is also elevated ground, the Ovinehøi. The harbour is accessible to vessels drawing 20 ft. Near the town are the ruined castle of ørkil, the watering-place Christiansminde, and the orchards of Gammel Hestehave, where wine is produced.

SVENDSEN, JOHANN SEVERIN (1840–1911), Norwegian composer, was born in Christiania on Sept. 30, 1840. He learnt the violin from his father, and after serving in the army, and touring with an orchestra, he entered the conservatorium at Leipzig through the aid of the king of Sweden. In 1883 Svendsen became court kapellmeister at Copenhagen. Though Svendsen was at one time intimate with Wagner, his own music was not influenced by him. His works include two symphonies, a violin concerto, a romance for violin and orchestra, and Norwegian rhapsodies for the orchestra. He died in Copenhagen on June 14, 1911.

SVERDLOVSK (formerly Ekaterinburg), the chief town of the Uralsk Area of the Russian S.F.S.R. on the eastern foothills of the Ural mountains. It is the centre of a gold, platinum, copper and coal-mining district; its population rose from 55,488 in 1897 to 136,494 in 1926. The important Verkhne-Iset copper mine, unlike most other copper mines in Russia, is still working (1928). An electric power station was opened in 1925–26, with a capacity of 6,000 kw., and supplies the numerous industrial undertakings which include iron, copper smelting, platinum refining, the manufacture of machinery and linen goods. There is also a jewel cutting and polishing industry, Sverdlovsk emeralds being specially famous. The town has a chemical laboratory for the assay of gold, a mining school and a magnetic and meteorological observatory.

Mining was developed here by Peter the Great in 1721 and the town was named Ekaterinburg in honour of his wife Catherine I. In 1735 a government mint for copper coinage was established and later a government engineering works, and an imperial factory for the cutting and polishing of malachite, jasper, marble, porphyry and other ornamental stones. In 1763 the Siberian highway was diverted to the town from Verkhoturye. This gave a great impetus to the two annual trading fairs, dealing mainly in cattle, cereals, iron, woollen and silk goods, and products from Siberia and Central Asia. Later the town became a railway centre and developed rapidly; it is well built, with wide streets. The Cathedral of St. Catherine's was completed in 1758, and that of the Epiphany in 1774. Sverdlovsk was a storm centre during the civil wars following the 1917 revolution; and it was captured by the Czech army under Gajda. In July 1918, the Czar Nicholas II., his wife, their four daughters and only son, were executed in a house formerly belonging to a merchant named Ipatiev.

SVERDRUP, JOHAN (1816–1892), Norwegian statesman, was born at Jarlsberg on July 30, 1816. His father, Jakob Sverdrup, was a land steward, and the founder of the first school of agriculture in Norway. Johan entered the Storthing in 1850. He built up a strong political party, supported by the peasantry, and in 1872, secured a bill for the admission of ministers to the Storthing, which was a step to parliamentary control. King Charles XV. refused his sanction to this bill, and on its third passing in 1880 Oscar II. opposed his absolute veto. Sverdrup then proposed the proclamation of the law in defiance of the king's action. The retirement of Frederik Stang removed Sverdrup's chief political opponent from the field. He was aided in his campaign by Björnstjerne Björnson, and after a series of political crises he became prime minister in June 1884. He soon found himself at issue with Björnson on church matters, although during his term of office no fewer than eighty-nine measures, many of them involving useful reforms, became law, he failed to satisfy the extremists and was driven to rely on the moderate Liberals. He was compelled to retire in 1889, and died on Feb. 17, 1892, at Christiania.

SWABIA, SUABIA or SUEVIA (Ger. *Schwaben*), one of the stem-duchies of mediaeval Germany, taking its name from the Suevi, a tribe who inhabited the district in the first century of the Christian era. They were joined by other tribes, and the district was called Alamannia, until about the 11th century, when the form Swabia began to prevail. In 496 the Alamanni were defeated by Clovis and governed by dukes dependent on the Frankish kings. In the 7th century the people were converted to Christianity, bishoprics were founded at Augsburg and Constance, and in the 8th century abbeys at Reichenau and St. Gall. The Alamanni had gradually thrown off the Frankish yoke, but in 730 Charles Martel again reduced them to dependence.

The duchy, bounded by the Rhine, the lake of Constance, the Lech and Franconia, was ruled by the counts of Raetia, one of whom, Burkhard, took the title of duke in 917 and was recognized as such by King Henry I., the Fowler, in 919. On his death in 926 he was succeeded by Hermann, a Franconian noble, who married his widow. When Hermann died in 948 Otto the Great gave the duchy to his own son Ludolf, who had married Hermann's daughter Ida; but he reduced the ducal privileges and appointed counts palatine to watch the royal interests. Ludolf revolted and was deposed, and other dukes followed in quick succession. During these years the Swabians were loyal to the kings of the Saxon house. In 1077, Rudolph, count of Rheinfelden, as duke, was chosen German king in opposition to the emperor Henry IV., but found little support in Swabia, which was given by Henry to his faithful adherent, Frederick I., count of Hohenstaufen. Frederick II. succeeded his father in 1105, and was followed by Frederick III., afterwards the emperor Frederick I. The earlier Hohenstaufen increased the imperial domain in Swabia, where they received steady support, although ecclesiastical influences were very strong. After numerous changes, the chief authority in Swabia in 1268 fell to the counts of Württemberg, the margraves of Baden, the counts palatine of Tübingen and the counts of Hohenzollern.

SWABIAN LEAGUE, an association of German cities, principally in the old duchy of Swabia. The cities had attained prosperity under the Hohenstaufen emperors, but on the extinction of that house in 1268, they were ill-defended against aggression by succeeding dynasties.

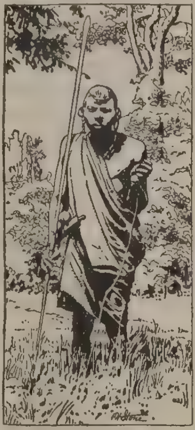
In 1331, 22 Swabian cities, including Ulm, Augsburg, Reutlingen and Heilbronn, formed a league at the instance of the emperor Louis the Bavarian, who in return for their support promised not to mortgage any of them to a vassal. The count of Württemberg was induced to join in 1340. Under Charles IV. the lesser Swabian nobles began to combine against the cities, and formed the *Schlegelerbund* (from *Schlegel*, a maul). Civil war ensuing in 1367, the emperor, jealous of the growing power of the cities, endeavoured to set up a league under his own control, for the maintenance of public peace. The defeat of the city league by Eberhard II. of Württemberg in 1372, the murder of the captain of the league, and the breach of his obligations by Charles IV., led to the formation of a new league of 14 Swabian cities led by Ulm in 1376. This league triumphed over the count of Württemberg at Reutlingen in 1377, and the emperor having removed his ban, it assumed a permanent character, set up an arbitration court, and was rapidly extended over the Rhineland, Bavaria and Franconia. Its professed aims were the maintenance of the imperial status of the constituent cities, the security against sale or mortgage and against excessive taxation, the protection of property, trade and traffic, and the power to suppress disturbances of the peace. There is no trace of co-operation with the Hanseatic towns.

For nearly a century there was no great effort at federation among the Swabian cities, though there were partial and short-lived associations. The growing anarchy in Swabia, where the cities were violently agitated by the constant infringement of their liberties (*e.g.*, the annexation of Regensburg by Bavaria in 1486), induced Frederick III., who required men and money for the Hungarian War, to conciliate the cities by propounding a scheme of pacification and reform. His commissioner, Count Hugo of Werdenberg, met the Swabian estates at Esslingen, and on Feb. 14, 1488, the Great Swabian League was constituted. There were four constituent parties, the archduke Sigismund of Austria, Count Eberhard V. of Württemberg, who became the first captain of the league, the knightly league of St. George, and lastly 22 Swabian imperial cities. The league received a formal constitution with a federal council consisting of three colleges of nine councillors each, a captain and a federal court with judicial and executive powers. The armed force which was to police Swabia consisted of 12,000 foot and 1,200 horse, each party contributing one-fourth. The league gained strength by the speedy accession of Augsburg and other Swabian cities, the margraves of Brandenburg-Ansbach, Bayreuth and Baden, the four Rhenish electors, etc., and in 1490 of Maximilian, king of the Romans, whom the league had helped to rescue from the hands of the Netherlanders in 1488. It did not render him the support he expected in his foreign policy, but it performed its primary work of restoring and maintaining order with energy and efficiency. In 1492 it compelled Duke Albert of Bavaria to renounce Regensburg; in 1519 it expelled the turbulent duke, Ulrich of Württemberg who had seized Reutlingen, and it sold his duchy to Charles V.; and in 1523 it defeated the Franconian knights who had taken up arms with Franz von Sickingen. In 1525 Truchsess, the league captain, aided by the forces of Trier and the palatinate, overthrew the rebel peasants of Königshofen on the Tauber and at Ingolstadt. The league, after several renewals, expired on Feb. 2, 1534, its dissolution being due to the Reformation. Futile attempts were made to renew it, in 1535 by the Bavarian chancellor, Eck, and in 1547 by Charles V.

See E. Osann, *Zur Geschichte des schwäbischen Bundes* (Giessen, 1861); K. Klüpfel, *Urkunden zur Geschichte des schwäbischen Bundes* (Stuttgart, 1846–53), "Der schwäbische Bund," *Hist. Taschenbuch* (1883–84). (A. B. G.)

SWAFFHAM, a town in Norfolk, England; 111 m. N.N.E. from London by L.N.E.R. Pop. (1921) 2,913. The cruciform church of St. Peter and St. Paul is Perpendicular, with central tower, and a carved wood roof. At Castle Acre, 4 m. N., are the ruins of a Cluniac priory, founded shortly after the Conquest by William de Warren. The castle of the founder has little left but its foundations, surrounded by a series of earthworks. The church of St. James, Castle Acre, contains Early English and Perpendicular work.

SWAHILI (swāh-hē′lĭ) (*Wa-Swahili, i.e.,* coast people, Ar. *sāhil,* coast), a term commonly applied to the inhabitants of Zanzibar and of the opposite mainland between the parallels of 2° and 9° S., who speak the Ki-Swahili language. The Swahili are derived from the negroes of the coast and the Arabs, with a varied admixture of slave blood. Colour and physique thus range from the full-blooded negro to the pure Semite. They are strong, handsome and inclined to stoutness.



BY COURTESY OF FREDERICK B. PATTERSON

A SWAHILI ELEPHANT TRACKER OF BRITISH EAST AFRICA

SWAHILI LANGUAGE. Swahili belongs to the Bantu family of languages (*q.v.*) and is spoken on the eastern coast of Africa, ranging approximately from Warsheikh, on the Somali coast, to the mouth of the Ruvuma (10° 30′ S.). It has also obtained wide currency as a trade language, having been carried by Arab caravans to the region of the Great Lakes before the middle of the 19th century and, since then, through European influence, into the Congo basin; and, in a very debased form, it is the vernacular of some Pygmy tribes on the Ituri.

Origin and History of the Language.—Swahili is not the language of any particular tribe; it grew up among the descendants of the Arab settlers on the coast, who intermarried with native women—usually Bantu. The name is derived from the Arabic Sâhil (صَاحِل), which means "the coast," the Arab colonists and their descendants being known simply as "the Coast-Dwellers." In the native speech, in which every syllable ends in a vowel, Sâhil became Swahili (accent on the second syllable). Pokomo, the speech of a very interesting Bantu tribe inhabiting the Tana valley, may have formed the groundwork of Swahili. The Pokomo would probably be the first Bantu tribe to meet the Arab colonists. Intercourse between Arabia and the east coast of Africa is as early as the 1st century A.D., when, as we learn from the *Periplus of the Erythraean Sea,* the people of Muza (in Southern Arabia) "sent thither many large ships, using Arab captains and agents, who are familiar with the natives and intermarry with them." But the earliest known settlement, that is Pate, is said to have been founded A.D. 689.

The Swahili language was first made known to Europeans by Henry Salt, whose *Travels* (he visited Abyssinia in 1809, by way of the Cape of Good Hope) was published in 1814. He calls it "Sowauli" and gives a short and very imperfect vocabulary. The first real study of the language was made by Johann Ludwig Krapf, 1810–82, a German who went to East Africa in the service of the Church Missionary Society, reaching Mombasa in 1844. His dictionary, recently revised and supplemented by Archdeacon Binns, is still a standard work; the principal English contributors to the subject are Edward Steere (Bishop of Zanzibar from 1874 to 1882), Arthur C. Madan (d. 1920) and the late William Ernest Taylor, for many years a missionary in Kenya Colony.

Character of the Language.—Swahili is a Bantu language. Its grammatical structure has been little affected by Arabic influence. It includes Arabic words. Contact with outside influences has tended to efface some characteristic Bantu peculiarities and brought about an extensive use of borrowed prepositions and adverbs, which gives it greater elasticity and increases its possibilities as a literary language.

Swahili has no grammatical gender, but a division of nouns into classes, each with its characteristic pronoun; it inflects nouns by means of prefixes, makes the possessive agree with the thing possessed ("the house of the man" not "the man's house"), and places the object-pronoun between the subject-pronoun and the verb, as if one should say "I him saw," in one word. Though these classes and their concords look formidable, the language is by no means difficult to learn and is quite easy to pronounce.

As the official language of Kenya Colony and Tanganyika Territory, it is indispensable to all civil servants, to settlers, missionaries and business men. It is spoken and understood by many natives, even where it is not the local vernacular.

Dialects and Literature.—The principal dialects are those of Lamu (northern), Mombasa (central) and Zanzibar (southern); the last-named being the standard for official use. That of Lamu has preserved many archaisms and comes nearest to that known as "Kingozi," in which the ancient poems, and those more recently imitated from them, are composed. A large body of poetry exists in manuscript, some few specimens having been published in Europe. The metres used are adapted from the Arabic, as closely as the differing rhythm of the two languages permits. Those traditionally attributed to Liongo Fumo may, if authentic, go back to the 12th or 13th century, and their language is certainly very archaic. In prose, almost the only texts available till recently, have been taken down by Europeans from native recitation, but of late years (not to mention translations made by Europeans) native writers have begun to appear, and the Swahili magazine, *Mambo Leo* published at Dar-es-Salaam, under European editorship, attracts an increasing number of native contributors. There is an immense amount of traditional matter in circulation: folk-tales, some indigenous to the soil, others of Indian, Persian or Arab origin, which, filtered through generations of oral transmission, have acquired a distinctly African colouring. The people, both men and women, have the same facility of improvisation as the Italian peasants. Some songs have a rhythm (probably chanted to the drum) but no metre. Others have both metre and rhyme, often of a very pleasing character. Songs and proverbs —frequently very pithy—have been collected.

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SWALLOW, the familiar bird, *Hirundo rustica,* in summer ranges all over Europe, and most of Asia; in winter it migrates south, reaching India, Burma, the Malay peninsula, and the whole of Africa. The common swallow of North America is the barn-swallow, *H. erythrogastra;* in summer it reaches Alaska, Greenland, and Lake Baikal. The winter migration extends to South Brazil. Returning in summer about the first week in April, the English swallow usually repairs to its old nest, near the abodes of men.

During spring, the swallow sings a sweet bubbling song. The food consists entirely of insects captured on the wing. The birds also drink on the wing from the surface of ponds and lakes. The nest is formed of moist earth, which, carried to the spot in the bird's bill, is arranged and modelled with short straws or slender sticks, into the required shape, generally that of a half-saucer. The materials dry quickly into a hard crust, which is lined with soft feathers, and therein are laid from four to six white eggs, blotched and speckled with grey and orange-brown, deepening into black. Two broods are usually reared in the season. The young, on leaving the nest, make their way to some leafless bough, whence they try their powers of flight, at first accompanying their parents in short excursions on the wing, receiving from them food until able to shift for themselves. The young birds collect in flocks and leave the country about the end of August or early in September, to be followed, after a few weeks, by their progenitors. It was formerly believed that swallows hibernated (*see* Gilbert White, *Natural History of Selborne*). They moult their feathers in their winter quarters. The chestnut forehead and throat, the shining steel-blue upper plumage, the dusky white of the lower parts, and the deeply forked tail are familiar.

The word swallow is used for all the Hirundinidae, excepting the martin (*q.v.*). The family includes from 80 to 100 species and has no near allies.

SWALLOW-HOLE, a cavity, forming the entrance to a subterranean stream-channel, produced by the solvent action of naturally acidulated water. Such holes are most commonly found in limestone and chalk districts. (*See* Cave.)

SWAMMERDAM, JAN (1637–80), Dutch naturalist, was born on Feb. 12, 1637 at Amsterdam, the son of an apothecary and naturalist, and took his doctor's degree at Leyden in 1667.

He neglected practice for investigations into the life histories of insects and into the anatomy of mayflies, bees and frogs. As regards human anatomy, he advanced the study of the circulatory system by his experiments on infections. He proved the ovarian character of the female testicles, discovered the valves of the lymphatics, was the first to describe the red blood-corpuscles (1658), studied the movements of the heart, the lungs and the muscles and made an important medico-legal contribution by demonstrating the floating of the fetal lungs after respiration has once taken place. By stopping his supplies, his father thought to induce him to practice, but the privation only impaired his health and he died at Amsterdam on Feb. 15, 1680.

He wrote *Allgemeene Verhandeling van bloedeloose diertjens* (Utrecht, 1669), *Miraculum naturae seu Uteri muliebris fabrica* (Leyden, 1672) and *Biblia naturae* (published by H. Boerhaeve in 1737).

SWAMP, a tract of wet, spongy, low-lying land, usually overgrown with vegetation, but too highly saturated with water to be fit for agricultural or pastoral purposes. The term swamp, however, is often indiscriminately applied to various wet, watery or miry places, as a marsh or a bog or, as in Australia, a shallow pond or lake. But as more commonly understood, especially in the United States, where the word first came into recorded use (early in colonial days), a swamp is an area of very moist or wet ground, with luxuriant vegetation, and largely free from standing water. It thus differs from a marsh, which is covered for the most part with a thin sheet of water. A swamp differs in a corresponding degree from a bog, which is a very wet, water-logged area, practically without drainage, in which extensive decomposition of vegetable matter is taking place, forming in northern latitudes deposits of peat (*q.v.*). A marsh or a bog may occur within or may border upon a swamp, with various intermediate stages in each case; hence the frequent interchange in meaning between these terms in popular usage.

The character of the vegetation in swamps varies with the nature of the soil and the extent of drainage. Usually swamps are filled with a dense growth of coarse grasses, trees and shrubs. Swamps are found on the shoreward side of tidal marshes along seacoasts and near inland lakes and ponds with low shores; swamps are common also in the alluvial valleys of rivers and smaller streams. Among swamps possessing marked historical as well as scientific interest are those in the Campagna near Rome, and those found in the Pripet marsh region in western Russia. Noteworthy swamp areas in the United States are the Great Dismal swamp in south-eastern Virginia, the cypress and the mangrove swamps of the Southern States, and the "tule" swamps of the San Joaquin valley in California. Vast swampy and boggy areas in northern Canada are known by the Indian name *muskeg*.

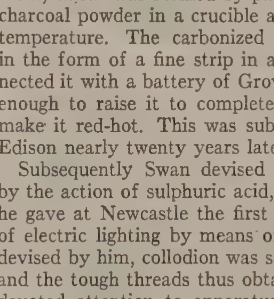
SWAMPSCOTT, a beautiful residential town and summer resort of Essex county, Massachusetts, U.S.A.; on Massachusetts bay, 13 m. N.E. of Boston, adjoining Lynn. It is served by the Boston and Maine railroad. Pop. (1925), 8,953 (State census).

SWAN, SIR JOSEPH WILSON (1828–1914), English physicist and electrician, was born at Sunderland on Oct. 31, 1828. After serving his apprenticeship with a druggist in his native town, he became first assistant and later partner in a firm of manufacturing chemists in Newcastle. Among its operations this firm included the manufacture of photographic plates, and thus Swan was led to one of the advances in photography with which his name is associated—the production of dry plates, which were the outcome of an original observation made by him on the effect of heat in increasing the sensitiveness of a gelatine bromide of silver emulsion. In 1862 he patented the first commercially practicable process for carbon printing in photography. (*See* Photography.) In 1879 Swan patented bromide paper.

In 1860, he produced an electric lamp with a carbon filament, which was formed by packing pieces of paper or card with charcoal powder in a crucible and subjecting the whole to a high temperature. The carbonized paper thus obtained he mounted in the form of a fine strip in an evacuated glass vessel and connected it with a battery of Grove's cells, which though not strong enough to raise it to complete incandescence, were sufficient to make it red-hot. This was substantially the method adopted by Edison nearly twenty years later.

Subsequently Swan devised a cotton thread "parchmentized" by the action of sulphuric acid, and on the 20th of October 1880 he gave at Newcastle the first public exhibition on a large scale of electric lighting by means of glow lamps. In another method devised by him, collodion was squirted into a coagulating solution and the tough threads thus obtained carbonized by heat. He also devoted attention to apparatus for measuring electric currents, to the improvement of accumulators and to the conditions governing the electro-disposition of metals. Swan was knighted in 1904. Holding many honours, he died at Warlingham on May 27, 1914.

SWAN, the name of birds forming the subfamily *Cygninae* of the *Anatidae*. The best-known species is the mute-swan (*Cygnus olor*), occurring wild in N.E. Europe and W. Central Asia, and kept semi-domesticated in parks and ornamental waters in most parts of Europe and America. In olden times, the young swan or cygnet was highly esteemed for the table, and in England no subject could possess one without a licence from the Crown. In a wild state, all swans migrate south in winter. The plumage in both sexes is white, the beak orange, surmounted by a black knob, the legs black and the voice a grunting hiss. The swan builds a large nest of aquatic plants, in which it lays five to nine olive-grey eggs. The young are at first clad in grey, replaced later by sooty-brown, and do not attain adult plumage for more than a year. The Polish swan has a pale bill and legs.



BY COURTESY OF THE N.Y. ZOOLOGICAL SOCIETY

MUTE SWAN (CYGNUS OLOR), THE SWAN SEEN IN PUBLIC PARKS AND GARDENS

Two other species of swans occur in Europe, over the greater part of which they are only winter visitors, breeding in the far North. These are the whooper swan (*C. musicus*) and the smaller Bewick's swan (*C. bewicki*). They may be distinguished from the mute-swan by their more upright carriage, the absence of the knob at the base of the bill and by the possession of loud and resonant voices (hence the legend of the "swan-song"). Two closely allied representatives occur in N. America, the trumpeter-swan (*C. buccinator*) with a black bill, and *C. columbianus*. From S. America comes the black-necked swan (*C. melanocoryphus*), while the black swan (*C. atratus*), inhabits Australia.

SWAN, HUNTER, AND WIGHAM RICHARDSON, LTD. The "Prince Albert," the first iron vessel ever built on the Tyne, was launched in 1842, from the Neptune works of the firm. In 1850, the present Neptune Shipyard was opened, with a pay-roll of 200 men. The Wallsend shipyard of the company, owned by C. S. Swan and Hunter, was established in 1872, and in 1880 employed 700 men. In 1903, C. S. Swan and Hunter, Ltd., Wigham Richardson and Co., Ltd., and the Tyne Pontoons and Dry Docks Co., Ltd., became Swan, Hunter and Wigham Richardson, Ltd., and today is associated with Barclay, Curle and Co., Ltd., on the Clyde, and the Glasgow Iron and Steel Co., Ltd., Wishaw, owning blast furnaces, cement works, ore mines and collieries. The company also owns works at Southwick-on-Wear and Londonderry. In all the company has 30 shipbuilding berths, of which the largest are capable of taking vessels up to 1,000ft. in length. Four of these, at the Wallsend shipyard, are covered by glass-roofed sheds fitted with electric light, enabling work to proceed in any weather and by day or night. The capacity exceeds 150,000 gross tons a year, and in 1927, including the Clyde Yards, the firm launched 181,224 tons. The share capital (1928) is about £2,500,000, with £323,000 of debentures.

The company builds all classes of naval and mercantile vessels. At the Wallsend shipyard there is under construction (1928) the immense floating dock for the new Singapore naval base, with a lifting capacity of 50,000 tons. More than 30 floating docks have been built by the company in recent years. One of them was towed through the Straits of Magellan to Peru, a distance of 11,000 miles. The firm built the "Mauretania" (32,000 gross tons), for the Cunard Company, which, while more than once crossing the Atlantic at an average speed of 26 knots, averaged 25½ knots for 27 consecutive voyages. It holds (1929) all Atlantic records for speed.

During the World War nearly 100 warships, with 230 other vessels, were built by the company, while the production of marine engines was 1,750,000 i.h.p. (L. C. M.)

SWANAGE, a seaport in Dorset, England. Pop. (1921) 7,106. It lies on the so-called Isle of Purbeck, the district lying south of Poole harbour. The coast is wild and precipitous, and numerous caves occur in the cliffs. Swanage bay affords excellent bathing. Stone from the Purbeck quarries is exported.

SWANSEA, Welsh *Abertawe,* a seaport of Glamorganshire, South Wales. Pop. (1921) 157,554. The population of the old borough in 1801 was 6,099.

The *Via Julia* from Nidum (Neath) to Loughor probably passed through the north of the borough, where Roman coins were found in 1835. The name Swansea stands for Sweyn's "ey" or inlet, and may have been derived from Sweyn Forkbeard, who certainly visited the Bristol Channel. The earliest known form of the name is Sweynesse, which occurs in a charter granted by William earl of Warwick some time previous to 1184; in King John's charter (1215) it appears as Sweyneshe, and in the town seal, of mediaeval origin, it is given as "Sweyse." The Welsh name, Aber Tawy, first appears in Welsh poems of the beginning of the 13th century. The town grew up round the castle which Henry de Beauchamp (or Beaumont) on his conquest of Gower about 1099, built on the west bank of the river. The castle eventually came by marriage to the Somersets and is still held by the dukes of Beaufort. It was finally destroyed by Owain Glyn Dwr. In the Civil War the town was royalist till the autumn of 1645 when Colonel Philip Jones was made its governor. The older part of the town, being the whole of the municipal borough previous to 1836, occupies the west bank of the Tawè near its mouth and is now wholly given up to business. Stretching inland to the north along the river for some 3 m. through Landore to Morriston, and also eastwards along the sea margin towards Neath, is the industrial quarter, while the residential part occupies the sea front and the slopes of the Town Hill (580 ft. high) to the west, stretching out to Sketty. The Mumbles or Oystermouth and a large part of the Swansea rural district were included in the borough in 1918. The east side of the river is known as St. Thomas's and Port Tennant.

The castle, first built by Henry de Newburgh about 1099, has entirely disappeared; but of the new castle, which was probably intended only as a fortified house, there remain the great and lesser halls, a tower and a so-called keep with the curtain wall connecting them, its chief architectural feature being a fine embattled parapet with an arcade of pointed arches in a style similar to that of the episcopal palaces of St. David's and Lamphey built by Henry Gower (d. 1347), bishop of St. David's, to whom the building of the new "castle" is also ascribed. Possibly some traces of St. David's Hospital, built by the same prelate in 1331, are still to be seen at Cross Keys Inn. The parish church of St. Mary was entirely rebuilt in 1895–98. Of the earlier work there remains the door of the rood loft (built into a wall), and a few private memorials. Within the parish of St. Mary was St. John's, a church once owned by the Knights Hospitallers. This church, which was entirely rebuilt in 1820, was renamed St. Matthew in 1880, when a new St. John's was built within its own parish. The Royal Institution of South Wales, founded in 1835, possesses a museum in which the geology, mineralogy, botany, prehistoric and later antiquities of the district are well represented. Its library is rich in historical and scientific works relating to Wales and Welsh industries. The free library and art gallery contains exhibits of local and general Welsh interest. The Glynn Vivian art gallery was opened in 1915.

The grammar school was founded in 1682 by Hugh Gore (1613–1691), bishop of Waterford. A college was added to the University of Wales in 1920, with a site in Singleton Park (300 acres). The town possesses the Llewelyn Park of 42 acres and other public grounds. De Braose's charter of 1305 gave the burgesses the right to take from the lord's woods sufficient timber to make four great ships at a time and as many small vessels as they wished. Coal was even then worked in the district. Cromwell in his charter of 1655 recognized Swansea as "convenient for shipping and resisting foreign invasions." Its status was only that of a "creek" in the port of Cardiff till 1685, when it was made independent.

From about 1768 to 1850 Swansea had a famous pottery. Beginning with earthenware which twenty years later was improved into "opaque china," it produced from 1814 to 1823 superior, beautifully decorated porcelain.

During the 18th century coal began to be worked at Llansamlet and copper smelting (begun at Swansea in 1717, though at Neath it dated from 1584) assumed large proportions. The coal was conveyed on the backs of mules and later by means of a private canal. Under an act of 1791 harbour trustees cleared the river bed and built a long pier on either side of it. A canal connecting the tidal part of the river Neath with the mouth of the Tawè, made in 1789, was in 1824 connected with the Vale of Neath canal by means of an aqueduct across the Neath river, when also a small dock, Port Tennant or Salthouse Dock, was made near the east pier, and this continued to be used till 1880. Meanwhile in 1798 the entire coal producing Swansea Valley was connected with the port by a canal 16½ m. long (acquired by the G.W.R. in 1872). In 1851 the river was diverted eastward into a new channel (called the New Cut) and its old channel was locked and floated, thereby forming the North Dock. (Area 11½ acres, and a half tide basin 2½ acres. Length of quays 5,500 ft.) The Swansea Valley canal has a connecting lock with this dock, and on the island between the dock and the New Cut are patent fuel works, copper ore yards and other mineral sheds. The South Dock, begun in 1847 and opened in 1859, is mainly used for shipping coal and for discharging timber. It has an area of 18½ acres; length of quays 6,550 ft.; depth of water in lock 34 ft. The next development was on the east side of the river where the natural inlet of Fabian's Bay, inside the harbour mouth, was utilized for the construction of the Prince of Wales's Dock (authorized 1874, opened October 1881, and subsequently extended), area 28 acres; length of quay 6,872 ft. and it is connected with the Tennant canal. The very rapid increase in the demand for anthracite coal (for the shipment of which Swansea has practically a monopoly) soon necessitated still further accommodation and in July 1904 was begun the King's Dock, which lies farther east and has an entrance direct from the bay. By means of the embankment made in connection with it, 400 acres were reclaimed from the sea. King's Dock and Basin is 71 acres; depth of water 40 ft. (high tide); length of quays, 14,050 ft. The Queen's Dock is 150 acres with 2,400 ft. of quays. There are numerous privately owned dry docks. The entire harbour has some 281 acres of deep water in the docks and over 6 miles of quay. The imports include timber, ores (copper, silver, iron, etc.), grain, pig iron, crude oil, etc. The exports are coal, patent fuel, refined oils, coke, tin plates, etc.

The town (which is often called "the metallurgical capital of Wales") is the chief seat of the copper, spelter, tin-plate and patent fuel industries. Copper smelting, which during most of the 19th century was the chief industry, has not maintained its relative importance, though Swansea is still the chief seat of the trade, but three-fourths of the tinplates manufactured in Great Britain and nineteen-twentieths of the spelter or zinc are made in the Swansea district, and its tube works are also very important. From about 1918 Swansea has become an important centre for the distribution of oil and extensive facilities for its storage and refining have been provided. It is by reliance on the metallurgical industries and the facilities for dealing with other fuel besides coal that Swansea has escaped in some measure the depression that has overtaken the purely coal-exporting areas of the South Wales coal-field since the slump of 1921. Trawlers usually land their catches at the south dock, where there is a well organized fish-market.

Administration.—The town claimed to be a borough by prescription, for its only known charters of incorporation are those of Cromwell and James II., which were never acted upon. It probably received its first grant of municipal privileges from William 3rd earl of Warwick some time before 1184. By a charter of 1215 (confirmed in 1234, 1312 and 1332), John granted the burgesses the right of trading, free of all customs due, throughout the whole kingdom (except in London). By 1305 the burgesses had obtained a most liberal grant of privileges from William de Braose. A patent of murage and pavage—from which it may probably be inferred that Swansea was a walled town—was granted by Edward II. in 1317 and another by Edward III. in 1338. Cromwell's charter of 1655 changed the title of portreeve into mayor, in whom, with twelve aldermen and twelve capital burgesses, it vested the government of the town. Four annual fairs were appointed, namely on the 8th of May, 2nd of July, 15th of August and 8th of October—the first being the only new one.

From 1535 to 1832, Swansea with other boroughs of Glamorgan sent one member to Parliament. In 1658, Cromwell gave Swansea a member of her own but the grant lapsed with the Restoration. In 1832, Swansea, with added parishes, was again granted a member and in 1885 a second member was added. The assizes and quarter sessions for Glamorgan are held at Swansea alternately with Cardiff. The borough has a separate commission of the peace, and, since 1891, a court of quarter sessions.

In 1923 the "Church in Wales" created a bishopric of Swansea and Brecon.

SWANWICK, ANNA (1813–1899), English writer and philanthropist, was born at Liverpool on June 22, 1813. She went in 1839 to Berlin, where she took lessons in German, Greek and Hebrew. In 1843 appeared her first volume of translations, *Selections from the Dramas of Goethe and Schiller,* followed by a translation of Schiller's *Jungfrau von Orleans* (1847), and others of *Faust, Tasso, Iphigenie* and *Egmont* (1850). In 1878 she published a complete translation of both parts of *Faust,* which appeared with Retsch's illustrations. In 1865 she published a blank verse translation of Aeschylus's *Trilogy,* and in 1873, a complete edition of Aeschylus, which appeared with Flaxman's illustrations. Anna Swanwick was a founder of Queen's and Bedford colleges, and advocated the admission of women to universities. She died in Nov. 1899. *See* M. L. Bruce, *Anna Swanwick* (1903).

SWARAJIST. The term *swaraj* (more properly *swarajya* from *swa*=own or self; *rajya*=rule or government) was originally employed in the ethical sense of control over self—self mastery. Prominence was first given to it in the political arena by Dadabhai Naoroji, who, in his presidential address to the Indian National Congress in Calcutta in Dec. 1906 claimed as the right of India *swaraj* "or self government like that of the United Kingdom or the Colonies," and the word soon gained currency as the equivalent of Dominion home rule. By a judicial decision of the Calcutta high court (1907, I.L.R., 34 Calc.), it was held not necessarily to mean "independent government" in the sense of government of the country to the exclusion of the present Government. "It may mean, as is now well understood, government by the people themselves under the King and under British sovereignty." Its adoption as the label of a particular political party was the outcome of the lengthy and ever-changing agitation set on foot by M. K. Gandhi in 1919. That movement commenced as one of passive resistance to the legislation known as the Rowlatt Act, which was designed to strengthen the hands of the Government in dealing with revolutionary crime, but, utilizing the resentment aroused among Mohammedans by the Turkish peace terms, which crystallized in the Khilafat movement, and the excitement which ran through the country as the result of disturbances in the Punjab and their sequelae, Gandhi, in the succeeding year, launched a campaign of protest under the guise of non-violent non-cooperation, which was to include the boycott of the courts and Government schools, the resignation of titles and Government office, and abstention from participation in the forthcoming elections to the new legislative councils under the Reforms scheme. In July 1920 the attainment of *swaraj* was included among the objects of the non-co-operation movement, and at the meeting of that year it was adopted by the Indian national congress as their avowed aim. But as to the precise meaning of *swaraj* there existed a vagueness which Gandhi did little to dispel. At one time he defined it as parliamentary government, whether within or without the empire; at another as dominion home rule; at a third as the universal employment of the spinning wheel; yet again as the triumph of the Khilafat party. On the other hand, at the first meeting of the legislative assembly in Feb. 1921, in the message from His Majesty the King Emperor, the ideal of *swaraj* was mentioned as the dream for years of patriotic and loyal Indians, while the reforms were cited as the beginnings of *swaraj* within the empire.

In the first elections under the 1919 act Gandhi's followers took no part, but by the beginning of 1922, an influential section of the congress acting under the leadership of C. R. Das and Pandit Moti Lal Nehru, announced on Jan. 1, 1923, the formation of a Congress Khilafat Swarajya party, in whose programme the capture of the councils and the obstruction of all business in them was the leading immediate item. After protracted dissensions and manoeuvres this section was finally victorious within the congress, and at the elections of Nov. 1923 Swarajist candidates took the field as such and, noticeably as against the Moderates, achieved considerable success, though failing to secure (except in one province) the clear majority for which they had hoped. Throughout the term of the second reformed councils the Swaraj party continued their wrecking tactics, succeeding in two provinces (Bengal and the Central Provinces) in bringing about a temporary suspension of the reformed constitution.

Towards the end of that year the party was split by the defections of some of its members, notably in Bombay and the Central Provinces, in the direction of "responsive co-operation," including the acceptance of office under Government, and in April 1926 an attempt was made to form an Indian national party of responsivists, independents and moderates "to prepare for and accelerate the establishment of *swaraj* or full responsible government in India, such as obtains in the self-governing dominions of the British empire." These differences bore fruit at the third election of the reformed councils at the end of 1926, when the Swaraj party definitely lost ground, noticeably in the assembly and in the United Provinces, Punjab and Central Provinces. The Indian national congress (which by that time was practically the Swaraj party) in Dec. 1927, declared for the complete independence of India.

SWARTHMORE, a borough of Delaware county, Pennsylvania, U.S.A., among wooded hills near the Delaware river, 11 m. S.W. of Philadelphia. Pop. (1920) 2,350; 1928 estimate over 3,000. Swarthmore college, founded by the Society of Friends in 1864, has a beautiful campus of 237 ac. (including a large tract of woodland and the rocky valley of Crum creek), upwards of 20 buildings and an endowment of $3,500,000. The enrolment is limited to 500. Swarthmore was incorporated in 1893.

SWASTIKA, a decorative and symbolic ornament consisting of a cross with equal arms, to the end of each of which is attached a line running at right angles to it, all these extensions occurring on the same relative side, so that all four extensions have the same rotary direction in relation to the centre. The swastika is one of the most ancient and widespread of all ornamental forms, appearing in both hemispheres. It is generally interpreted as a sun symbol. It occurs in Aegean and archaic Greek pottery and in certain types of fret, found in Egypt and Greece. In some examples it appears as two identical S-curves, intersecting in the middle and set at right angles. Occasionally three arms are found, and the heraldic symbol of three running legs set radially, may be a development of the swastika.

(T. F. H.)

SWAT, a tract on the Peshawar border of the North-West Frontier Province of India, consisting of the valley of the Swat river above its confluence with the Panjkora, which is reached by the Malakand, the Shahkot and other passes from the south.

The Swat river rises in the Kohistan, not far from the source of the Gilgit river and is utilized by canals to irrigate about 160,000 acres. A tunnel through the Malakand range, when complete, will tap the river much higher up.

The old name of the river was Suastos, and that of the Panjkora was Ghoura, under which names they figure in the history of Alexander's campaign. Only the lower portion of the Swat valley is of military significance. The upper valley is closely gripped between mountain spurs of the Hindu Kush. The valley, narrow though it is, and traversed by the worst conceivable type of hill tracks, is fairly thickly populated. The district lies on the direct road to Chitral.

The Swatis are a clan of Yusafzai Pathans numbering 40,000 fighting men but are of poor physique, due to malaria. They are Suni Mohammedans, the most bigoted of all the Afghan tribes. As religious leader, the Akhund of Swat, Abdul Ghafur, born in 1794, ruled for the last 30 years of his life, and died in 1877. The Akhund, after his experience of the British strength in the Umbeyla Campaign of 1863, always exerted his influence in favour of peace with the British government. He was succeeded by his son Mian Gul, who never possessed the same influence as his father.

SWATH-TURNER: *see* CULTIVATING MACHINERY.

SWATOW (also SHAN'TOW), a port in the province of Kwang-tung, China, situated at the mouth of the main branch of the Han river. Population about 80,000 (estimated). It was formerly a small fishing village, and the present town has been built to a large extent on reclaimed land. English merchants settled on Double island, in the river, as early as 1856, and began trading. Swatow is a great emigration port and was the scene of many kidnapping adventures on the part of foreigners in the early days. The region retained a full tribal organization until the latter half of the 19th century. Serious difficulties arose with the T'aip'ing rebellion and foreign interferences. The city is the outlet for Chao-chow, some 30 m. up the river, and the centre of a sugar cane district. Bean cake is manufactured and is also imported from Niuchwang, Shanghai and Hongkong. Among the leading exports are tea (since about 1872), sugar and oranges, paper, tobacco, grass cloth (manufactured at Swatow from the so-called Taiwan hemp), lace, drawn thread work embroidery. The imports include cereals, peas, beans, kerosene oil and piece goods. The port was opened to foreign trade in 1869. By its situation at the southern end of Formosa strait the town is exposed to the full force of the typhoons.

SWAYTHLING, SAMUEL MONTAGU, 1ST BARON (1832–1911), British financier, was born at Liverpool on Dec. 21, 1832, of a Jewish family named Samuel. He took by royal licence the name of Montagu. He rose to be the head of the most important arbitrage house in London. He was Liberal M.P. for the Tower Hamlets from 1885–1900; he was a member of the Gold and Silver commission of 1887–1890, being himself a bimetallist. He was created a baronet in 1894 and raised to the peerage in 1907. He was a zealous promoter of Jewish interests, founding the loan fund of the Jewish board of guardians, the Jewish working men's club, and several synagogues. Lord Swaythling succeeded Sir Julian Goldsmid as chairman of the Russo-Jewish committee, and also helped to establish a modern secular school for Jews at Jerusalem (1875). He died on Jan. 12, 1911, in London. His son, E. S. Montagu was Secretary for India.

SWAZI. This African tribe is a member of the Eastern or Zulu-Xosa group and, in the early 19th century, occupied the country north of the Pongelo river. Driven northwards it settled under Sobhuza in Swaziland (Natal). Mbandini—second in succession to Sobhuza—was generous in concessions, and though the independence of Swaziland was guaranteed by Conventions in 1881 and 1884, developments led to the administration of Swaziland under the High Commissioner for South Africa through a Resident, with a Council to advise on purely European matters. The paramount chief and other chiefs, administer justice according to native custom, with appeal to the Resident. The recovery from the ravages of rinderpest in 1894 has been very marked.

Both levirate and sororate seem to exist and a man may marry the daughter of his wife's brother. Under conditions, his son, as cousin, may inherit the right to marry the girl.

See the *Official Yearbook of the Union of South Africa,* No. 9 (1927); *see* also *Africa,* Vol. I., No. 4 (1928), H.M. Stationery Office.

SWAZILAND extends between the Drakenberg and the Lebombo range. It is cut off from the Indian ocean by a strip of country from 30 to 50 m. broad. Its area is 6,705 sq. miles.

Much of the country consists of ridges of high land running out from the Drakenberg. In the west, the general elevation is about 4,000 feet. In the east, the ground falls to 400–1,000 feet. Swaziland is drained by the Usutu and other tributaries of the Maputa; and by the Komati (*q.v.*) and Umbelozi which flow through watergaps or poorts into Delagoa bay.

The low veld, in the rain shadow of the Lebombo range, has a low rainfall, but on the high veld in the west, rains are more copious and good pasture is present. The relation of altitude to mean annual rainfall is Mbabane (3,800ft.) 52 in.; Bremersdorp (1,500ft.) 34 in.; Natalia Ranch (800ft.) 25 inches. The mean temperature at the last station is about 71·8° F; at Mbabane it is about 9° less. The flora and fauna are similar to the Transvaal and Zululand (*q.v.*). The high veld is free from malaria, which occurs elsewhere, especially in the low veld. Swaziland is dependent on road transport, which is either motor-driven or drawn by oxen or mules. Mbabane, the capital, is 5 hr. by mail car from Breyten, in the Transvaal.

The population in 1921 consisted of 2,205 Europeans, seven Asiatics, 444 coloured persons, and 110,295 natives. There are four European villages—Mbabane (260), Bremersdorp (120), Hlatikulu and Goedgegen, and there are Government stations at Mankaiana, Stegi and Pigg's Peak. Most of the Europeans are engaged in farming. The natives are Amaswazi, with a few Amazulu in the south-eastern districts. Seven or eight thousand natives are usually absent, working in the Transvaal.

Of the total area, 163,500 ac. were set aside as native reserves, and the Amaswazi purchased a further 77,000 acres. The rest of the country was regarded as Crown land, and about four-fifths of it has been alienated.

The natives grow maize, Kafir corn and other crops. In 1926 the estimated numbers of live stock were 300,000 cattle, 932 horses, 4,893 asses, 444 mules, 10,000 pigs, 325,000 sheep and goats. A further 300,000 sheep come every year to winter in Swaziland. Maize is also cultivated by the white farmers. The country appears to be well suited to fruit growing. Citrus fruits do well in most parts; on the high veld apples, pears, apricots and peaches can be grown, while in the lower parts tropical and sub-tropical fruits succeed. In 1924 about 8,000 ac. were under cotton. Tobacco is also being grown. The chief market is among the natives, whose wants, however, are few, except for maize.

Gold mining has almost ceased. In 1926 only 1,510 oz. were produced. Cassiterite is worked near Mbabane, the output for 1926 being 189 tons. In 1910 Swaziland came into the customs scheme of the Union of South Africa.

Swaziland does not form part of the Union of South Africa. It is governed by a resident commissioner, responsible to the high commissioner for South Africa. He is assisted by an advisory council of nine members, who are consulted on European matters. Most of the revenue is derived from the native hut tax and from customs.

In addition to several Government primary schools at several centres, there are schools connected with the various missions, at which over 4,000 native pupils are being educated. For more advanced work, promising native scholars are sent to institutions in the Union, such as Lovedale, Tiger Kloof, etc. The cost of their tuition and board is paid by the Swazi National Fund, to which each native taxpayer contributes two shillings per annum. There are 16 religious bodies carrying on work in the country, including the English, Dutch, Norwegian, Roman and Swedish Churches. As far as possible most of these bodies avoid encroaching on each other's sphere of work. (R. U. S.)

History.—Ama-Swazi tribes have been long settled in the country now known as Swaziland. They were formerly called Ba-Rapuza or Barabuza after a chief under whom in the 18th century they acquired homogeneity. Early in the 19th century they fell under the dominion of the newly constituted Zulu nation but in 1843 under a chief named Swazi they achieved independence. According to custom they adopted the name of their deliverer. The Boers of the Transvaal were then beginning to occupy the regions adjacent to Swaziland and in 1855 the Swazi in order to get neutral territory between themselves and the Zulu, whose power they still dreaded, ceded to the Boers the narrow strip of land north of the Pongola river now known as the Piet Retief district. With the Boers the Swazi remained on friendly terms and this friendship was extended to the British on the occupation of the Transvaal in 1877. In 1879 they joined the British in the attack on the Bapedi chief Sikukuni, capturing from him certain "rain medicine," the possession of which increased the prestige of the paramount chief of the Swazi among the natives of South Africa.

On the retrocession of the Transvaal in 1881 and again by the London Convention of 1884, the independence of the Swazi was recognized by the Boers. Immediately afterwards, however, the Boers began a series of efforts to obtain control of the country. In consequence Umbandine (Mbandini), the paramount chief asked in 1886 for British protection, but without avail. In 1887 gold prospectors of all nationalities were overrunning his country, and a colony of Boers settled within the Swazi territories and proclaimed "The Little Free State." It appeared on enquiry that Umbandine, a worthless and bibulous man, had granted concessions, such as "postal, telegraphic, banking, customs," etc., to the Transvaal, and concessions of land, mining and grazing rights to any adventurer who would give him champagne and greyhounds. His concessions included exemption from taxation. The British Government refused assent to the request of President Kruger to annex the country to the Transvaal and a dual control was arranged in 1890. This scheme proved abortive owing to the objection of the Transvaal to join the South African Customs union. However, in 1894, by arrangement with the British, the administration, with certain reservations as to the rights of the natives, was taken over by the Transvaal. In seeking to acquire Swaziland President Kruger's main object was also to annex the coast lands to its east and thus obtain for the Boers—at Kosi bay—a seaport of their own. Great Britain settled the matter in 1895 by annexing Amatongaland, the region in question. (*See* TRANSVAAL, *History*.)

Umbandine died in 1889, and his widow Naba Tsibeni (or Labotsibeni) was known as the queen regent. Before the Anglo-Boer war in 1899 she took the side of the British. On the cessation of hostilities a British special commissioner was sent into the country—then in a condition bordering on anarchy—and a provisional administration established. Eventually it was decided, in 1906, to make Swaziland a British protectorate under the High Commissioner for South Africa. In that year a lad, Sobhuza II., born about 1898, was selected as ruler, Naba Tsibeni, his grandmother, being confirmed as regent during his minority. In 1921 Sobhuza was installed as paramount chief; Naba Tsibeni died in Dec. 1925. She was a fine type of the older generation; Sobhuza was educated at the Lovedale missionary establishment; speaking fluent English and wearing European clothing, he was typical of many Swazi of the new school.

A legal division of the land in 1914 between the natives and the concessionaires left fully half of it in possession of Europeans. The Swazi, however, claimed overlordship and it was not until April 1926 that the judicial committee of the privy council decided that the Crown had acquired sovereign rights of disposal. In 1924 Gen. Hertzog, as prime minister, desired to incorporate Swaziland in the Union. The Swazi objected; the white settlers favoured the proposal only if the separate entity of the country was preserved and up to 1929 nothing had been done. To the able administration of De Symons Honey, Swaziland owed much.

See the *Official Year Book of the Union of South Africa* (Pretoria); the annual *Report on Swaziland*, issued by the Colonial Office, London; and Eric A. Walker, *A History of South Africa* and authorities there cited. (F. R. C.)

SWEARING. The common use of the word is for the uttering of profane oaths or curses. In English law, while blasphemy (*q.v.*) was at common law an indictable offence, cursing or swearing was left to the ecclesiastical courts. The Profane Oaths Act 1745 inflicted a sliding scale of fines for the use of profane oaths according to the rank of the offender: 1s. for a common labourer, soldier or seaman, 2s. for everyone below the rank of gentleman and 5s. for those of or above that rank; procedure under this Act is regulated by the Summary Jurisdiction Acts. By the Town Police Clauses Act 1847 the use of profane or obscene language is an offence punishable on summary conviction by a fine not exceeding 40s. or imprisonment not exceeding 14 days. The offence must be committed in a street. In the United States, blasphemy is a crime under either the common law or the statutes of substantially all of the States.

SWEATER, a jacket or short coat of a woollen material, usually knitted, and sometimes called a jersey, because it was worn by the sailors of the Island of Jersey. The first sweaters were heavy dark blue jackets, which were pulled on over the head, and were worn by the participants in athletic contests before and after games, to prevent cold.

SWEATING-SICKNESS, a disease which made its first appearance in England in 1485. It caused great mortality and was distinguished from the plague and other epidemic diseases by its rapid course.

From 1485 nothing more was heard of it till 1507, when the second outbreak occurred, which was much less fatal than the first. In 1517 was a third and much more severe epidemic. In Oxford and Cambridge it was very fatal, as well as in other towns, where in some cases half the population are said to have perished. The disease spread to Calais and Antwerp, but with these exceptions it was confined to England.

In 1528 the disease recurred for the fourth time, and with great severity. It first showed itself in London at the end of May, and speedily spread over the whole of England, though not into Scotland or Ireland. In London the mortality was very great; the court was broken up, and Henry VIII. left London, frequently changing his residence. It spread to the Continent, suddenly appearing at Hamburg, where in a few weeks more than a thousand persons died.

It caused fearful mortality through northern and eastern Europe, France, Italy and the southern countries were spared. It spread much in the same way as cholera. In a given place, it prevailed for generally not more than a fortnight. By the end of the year it had entirely disappeared, except in eastern Switzerland, where it lingered into the next year; and the terrible "English sweat" has to date never appeared again, at least in the same form, on the Continent. In 1551, however, it recurred in England and was described by an eye-witness, John Kaye or Caius, the eminent physician.

The disease began suddenly with a sense of apprehension, followed by cold shivers (sometimes very violent), giddiness, headache and severe pains in the neck, shoulders and limbs, with great prostration. After the cold stage, which might last from half-an-hour to three hours, followed the stage of heat and sweating. The characteristic sweat broke out suddenly, and, as it seemed to those accustomed to the disease, without any obvious cause. With the sweat, or after that was poured out, came a sense of heat, and with this headache and delirium, rapid pulse and intense thirst. Palpitation and pain in the heart were frequent symptoms. No eruption of any kind on the skin was generally observed; Caius makes no allusion to such a symptom. In the later stages there was either general prostration and collapse, or an irresistible tendency to sleep, which was thought to be fatal if the patient were permitted to give way to it. The malady was remarkably rapid in its course, being sometimes fatal even in two or three hours, and some patients died in less than that time. Those who survived for twenty-four hours were considered safe.

The disease, unlike the plague, was not especially fatal to the poor, but rather, as Caius affirms, attacked the richer sort.

Causes.—Some attributed the disease to the English climate, its moisture and fogs, or to the intemperate habits of the English people, and to the frightful want of cleanliness in their houses and surroundings which is noticed by Erasmus in a well-known passage, and about which Caius is equally explicit. But the sweating-sickness was in fact a specific infective disease, in the same sense as plague, typhus, scarlatina or malaria.

The only modern disease resembling sweating-sickness is that known as *miliary fever* ("Schweissfriesel," "suette miliaire" or the "Picardy sweat"), a malady which has been observed in France, Italy and southern Germany, but not in the United Kingdom. It occurs in limited epidemics, not lasting more than a week or two (at least in an intense form). The attack lasts longer than the sweating-sickness, is accompanied by eruption of vesicles, and is not usually fatal. The first clearly described epidemic was in 1718 (though probably it existed before), and the last in 1861. Between these dates about 175 epidemics have been counted in France alone.

BIBLIOGRAPHY.—For history *see* Bacon's *Life of Henry VII.*, and the chronicles of Grafton, Holinshed, Baker, Fabyan, etc. The only English medical account is that of John Caius, who wrote in English *A Boke or Counseill Against the Disease commonly called the Sweate, or Sweating Sicknesse* (London, 1552); and in Latin *De ephemera britannica* (Louvain, 1556; reprinted London, 1721). The English tract is reprinted in Babington's translation of Hecker's *Epidemics of the Middle Ages* (Syd. Soc., 1844). This also contains Hecker's valuable treatise on the English sweat, published in German (1834), and also printed in his *Volkskrankheiten des Mittelalters*, edited by Hirsch (Berlin, 1865). Grüner's *Scriptores de sudore anglico* (Jena, 1847), contains nearly all the original documents, including the two treatises of Caius. *See* also Hirsch, *Handbook of Geographical and Historical Pathology*, trans. by Creighton (New Syd. Soc., 1885).

SWEATING SYSTEM, a term used to describe oppressive industrial conditions in certain trades. This "system" originated early in the 19th century, when it was known as "the contract system." Contractors supplying the government with clothing for the army and navy got the work done by sub-contractors. Afterwards this plan was adopted in the manufacture of ready-made clothing for civilian use, and of "bespoke" garments (made to the order of the customer). Previously the practice had been for coats, etc., to be made up by workmen directly employed by the master tailor. The new plan brought workpeople possessing little skill and belonging to a very needy class into competition with the regular craftsmen; and a fall in wages affected the whole body of workmen in the trade.

The work was done in overcrowded and insanitary rooms, and the earnings of the workers were extremely low. In 1850 a vigorous agitation against "the sweating system" was commenced, based mainly upon a series of articles in the *Morning Chronicle* (London), which were followed by a pamphlet, *Cheap Clothes and Nasty,* written by Charles Kingsley under the name of "Parson Lot," and by his novel *Alton Locke.* Kingsley and his friends, the Christian Socialists, proposed co-operative workshops; but experiments met with little success. In 1876–1877 the outcry against the sweating system was renewed (principally on the ground of the risk of infection from garments made up in insanitary surroundings), and in 1887, attention was drawn to the immigration of poor foreigners into East London, who were employed in tailoring, boot-making and cabinet-making. A select committee of the House of Lords heard 291 witnesses in relation to tailoring, boot-making, furriery, shirt-making, mantle-making, cabinet-making and upholstery, cutlery and hardware manufacture, chain and nail-making, military accoutrements, saddlery and harness-making and dock labour—reporting in 1890. Sweating involved "(1) A rate of wages inadequate to the necessities of the workers or disproportionate to the work done; (2) excessive hours of labour; (3) the insanitary state of the houses in which the work is carried on." They stated that, "as a rule, the observations made with respect to sweating apply, in the main, to unskilled or only partially skilled workers, as the thoroughly skilled workers can almost always obtain adequate wages."

It would be a mistake to suppose that "sweating" never took place where no "middlemen" were employed. "Sweating" was sometimes to be found in large factories where workers were directly employed.

The plight of the homeworkers, most of whom were women, may be easily imagined. Compelled to work, either to eke out an insufficient family income or to support her own isolated existence, but normally unable to leave her home, such a woman had no alternative but to accept wages at the wretched level to which they had sunk as the result of unfettered competition and of the inability of the workers to act collectively.

The position of the worker employed by the small sub-contractor was little better. On the one hand there was keen competition amongst the "middlemen," which led them to accept sub-contracts at prices which often made it impossible for them to pay more than a meagre wage. On the other hand the sub-divisional methods of manufacture which were then beginning to be widely adopted drew into various trades which had previously been closed to them, a large number of comparatively unskilled and inexperienced workers, who knew nothing of the tradition which had maintained organisation and standard rates of wages amongst the skilled workers by whom the work of the trade had previously been done. The organisation of the employees of the small sub-contractors presented insurmountable difficulties. They worked in small, scattered groups; their employers were unstable and their employment erratic.

When, moreover, trade was brisk extremely long hours would be worked in seriously overcrowded workrooms. On the other hand, when trade was slack the sub-contractor, whose overhead charges did not, of course, compare with those of the factory employer, found it perfectly practicable to dismiss as many workers as he could do without—a facility which encouraged inefficient organisation of work in the trades which enjoyed it.

The workers toiled during night and day. Work-room, living-room and bedroom were often all one. The laws concerned with hours of employment and the conditions, from the point of view of health, were very difficult of enforcement.

Such were the conditions at the beginning of the present century in a number of trades. In 1929 while there may still be "pockets" of "sweating" in a very few trades the evil is unknown. To this result two main factors have contributed: first the fixing of statutory minimum rates of wages in the "sweated" trades and in those trades in which organisation of employers and workers was insufficient for wages and conditions to be negotiated in the ordinary way; and secondly the constantly increasing economies of factory production. (*See* TRADE BOARDS.)

The rapid development of factory organisation and the employment of expensive, high-speed machinery on sub-divisional methods of production militated against the giving out of work either to homeworkers or to small sub-contractors. Despite the fact that "outwork" saves the employer considerable overhead charges such as rent, rates, heating and interest on capital sunk in buildings and machinery, it becomes less and less able to compete with the well-equipped and efficiently organised factory. And where there is a trade board it cannot any longer flourish on low wages. It may be that the widespread use of electric power may bring about a revival of the small workshop in those trades which can be carried on with comparatively small and inexpensive machinery. (J. J. M.)

THE UNITED STATES

The sweating system arose in the United States during the Civil War, when soldiers' wives were given uniforms to make with the then newly invented sewing machines. Its growth was slow until, in the '80s, the vast Russian emigration followed the assassination of Czar Alexander II. Steam-power had already been applied to sewing machines, and the influx of cheap labour created the American ready-to-wear garment trade and its early concomitant, the sweating system.

Three elements compose the sweating system: (1) A mass of unskilled, unorganized poverty-stricken men, women and children incapable of resisting the economic pressure to compete, women against their husbands and children against their parents. (2) Power-using factories or shops, where materials are prepared for simple processes, which are done in smaller shops or in the homes of the workers, or in both. (3) Transportation to and from the sweatshops and tenement dwellings, formerly done on foot by heavily laden men, women and children. During the present century automobile trucks and the parcel post have contributed to widen enormously the area within which the sweating system is carried on, and to reduce the crowding of slums adjacent to factories engaged in the sweated trades.

As the first simple foot-power sewing machine brought the sweating system to the soldiers' families, so the ceaseless evolution of the power-driven machine, first steam, now electric, has served to concentrate the production of garments in vast skyscrapers near railway stations through which the employees go to their widely dispersed homes. This concentration has, in recent decades, so facilitated labour organization within the garment industry, that the Amalgamated Garment Workers now owns its building, its bank, journal, blocks of modern apartments, and voluntary unemployment insurance fund, the last being carried on co-operatively by employers and employees. They successfully combat both sweating and strikes.

Outside the garment trades, also, the unions have striven ceaselessly against sweating. In 1889 the tobacco workers obtained the passage of the New York statute forbidding all manufacture of tobacco in any tenement house. This the Court of Appeals of New York held unconstitutional, so prolonging for two generations homework in tenements.

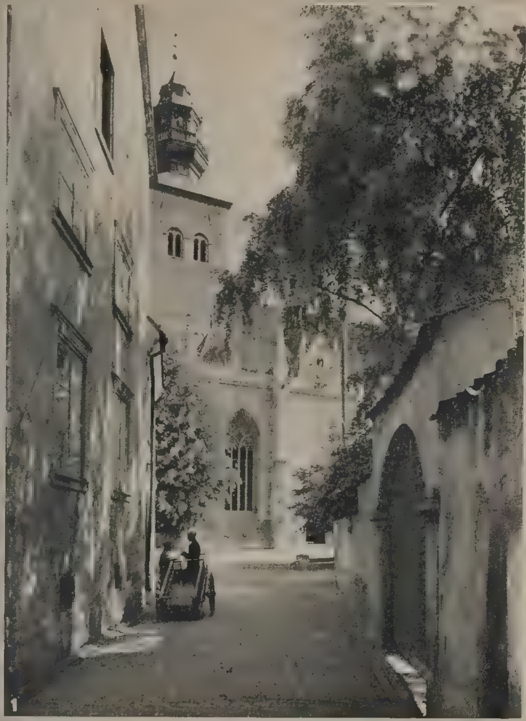
Beginning in 1912, in Massachusetts, 13 States passed laws creating minimum wage boards or commissions. These the Supreme Court of the United States, in the Sutherland decision, held unconstitutional by a decision of five justices to four, rendered in April 1923.

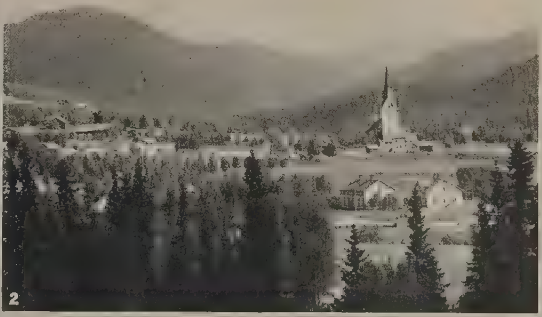
There remain now two means of control. Legislation in the name of the public safety may be resorted to, as when a man killed himself and his little son in making fire crackers in his home, for a Fourth of July celebration. So, too, the local health authority could summarily stop a young girl found suffering from an open syphilitic infection of the hands from making, in her home, powder puffs for babies. (F. Ke.)

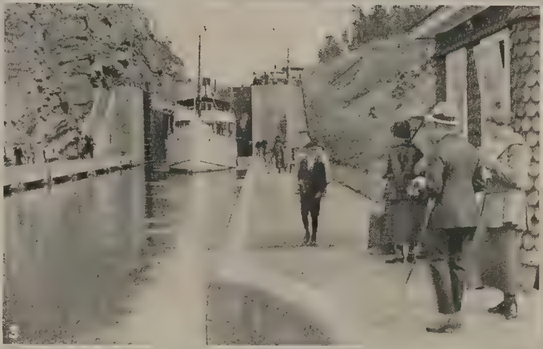
SWEDEN (*Sverige*), a kingdom of northern Europe, occupying a part of the Scandinavian peninsula. The length is about 990 m., the extreme breadth (mainland) about 250 m., and the total area, inclusive of inland waters, of which the four great southern lakes comprise 3,510 sq.m., is estimated at 173,154 sq.m. Strelbitsky estimated the boundary at 6,100 m.; 4,737 m. are coastal, the Norwegian frontier is 1,030 m., and the Finnish 333 miles.

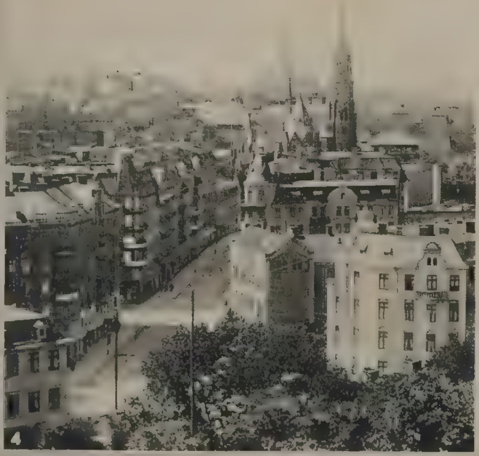
Physical Features.—The backbone of Sweden is an ancient mountain range of which the crest line forms the Norwegian boundary. The three main territorial divisions of Sweden are Norrland, Svealand and Götaland. The country may be described in four main physical divisions:—the northern mountains and lake region district, covering all Norrland and the western part of Svealand; the lowlands of central Sweden; the Småland highlands, in the south and south-east; and the plains of Skåne, occupying the extreme south of the peninsula. The first district is much the largest and highest, and contains the finest scenery. The greatest heights lie along the boundary and several exceed 6,000 ft. Kebnekaise (6,965 ft.) formerly considered the highest point in Sweden, is a bold, somewhat isolated summit. Slightly south, beyond the Lule älf, is a lofty mass in which Sarjektjåkko (6,971 ft.) slightly overtops the other summits. Still farther south is the better-known Sulitjälma (6,158 ft.); beyond is a progressive decrease in height southwards until Åreskutan (4,656 ft.) is reached. Near the southern flanks of Åreskutan the railway from Trondhjem (Norway) crosses into Sweden. South of the railway the highland line passes into Norway, but before doing so the mass rises into such heights as Helagsfjäll (5,896 ft.). Here the snow line, which is about 3,000 ft. in the north, rises to 5,500 ft. The numerous rivers are linked with long, narrow, high-level (900–1,300 ft.) lakes, due mainly to dams of moraine. Amongst European countries only Finland exceeds Sweden in the number of its lakes. In Sweden they cover over 14,500 sq.m. (about 8% of the country), but the largest lie in the central lowlands. The northern rivers run through forests and enter the sea usually through long estuaries. The Torne, which, with its tributary the Muonio, forms the boundary with Finland, has a length of 227 m., and drains Torneträsk (126 sq.m.). Along and near to the shores of the lake the railway from Gellivare runs to Narvik (Norway). The Kalix (208 m.), with numerous rapids, is paralleled by the Lule, whose main stream is 193 miles. One of its branches, the Stora Lule drains the Langasjaur and Luleträsk, which together have a length exceeding 50 m. but a total area of only 87 sq. miles. Just below Stora Lule lake is the Harsprång (hare's leap; Njuommelsaska of the Lapps), the largest and one of the finest cataracts in Europe. At the head of the Langasjaur is the Stora Sjöfall (great lake fall; Lapp, Ätna Muorki Kartje), 130 ft. In the southern mountain valleys of the region there are several beautiful falls, such as the Tännfors, not far from Åreskutan. Still farther south of the Lule are the Pite river (191 m.) and the Skellefte (205 m.)—the latter drains Hornafvan and Storafvan (total area 275 sq.m.). Hornafvan is a straight and sombre trough, but Storafvan and the intervening Uddjaur are broad and picturesquely studded with numerous islets. The Ume (237 m.) with its tributary, the Vindel, of almost equal length, drains several lakes, including Stor Uman (64 sq. miles). The further principal rivers of this region are the Ångerman (279 m.) with the magnificent Hällingså fall within its drainage area, Indal (196 m.) and Ljusnan (230 miles). The Dal (320 m.) embraces Lake Siljan (110 sq. miles). The Klar has its upper waters—the Faemund—in Norway and reaches Lake Vener after a course of 228 miles. The Torne has a drainage area of nearly 17,000 sq.m. but the Ångerman has the largest basin (over 12,500 sq.m.) of any river entirely in Sweden; the average for the other large northern streams is less than 8,000 sq. miles. The northern rivers are liable to flooding so serious that they change their courses.

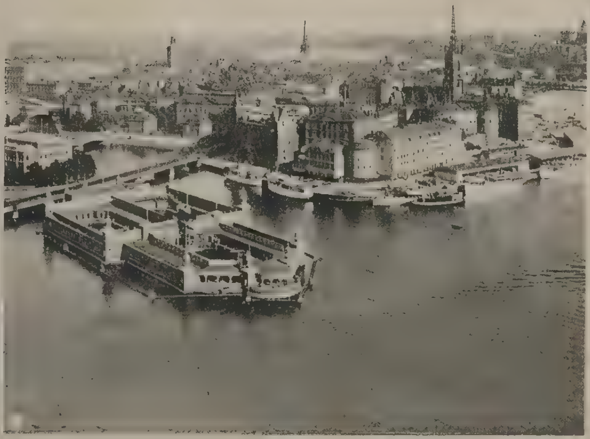
The lowlands resemble the coastal belt. Here are fertile plains of clay, with innumerable lakes, including Vener, Vetter, Mälar and Hjelmar with areas respectively 2,141, 733, 444 and 185 sq. miles. The scenery is quietly beautiful, especially of Mälar, in the pleasant environs of the city of Stockholm. Granulite, also called eurite and halleflinta, is the most important of the Archaean formations and contains all the metalliferous deposits of Sweden. The rock is a very compact and fine-grained mixture of felspar, quartz and mica, often grading into mica schist, quartzite and gneiss. The Cambrian and Ordovician strata occur in isolated patches. The deposits in most places are very little disturbed and form horizontal or slightly inclined layers. South of Vener they are capped by thick beds of eruptive diabase. Conspicuous local features are the eskers, or gravel-ridges (*åsar*) 100 to 200 ft. in height, in direction north-north-west. Their practical value lies in their excellent water supply and gravel. South of the central lowlands the Småland highlands lie in the heart of Götaland and are a detached part of highland Sweden. They lie roughly south of Vetter and reach the south-west coast. The general elevation of this region exceeds 300 ft., and in the eastern part 600 ft.; the principal heights are Tomtabacken (1,105 ft.) and Galtåsen (1,188 feet). There is much coniferous forest, but agriculture is profitable. The Småland highlands abut southward upon the plains of Skåne. Newer rocks of Cretaceous and Jurassic ages, together with recent marine deposits, have











BY COURTESY OF (1, 3) THE SWEDISH AMERICAN LINE, (2, 4, 5) THE SWEDISH STATE RAILWAYS

TOWNS AND WATERWAYS OF SWEDEN

1. The cathedral church (13th century) of St. Mary at Visby, on the island of Gotland. Visby, a very old port, reached its greatest prosperity in the days of the Hanseatic League.
2. Duved, a tourist resort in Jemtlands Län, which forms a convenient centre for the magnificent mountain and lake scenery of the Swedish-Norwegian border
3. Locks at Trollhättan on the Götha canal (1810–1832), which with its Trollhätte canal extension (1838–1844) and intermediate lakes connects Gothenburg and Stockholm. These waterways make use of numerous rivers; hence of the entire 360 miles route less than 60 miles have been artificially constructed; in all, there are 74 locks
4. The business centre of Gothenburg, principal seaport and second city of Sweden, situated 5 miles from the outlet of the river Götha
5. Stockholm, showing the Riddarholmen (noble's island), the oldest portion of the city. Sweden's capital was founded in the 13th century as a fortified port and has subsequently extended over numerous islands connected with one another and with the mainland by a network of bridges; hence its claim to the title, "Venice of the North"

yielded level plains, with rich open meadows and cultivated lands, the monotony of which is in some parts relieved by beech woods. The Triassic formation (Rhaetic) in the northern part of Malmöhus consists of sandstones and clay beds with coal.

On the whole the rivers of south Sweden are few and short. Lake Vener is drained to the Kattegat by the short Göta river, on which, near the lake, are the celebrated falls of Trollhättan.

Coast.—The coast of Sweden, though not indented with so many or so deep fjords as that of Norway, yet resembles it in having a fringe of islands which, throughout nearly the entire length, shelters the coast of the mainland from the open sea. This *skärgård* is only interrupted round the southern shore off Skåne. Between the *skärgård* and the mainland lies a connected series of navigable sounds of advantage to coastwise traffic.

The island belt is widest (45 m.) off the city of Stockholm (noted for its beautiful sea approach). Farther north, only the narrow Ålands Haf lies between the Swedish coast and the vast Åland archipelago, which extends to Finland. The *skärgård* islands as a whole are rugged and picturesque; in the Baltic several are well wooded, but the majority, particularly in the Gulf of Bothnia, are bare or heath-clad. For the large islands Öland and Gotland *see* separate articles.

Climate.—Several factors contribute towards variations of climate in Sweden's several regions. The land runs through more than 13½° of latitude; about 15% of its area is within the Arctic Circle; the boundary mountains are sufficiently high to be much colder than the adjacent coastal lands, but are not high enough to shut out entirely the warming effects of those drifts of wind and water from the south-west which give Norway its remarkable climate; the eastern and southern borders are washed by the sea; the piercing winter winds from the great Russian pool of cooled atmosphere can sweep westwards over the Swedish lowlands or can reach the mountain tops which, on the whole, offer but moderate gradients for ascents. February is the coldest month and has a mean temperature of below 32° F over Sweden. Stockholm averages 25·7°, Göteborg 30·4°, Haparanda 10·6°, but the coldest region is in the heart of Lappland; here the average for Karesuando is 5·2°. In some northern parts frost occurs in every month of the year, and at Karesuando only five months have a mean temperature above freezing point. July is generally the warmest month. Göteborg has a July mean of 62·2°; Stockholm of 62°; Haparanda, 59° and Karesuando 54·2°. The summer is short but high maxima are sometimes recorded; *e.g.*, 88° at Karasjok in Lappland.

The relative length of the seasons shows contrasts resembling those of temperature. At Karesuando the last day-frost of spring occurs on an average on June 15, and the first of autumn on Aug. 27, while at Stockholm four and a half months, and at Hven in the Sound more than six months are frostless. Ice forms in October in the north and breaks up in May or June, while in the midlands and south the corresponding months are late November and April. The ice-covering of the lakes ranges from 100 days annually in the south to upwards of 200 days in the north, though local increases of the ice period occur in the upper Småland highlands. Drifting sea-ice generally appears in the Kattegat in January; but the Sound becomes obstructed later largely by drift ice from the Baltic. In exceptional winters, *e.g.*, 1916–17, the Sound may be completely frozen over. Ice conditions in the Baltic vary considerably from year to year but usually navigation in the southern part of the Gulf of Bothnia is impeded from the end of November to the beginning of May, and in the north the gulf is covered with ice from November to mid-May, but among the islands it may linger until June.

The length of the Swedish summer day varies between wide limits. At Karesuando in 68° 26′ N. the sun is continuously above the horizon from May 26 to July 18; at Haparanda for 23 hours, and at Lund for 17½ hours at the summer solstice. Refraction increases the average length of the day by 30 min. in the north and by 15 min. in the south. More important is the effect of twilight, which results in daylight lasting without interruption from June 16 to 27 as far south as Hernösand (62° 38′ N.).

The average annual rainfall for Sweden increases, on the whole, from north to south, reaching a maximum towards the south-west. Thus the average in the north of Norrland is 16·5 in., and in the south is 22·5 inches. At Borås, midway between the south end of Lake Vetter and the Kattegat, the average is 35 inches. The minimum at Karesuando is 12·3 inches. The period of maximum is generally the latter half of the summer, and the minimum in February and March. The proportion of total precipitation which falls as snow ranges from 36% in Lappland to 9% in Skåne. Snow lies 47 days on an average on the plains of Skåne, while in the north it lies from 140 to 190 days. The Swedish glaciers cover some 135 sq. miles. They occur in the northern highlands about Kebnekaise, Sarjektjåkko and Sulitälma. The most southerly is on the slopes of Helagsfjäll in Lat. 62° 54′ N.

Flora.—The extensive range of latitude and altitude produces many local vegetation differences. Four main regions can be distinguished tending to grade into one another near their adjacent fringes. In descending order of altitude, and largely of latitude also, are: (1) alpine regions, (2) zone of birch woods, (3) coniferous forest region, (4) the beech wood patches. The alpine region occupies only the upper flanks of the spinal mountain-range, at an altitude above 1,600 ft. in the north and above 3,000 ft. in the south. It is treeless, though shrub-like willows and birch exist together with numerous berry-bearing plants. These are intermingled with extensive tracts of heather. In the bleaker wind-swept spots reindeer "moss" occurs with an occasional arctic poppy or a saxifrage. The birch forests are much more extensive in the north and form patches of woodland 10 to 20 m. wide; southwards the strip narrows to individual trees. Rowans, aspens and wild cherries occur and there is considerable undergrowth. At the higher elevations the birch becomes stunted and the lighter woodland is marked by considerable growths of wild strawberry and raspberry. The coniferous forests are the most extensive and cover nearly all of the country north-east of Lake Vener. The important tree on the drier and higher ground is the Scots pine (*Pinus sylvestris*) but enormous numbers of spruce (*Abies excelsa*) are also found. The conifers extend from sea-level to 2,500 or 3,000 ft. and though the pine and spruce predominate yet there is a sprinkling of lowland birches, rowans and aspens, in the north, while large numbers of such deciduous trees as oaks, ash, lime, maple and elm are found in the south. These latter trees seldom extend beyond 1,600 ft. altitude and the oak ceases about 61° N. (inland) and 63° N. (coastal). The undergrowth is usually slight but in the thinner-soil areas the bilberry (spruce) and whortleberry (pine) flourish. Much of the coniferous forest has been depleted by forest fires and lumbering, particularly along the lower courses of the larger streams. The beech forests with occasional oak are restricted to Skåne, southern Öland and the shores of the Kattegat. They are tending to be reduced by extended land cultivation. The flowering plants are largely immigrants since the last glacial epoch and the number of species shows a decrease northwards.

Fauna.—The effects of the great latitudinal range of Sweden are also shown in the case of fauna. Only a few animals such as the hare, ermine and the weasel are common to the entire country, but the squirrel, fox and various shrews have a wide range over the lower lands. Formerly bounties were paid for the extermination of the larger animals which have been greatly reduced in number. The bear is now protected. This and the wolf, the glutton or wolverine, and the lynx are becoming restricted to the more solitary depths of the northern forests. The wild reindeer, now protected, is rare, though large domesticated herds form practically the sole source of livelihood to the Lapps. The elk, also carefully preserved, haunts lonely forests over a considerable range; the roe-deer is confined to the south. In the midland plains the common fox is still abundant and the badger exists in large numbers. The latter and the otter, together with the pine-marten of the coniferous forests, are hunted for their skins. The common porpoise, is the only whale occurring in the Baltic; it, and the common grey seal are held to be responsible for much damage to fisheries. Bird life is very abundant in summer; several types such as the teal, snipe, golden plover and wagtail are common to the whole country. The arctic fox and the lemming are mountain animals; the former is normally confined to the highlands of the north, but it also joins in the chase when the lemmings make their non-periodical migrations to the lowlands during which their vast moving hordes are the prey of bird, wild and domesticated animals and man alike.

In the northern mountains the ptarmigan is common; ducks and other water-fowl frequent the lakes both here and in the south; the golden eagle, certain buzzards, owls and the small Lappland bunting are found. In the coniferous forests, grouse, capercailzie and woodcock are the principal game birds; the crane lives in marshy clearings, birds of prey are numerous and jays range over a wide area. In the midlands the partridge is fairly common and doves occur. On the coast large numbers of gulls and terns are found, also the eider-duck and the sea-eagle. There are very few reptiles or amphibians and the viper is the only poisonous species of snake. The rivers and lakes are generally well stocked with fish, such as salmon, trout, char, pike and perch, and fisheries, both fresh-water and sea, are of some consequence, though Baltic waters are less favourable to marine species than the open waters off Norway. Cod, flatfish, mackerel and sprat are caught, but great numbers of a small herring called *strömming* form the most important fishing product of the Baltic. In the brackish waters of the east coast salt-water and fresh-water forms are found. The crayfish is common in many places in central and southern Sweden and when tinned forms a valuable export. Pearls are at times found in a fresh-water mussel and oysters are dredged along the western Baltic coast. Among the lower marine animals a few types of arctic origin are found, not only in the Baltic but even in Lakes Vener and Vetter, having survived the changes consequent on the separation of the Baltic sea and Arctic ocean. Insect fauna is rich, even in the north, where very rare and brilliant butterflies are found. In summer in the northern lowlands the mosquito is sufficiently common to cause annoyance to the reindeer which it drives to the upper pastures.

POPULATION

People.—The population of Sweden at the 1920 census was 5,904,489 (est. Dec. 1926—6,074,368). Public registration is in the hands of the clergy and, particularly in large parishes, encroaches largely upon their time, but it results in much of that close contact between Church and people which is such a marked feature of Swedish life. A general census is taken every 10 years and approximate returns are made annually.

The table in the next column shows the distribution of estimated population in 1926 in the several governments (*Län*). The older "province" divisions differ from the *län,* but their names remain in common use.

The previous approximate totals were: 1750, 1,780,000; 1800, 2,347,000; 1850, 3,482,000; 1900, 5,136,000. The average annual increase was 7·86 per 1,000 in the 19th century, reaching a maximum of 10·39 in 1841–60; in 1920 it had fallen to 6·9. Emigration, especially to the U.S.A., increased rapidly from 1860 onwards with a maximum during the period 1881–90 (average 37,640 per annum). From 1921 to 1926 the total has oscillated about 11,000 per annum, but reached nearly 30,000 in 1923. The immigrants are usually considerably fewer, but they exceeded the emigrants during the World War and in 1920. Men predominate among the emigrants and partly explain the unequal number of the sexes resident in Sweden. In 1920 there were 3,006,2[illegible]3 females and 2,898,256 males. The Swedish people belong to the Scandinavian race, but the population included (1920) about 30,000 Finns and 7,200 Lapps, living in the north. The population is as a whole homogeneous.

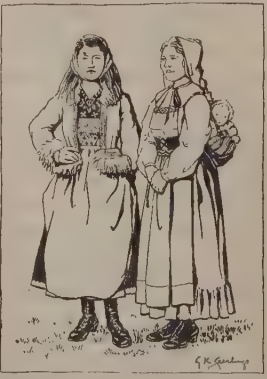
Population is denser in the south than in the north; in 1926 Malmöhus Län had about 269 persons per sq.m., but in Norrland there are less than 11 persons per sq.m. However, the increase in Norrland has been important. The annual excess of births over deaths in 1926 was 31,053 or 5·12 per thousand. The death rate was only 11·75 per 1,000 in 1926. The lowest mortality is found in the southern districts; the highest in the northern and the east midland districts. The percentage of illegitimacy (14·9% of total births in 1926) is tending to decrease; the percentage of married persons is low. Previously, social evils were associated with intemperance. In 1775 Gustavus III. made the manufacture of spirits (*brännvin*) a Government monopoly, and the drinking habit was actually fostered. By 1830 some nine gallons of spirits were consumed annually per head. Mainly through the efforts of Peter Wieselgren, dean of Gothenburg (1800–77), a strong temperance reform movement set in, and in 1855 restrictive liquor laws were passed. Municipal control of intoxicants was devised in Falun (1850) and applied to Gothenburg (1865). By 1910, prohibition had become popular but in 1922 a plebiscite was against it. Dr. Ivan Bratt's system eliminates many evils of alcohol and has led to legislative control of the trade.

Old provinces	Län	Area sq. m.	Pop. 1926
Norrland—			
Lappland, Norrbotten	Norrbotten	40,742	192,441
Lappland, Vesterbotten	Västerbotten	22,755	198,044
Ångermanland, Medelpad	Västernorrland	9,858	274,373
Jemtland, Herjedal	Jämtland	19,975	136,507
Helsingland, Gestrikland	Gävleborg	7,617	278,523
Svealand—			
Dalarne (Dalecarlia)	Kopparberg	11,589	252,865
Värmland	Värmland	7,427	270,846
	Örebro	3,561	222,071
Västmanland	Västmanland	2,608	164,487
Nerike	Södermanland	2,630	191,785
Södermanland	Uppsala	2,051	140,030
Uppland	Stockholm dist.	2,988	263,043
	Stockholm, city	53	453,332
Götaland—			
Östergötland	Östergötland	4,265	310,493
Vestergötland	Skaraborg	3,274	245,428
Dal	Älvsborg	4,915	311,183
Bohuslän	Göteborg och Bohus	1,949	444,022
Halland	Halland	1,900	149,757
	Jönköping	4,448	231,497
Småland	Kronoberg	3,826	157,702
	Kalmar	4,456	231,455
Blekinge	Blekinge	1,173	147,951
Skåne	Kristianstad	2,493	245,579
	Malmöhus	1,871	503,997
Gottland	Gottland*	1,220	56,957
Öland†	..	..	..
Total		173,154‡	6,074,368

*The island and adjacent islets.

†Island included in Kalmar Län.

‡Including the four great lakes, Vener, Vetter, Mälar, Hjelmar, 3,510 sq. miles.



BY COURTESY OF SWEDISH STATE RAILWAYS

DALECARLIA PEASANTS IN WINTER COSTUME

The Swedes probably possess the purest Teutonic blood in existence; they are nominally light-hearted and vivacious. In the more remote parts of the country old customs are maintained and picturesque local costumes still worn, as in Dalecarlia (*q.v.*). Although the characteristic celebrations at weddings or periodical festivals are somewhat decreasing in favour, there are certain occasions such as Christmas Day and Midsummer, which are observed as holidays with much ceremony. Food in the midlands and south is plentiful and good; in the remoter parts of the north an unfavourable summer may mean a winter of scarcity or even famine; and in these parts meat is little used. Rye was extensively employed in the rural districts for the making of a hard bread in flat cakes (*knäckebröd*); it is now increasingly giving place to wheat. A formerly prevalent, but now decaying, custom among the better classes is that of beginning meals with a selection of such viands as anchovies, smoked salmon or slices of meat, of which a large variety of small quantities are provided (*smörgås-*

bord). These are taken with bread and butter and a glass of spirits. Swedish national games have been revived considerably during the 20th century. These include ski-running (*skid-löpning*), skating and skate-sailing, tobogganing, sledging and sailing. The Royal Swedish Yacht Club (Stockholm) is the largest in the world. Among games, lawn-tennis and football, together with the game of *pärk*, peculiar to Gottland, are played.

Towns.—Up to 1860 the percentage of urban population remained nearly stationary at about 11. Its subsequent figures have been 1880, 15·12; 1900, 21·49; 1926, 31. The towns with a population exceeding 25,000 in 1927 are Stockholm (453,332), Göteborg (231,213), Malmö (116,827), Norrköping (60,400), Hälsingborg (52,470), Gävle (39,418), Örebro (36,463), Borås (33,544), Eskilstuna (30,655), Uppsala (30,156), Jönköping (29,996), Linköping (29,165), Västerås (29,059), Karlskrona (27,188). Stockholm shows the greatest increase during the 20th century—over 150,000.

CONSTITUTION

Constitution and Government.—Sweden is a limited monarchy, the Constitution resting primarily on a law (*Regeringsformen*) of June 6, 1809. The executive and judicial authority is vested in the king alone but his resolutions must be taken in the presence of the Council of State (*statsrådet*). The councillors, appointed by the king, are responsible to the parliament (*Riksdag*). At present they are 12 in number, one being prime minister (*statsministern*) two others consultative ministers, without portfolio, and the remaining nine are heads of the departments of administration, which are justice, foreign affairs, defence, social affairs, communications, finance, public worship and education, agriculture, commerce. Administrative posts are in principle equally open to men and women. Holders of Government offices are appointed by the king on the advice of the Council of State. Apart from a very few exceptions, none may be dismissed except in case of default and after trial and judgment. The king shares legislative powers with the Riksdag, possessing the rights of initiation and absolute veto. He has also, in certain administrative and economic matters, *e.g.*, the police system, a special legislative right. The general tendency in the constitutional system of Sweden, however, since 1809 has been to restrict the influence of the Crown in favour of the Riksdag.

The Riksdag consists of two elected chambers. The members of the upper chamber are elected by the *landsthing* (representatives of the *län*) and by the municipal councils of the larger towns. They number 150, and are distributed among the 19 constituencies in proportion to population; the distribution being revised periodically. Eligibility necessitates Swedish birth, an age of at least 35 years, and the possession, at the time of election and for three years previously, either of real property to the value of 50,000 kronor (£2,777), or an annual income of 3,000 kronor (£166) on which taxes have been paid. Members are elected for eight years. The members of the second chamber number 230, chosen in 28 election areas and elected for four years. The members of both chambers receive travelling expenses to and from the Riksdag, together with a salary for 140 days. The salary 24 kronor or 32 kronor a day is dependent on the place of home residence. The franchise was for long extremely limited, but it is now universal for men and women over 23 years of age. The agreement of both chambers is necessary before a bill is sent forward for royal assent, but when they differ on taxation questions—for which the Riksdag alone has the power of decision—the matter is settled by joint voting, which arrangement gives the second chamber a certain advantage from the greater number of its members. A feature of the Riksdag is the numerous standing committees, controlling the army, navy and other departments.

Local Government.—Sweden is divided into 25 administrative districts or *län* (*see* population statistics). The elected representative body in each is the *landsthing*, which deliberates on the more local affairs of the *län*. The chief official of the *län* is the governor (*landshöfding*) under whom are secretarial, police and fiscal departments. Seven privileged towns, receiving their privileges from the Government (not necessarily on the basis of present population), are under a mayor (*borgmästare*) normally a professional lawyer, and aldermen (*rådmän*). The aldermen are elected by the citizens, while the mayor is appointed by the Government from the first three aldermen on the poll, is paid and holds office for life. The city of Stockholm (*q.v.*), a *län* in itself, has a special form of government. The major rural divisions are the 119 *fögderier*, under bailiffs, a subdivision of which is the *länsmansdistrikt* (489 in all), under a constable.

Justice.—Justice is administered by tribunals of three instances (1) District and borough courts. There are 125 rural judicial circuits (*domsagor*), which may be subdivided into judicial divisions (*tingslag*). Each *tingslag* has a district court (*häradsrätt*), consisting of a judge and 12 unpaid assessors (*nämndemän*), elected by the people for a period of six years. If all jurors present are unanimously of a different opinion from the judge, they can outvote him. The town-courts in the privileged towns are called *rådhusrätt*, and consist of the mayor and at least two aldermen; they are without jurors and therein differ from the district courts. (2) There are three courts of appeal (*hofrätter*), in Stockholm, Jönköping and Malmö. (3) The Supreme Court (*Högsta Domstolen*) passes sentences in the name of the king, who is nominally the highest judicial authority. The court, which meets at Stockholm, has a membership of 24 justices (*justitieråd*). The Law Council (*Lagrådet*) which consists of three high court judges and one member of the Supreme administrative Court (*Regeringsrätten*) examines all legislative bills before they are laid before the Riksdag.

Religion and Education.—The non-Protestants number but about 11,000, 6,500 Jews, 3,500 Roman Catholics, and more than 99% of the total population belong to the Swedish Lutheran Church, of which the king, who must profess the pure evangelic creed, is the supreme administrator. Sweden is divided into 12 dioceses (with Uppsala, since 1164, as the Metropolitan see) and 188 rural deaneries. The parishes number 2,588, united into 1,419 rector's districts. All citizens contribute to the Swedish Church, in consideration of the secular duties of the priests. Contributions may be reduced for those who support another Church which is legally recognized. Since 1842 public elementary education has been free and compulsory, and, in the case of children not attending the state schools, the parents must show proof that they are being privately educated. There were (1928) 77 public secondary schools, 53 people's high schools, various technical and special schools. Sweden has two old universities, at Uppsala (founded 1477) and Lund (founded 1668); there are State faculties in certain branches of learning at Stockholm and Göteborg.

BIBLIOGRAPHY.—The Government of Sweden has a statistical department which publishes a number of annual volumes. For an extensive list of these and also of non-official publications relating to Sweden *see* the *Statesman's Year Book*, issued annually (London). An annual statistical summary is also issued, *Statistisk Årsbok for Sverige.* The Swedish Government also published, in 1914, *Sweden:* Historical and Statistical Handbook by J. Guinchard. (There are Swedish, English and German editions.) The two large volumes give a comprehensive account of geographical, historical and economic aspects of the country, and largely replace *Sweden; its People and its Industry* (edit. G. Sundbärg) which the Swedish Government had issued previously (English ed., Stockholm, 1904). *The Sweden Year Book* (annual) edited and published with the assistance of public authorities, includes a very extensive bibliographical section. An important British publication is *A Handbook of Norway and Sweden,* compiled by the Geographical Section of the Naval Intelligence Division, Naval Staff, Admiralty (1920). *See* also Sten De Geer, *Befolkingens Fördelning i Sverige* with maps on a scale 1/500,000 (Stockholm, 1919); maps and year books, *Svenska Turistföreningen.* (W. E. WH.)

DEFENCE

Since Sweden, a province of Denmark from 1397 to 1521, became an independent kingdom, its military history has been marked by the accession to the throne in 1523 of the national hero Gustavus Vasa; by the accession to the throne in 1611 of Gustavus Adolphus (*q.v.*), the great leader who headed the Protestant cause in Germany and was killed at Lützen (*q.v.*) (Nov. 1632); by victory on the part of the Swedes over a Russian army at Narva (Nov. 1700) and defeat at the same hands at Pultowa

(July 1709), both in the reign of Charles XII., who after prolonged conflict was killed at the siege of Frederikshald (Dec. 1718); by the seizure of Swedish Pomerania by Napoleon in 1812, followed, in 1813, by the accession of the Swedes to the grand alliance against him; and by the cession of Norway to Sweden under the treaty of Kiel (Jan. 1814), an arrangement that endured until October 1905. Sweden did not rally to the cause of Denmark when attacked in 1864, and remained neutral in the Franco-Prussian war of 1870 and in the World War. Agitation by Norway for independence in 1892 led to the passage of acts for the reorganization of the army.

Present-day Army Recruitment and Service.—Liability for every male Swedish subject to perform military service begins in his 21st and ends with the commencement of his 43rd year. The yearly contingent up to 1935 is estimated at 37,700, of whom 31,360 are allotted to the army, 7,000 of them going direct to the reserve. Training of recruits lasts from 140 to 260 days. Special training for officers takes 2¾ years.

Strength and Organization.—The strength, including recruits, varies with the period of the year. The average can be taken at about 31,000, including 2,800 officers and about 2,000 non-commissioned officers who form a class apart from "other ranks."

There is a special committee of military training under an inspector, and the following establishments: (a) Royal military academy, Stockholm; (b) Royal ordnance and engineer academy, Stockholm; (c) Royal military college, Karlberg; (d) Riding school, Stromsholm; (e) Musketry school, Rosersberg; (f) Non-commissioned officers' school, Stockholm.

The Swedish air force consists of 4 groups of aeroplanes and 318 recruits are trained annually, including volunteers.

See also League of Nations *Armaments Year-Book* (Geneva, 1928). (G. G. A.)

Navy.—Sweden has to face the numerically formidable, if inefficient, fleet of Soviet Russia across the Baltic.

Sweden possesses eleven coast defence battleships, three being comparatively modern. These latter are the "Sverige," (7,600 tons), and the "Drottning-Victoria" and "Gustaf V." each of 7,900 tons. These carry four 11" and eight 6" guns. Other ships are: 1 old armoured cruiser, 10 destroyers, 27 torpedo boats, 17 submarines, 3 miscellaneous craft.

A new type of coast defence ship is projected and two new destroyers and two new submarines are building. The personnel consists of about 5,500 officers and men, recruiting being conscriptive.

See *Brassey's Naval and Shipping Annual;* F. T. Jane, *Fighting Ships.* (E. A.)

ECONOMIC CONDITIONS AND TRADE AND COMMERCE

Not quite one-third of the population live in the towns. About 44% now earn their living by agriculture compared with 70% fifty years ago. Within the same period the industrial population has increased from 15% to 35% and the population living by trade and communications from 5% to 15%.

The cultivated soil is only 9·3% of the whole; about 2% consists of natural meadowland. About 60% is covered by forests, principally pine-forests; the rest is mountain and barren land. The cultivation of corn—especially of wheat—is practised most in the southern provinces, while cattle-raising is easily predominant in the north. What used to be fallow-land is used for fodder roots. In Skåne sugar-beet is grown. The wheat produced per acre is exceeded only by Denmark, the Netherlands, Belgium and Great Britain. About 200,000 tons of wheat are imported annually. But although Sweden is not self-sufficing in grain, there are considerable surpluses of butter and bacon (in 1927, 18,500 and 26,700 tons respectively), which are exported, chiefly to England. But oil-cakes and other "strong food" are imported. Small farms of less than 20 acres take up about 33% of the whole cultivated area; those of medium size of from 20 to 100 acres about 45%; the farms of over 100 acres take up the rest. Of all the land in private ownership, about one-fourth is held on lease.

Forestry.—The forest-industry is chiefly in Norrland, *i.e.*, in the region north of the 60th degree of latitude. The winter snows facilitate the transport of the felled tree-trunks, and over the waterways they can be transported inexpensively to the saw-mills and factories on the coast. The length of floating ways is nearly 20,000 English miles. The annual consumption of timber from the Swedish forests is estimated at 45 million cubic metres (nearly 1,600 million cubic feet). Of this nearly half is exported as deals, battens, box-boards, and pulp. Charcoal is still used for iron production. Pit-props are exported to England. The forests are beginning to be exhausted and there is systematic afforestation. A balance is now preserved between the growth of the forests and the cutting down. The exportation from the saw-mills amounts annually to from 4 to 5 million cubic metres (about 1,000,000 standards). The greatest consumer is Great Britain.

Wood Pulp.—The manufacture of pulp, mechanical as well as chemical (sulphite as well as sulphate) has long been in progress on an increasing scale. It now (1928) reaches nearly 2 million tons (dry weight) annually. The exportation of it for 1927 was about 1,450,000 tons (dry weight) of which 80% was chemical and 20% mechanical. Of all the mechanical pulp produced by the world about one-fourth comes from Sweden, and of the chemical about one-half. Pulp is exported and used for making paper.

Out of a production of about 500,000 tons in 1927 there were exported over 400,000 tons of paper. The principal customers are Great Britain and the United States. The export of the wood products in 1927 represented a value of £40,000,000, equal to 45% of the country's entire exports.

Fuel and Power.—Only in the north have coal deposits been found, in which about 400,000 tons of coal are hewn annually with fireproof clay. The import of coal is high; in 1927, the figure was 5,900,000 tons, chiefly from England. As fuel, wood and peat are used. The waterfalls could produce up to 4,500,000 horse-power. Of this about 1,400,000 is taken into use. A number of power-works distribute electric energy. The largest power-works, those at Trollhättan on the Götaälv, Älvkarleby on the Dalälv and Porjus on the Luleälv in Lapland, belong to the State.

Minerals.—Sweden's iron deposits are amongst the richest in the world. They consist of the mines in central Sweden, *Bergslagen*, long worked, and of the later mines in northern Lappland, Kirunavaara, Luossavaara, etc. The former, which contain a singularly pure iron, are used principally by Sweden herself. The Lappland mines, the iron of which is phosphorus-bearing but very rich (60 to 70% iron), are worked for export. Of Europe's total resources in high percentage iron-ore more than 90% is to be found in these Lappland mines. Proprietorial rights belong to the Swedish State and to the Grangesberg company in common, but the industry is in the hands of the company only. The export of iron ore, chiefly to Germany, amounted in 1927 to 10,700,000 tons.

In the 18th century Sweden took first place among iron-producing countries. The use of coal changed this pre-eminence. As regards quality, however, Swedish output is unsurpassed. After the World War, production went down greatly. Pig-iron manufacture amounted in 1927 to only 413,000 tons, steel manufacture to only 517,000, compared with 730,000 and 750,000 respectively in 1913. The exportation of iron has decreased from 480,000 tons in 1913 to 263,000 in 1927.

Machinery.—The making of machinery has been developed, for instance, separators, motors, electrical machines and apparatuses, agricultural machines, ball bearings, etc. Minor iron articles, also, such as cutlery, enamelled vessels and other household things made of iron, are being exported on a large scale. The shipbuilding industry also has gone ahead strongly of recent years. The export of iron products amounted to about £15,000,000 in 1927.

Other Industries.—There is a preparation of granite for road-making and building purposes, and the cement industry. Beet-sugar also is refined. The match industry has been merged into one single Trust (*Svenska Tändsticksaktiebolaget*). This organisation now covers the whole world and, with the help of English and American capital, controls the production of matches in most countries.

Actual industries, apart from hand-work and building operations, employ about 400,000 workers (in 1900, the number was 296,000).

The value of the foreign trade per inhabitant is about half that in Great Britain. Imports amounted in 1927 to £86,700,000, exports to £88,700,000. Ordinarily the excess is on the side of imports. Of exports in 1927, pulp and paper represented 26%, wood products 18%, metal-work and machinery 17% and iron ore 9% of the value of the total exports. The greatest consumer of Swedish products is Great Britain (28%); next come Germany (17%) and the United States (11%). From these same countries Sweden obtains the bulk of its imports but here Germany occupies the first place.

Before the World War as a general rule much capital came into Sweden from abroad, the country's own command of capital being inadequate for the great activity manifested in the building of railways, the construction of industrial plants, etc. But the war turned Sweden into a great exporter of capital. At the moment, the imports and exports of capital seem to maintain a balance. Sweden's policy is moderately protective. There has been little increase of tariff since the war.

Shipping.—About half Sweden's imports and exports are transported on Swedish tonnage, about half on foreign tonnage. Her commercial navy has grown greatly since the beginning of this century. It amounts now to nearly 1,500,000 tons register gross, of which 93% is represented by steamers and motor-vessels.

Internal Communication.—Sweden possesses a highly developed network of railways, the beginning of which dates from the 1850's. The total length of the lines amounts to about 10,000 English miles. In proportion to the population this is the highest figure reached by any European country. About 3,700 miles belong to the State. Their total freight revenue exceeds that of all the other railways. By means of ferry-steamers the Swedish State lines are in direct communication both with Germany (Trälleborg-Tassnitz) and with Denmark (Malmö-Copenhagen and Hälsingborg-Hälsingör).

The number of telephones in Sweden amount to 440,000, *i.e.,* 1 to 14 inhabitants; the corresponding figures in Great Britain are 1 to 40. Swedish firms have been employed in setting up and managing central telephone establishments in other countries.

Finance.—Sweden's financial system since the year 1873 has been on a gold basis, the counting-unit being one krona, which is divided into 100 öre. £1 equals 18·16 kronor. There is no actual circulation of gold but the ordinary method of payment is in notes issued by the Riksbank. During the war, in Sweden as in other European countries, the redemption of notes was suspended. Their value sank to a certain degree in relation to gold, in the year 1920 down to 40%. There was then a rapid movement up again, followed by a heavy fall in prices, and on April 1, 1924, the redemption of gold was brought back definitively to par. Sweden was the first country in Europe thus to restore her gold currency after the war to its pre-war basis.

The Riksbank, which is the central bank of the country (and the oldest in Europe, with a history going back to 1668), is a State bank, pure and simple, and since 1904 has had a monopoly in the issuing of notes. Of its board of directors, one member, who is also chairman, is appointed by the king, and six members are appointed by the *riksdag*. Commercial banks began to come into existence in the 1830's, at first in the form of companies with joint responsibility. Bankers of this type had the right to issue notes down to 1904. Some of them are still in existence; the most prominent of them is Stockholms Enskilda Bank. Most of the commercial banks of more recent origin, however, have taken the form of joint stock companies. A strong concentration movement has of late been in progress in the banking world, whereby the total number of banks has been reduced from 80 in 1910 to 31 in 1928. Four large banks have come into existence, namely, AB Svenska Handelsbanken, Skandinaviska Kredit AB, AB Göteborgs Bank, and Stockholms Enskilda Bank, which handle about two-thirds of the commercial business. Their capital and funds amounted in 1927 to about £26,400,000 and their turnover to about £174,000,000. The Swedish commercial banks do not as a rule (like the German banks) found new businesses.

There are nearly 500 savings banks, apart from the State's post office bank. The deposits handled by these are about £160,000,000.

Revenue.—The State's revenue and expenses for the Budget year of 1927–28 balanced on a sum of about £39,000,000. Of this about £37,000,000 was made up of taxes and other real State revenue, the rest of loans. Of the former something over £11,000,000 comes from taxes on income and property, about £18,000,000 from customs and excise, the rest mostly from profits on State enterprises and from productive funds. The State's debts amount to about £100,000,000. Formerly the funded State's debts were placed abroad but the repurchase of Government bonds has taken place on a large scale, and State loans have been taken up at home. Of all the State debentures about 80% may be in Swedish hands. The yearly interest paid on the State debt, £4,700,000, is covered by productive activities bringing in about £5,700,000. During 1913–14 the State's taxation revenue amounted to 62%, that of the local authorities to 38% of the total taxation. According to the latest figures the proportions were 55 to 45. The burden of debt which rests on the local authorities amounts to about £70,000,000. (K. Å.)

HISTORY

The first historical notice relating to Sweden is found in Tacitus, *Germania,* cap. 44, in which we find the name of the chief people of the peninsula, the Swedes proper, Suiones (O.N. *Sviar,* Swed. *Svear,* A.S. *Sweon*), who eventually gave their name to the whole country. According to Tacitus they were governed by a king whose power was absolute, and possessed a strong fleet which secured them from hostile incursions. Their original territories lay on both sides of the Mälar, in the provinces later known as Upland, Södermanland and Westmanland. Other early Roman writers, Mela and Pliny, mention the country under the name Skäne. (*See* SCANDINAVIAN CIVILIZATION.)

The people next in importance to the Suiones in the peninsula (Swed. *Götar,* O.N. *Gautar,* A.S. *Geatas*) are first mentioned by Ptolemy (under the form Goutai for Gautoi). He puts them in the southern part of the country. Götaland consisted of Vestergötland and Östergötland divided from one another by Lake Vetter, together with Småland. In early times Vestergötland seems to have been the most important; Vermland, the district to the north of Lake Vener and the whole of the country to the north of Svealand seem to have been of small importance. Jämtland was always considered a part of Norway. After the time of Ptolemy we hear no more of Sweden until the 6th century, when a surprisingly full account of its peoples is given by the Gothic historian Jordanes. He speaks of trade in furs of arctic animals which were sold by merchant to merchant until they reached Rome.

For the same period information is to be found in the Anglo-Saxon poem *Beowulf.* The hero himself belonged to the Geatas (*i.e.,* in all probability Götar), his mother being the daughter of their king Hrethel. Haethcyn, Hrethel's son, is said to have perished in a disastrous battle against the Svear, but his fall was avenged by his brother Hygelac in a subsequent engagement in which the Swedish king Ongentheow was killed. This Hygelac is clearly identical with that Chochilaicus wrongly described as a Danish king by Gregory of Tours (iii. 3) who died in battle with the Franks under Theodberht about A.D. 520. We learn further that about the time of Hygelac's death strife broke out in the royal family of the Svear, between Onela, the son and successor of Ongentheow, and Eanmund and Eadgils, the sons of his brother Ohthere. The latter fled for protection to the Götar and the war which ensued cost the lives of Eanmund and of Heardred the son and successor of Hygelac. According to the poem, Beowulf himself became king of the Götar, but Beowulf's later history has a mythical character, and for three centuries after this time we have no reference to Swedish affairs in English or other foreign authorities. The kingdom of the Götar probably ended soon after the 6th century.

At a later time the kings of Norway claimed descent from the ancient royal house of the Svear, and their traditions, though in great part mythical prove at least its high antiquity. They trace back its origin to the god Frey, son of Niörðr, who is said to have founded Uppsala, the ancient capital of Sweden. Among his descendents Athils, the Eadgils of *Beowulf*, is a prominent figure and, in general, the account given of him agrees with *Beowulf*.

Early Kings.—Four generations after his time a king named Ingialdr was overthrown by a prince from Skåne, called Ivarr Viðfaðmi. His son Olafr Trételgia withdrew to Vermland, which he brought into a state of cultivation, though he was subsequently sacrificed by his subjects in a time of famine. The sons of Olafr Trételgia moved westward into Norway, and if we may trust later traditions Sweden passed out of their family. The subsequent kings of Sweden are said to have been descended from Ivarr Viðfaðmi. About 830 the missionary bishop Ansgar made his way to Birca on the Mälar. For more than a century after Ansgar's death no serious mission seems to have been attempted.

During the 9th century extensive Scandinavian settlements were made on the east side of the Baltic. The famous expeditions of Rurik and Askold which resulted in the origin of the Russian monarchy appear to have taken place towards the middle of the century, but it is not possible to connect these names with any families known to us from Swedish tradition. Many names in Russian chronicles seem to be Swedish.

The continuous history of Sweden begins in the early 10th century, when a king named Eric son of Emund was reigning at Uppsala. Before the end of the century his descendent Olaf Skötkonung had created what for the moment was the strongest kingdom in the North. Under him Christianity was established in Sweden. As a leading ally in a coalition which included Sweyn king of Denmark and earl Eric of Lade he overthrew Olaf Tryggvason, king of Norway, and annexed for a time part of Trondhjem and the district now called Bohüslan which he handed over to earl Sweyn, brother of earl Eric as a marriage portion for his daughter Holmfrið. Some years later another Norwegian prince, Olaf Haraldsson (the Fat), returning to Norway as king, put an end to the Swedish and Danish supremacy, and in 1015 forced earl Sweyn to leave the country. An attempt to arrange a marriage alliance between Olaf Skötkonung and the new king of Norway was unsuccessful, and the relations between these kings were still strained when the former died probably in the winter of 1021–2.

Anund, his son, early in his reign allied himself with Olaf Haraldsson against Canute of Denmark, who had demanded the restitution of the rights possessed by his father Sweyn in Norway. The allies took advantage of the Danish king's absence to harry his land. On his return an indecisive battle was fought at Helgi Å, and Anund returned to Sweden. Olaf was driven from Norway by the Danes, but in 1030 he raised a small army in Sweden only to meet his death at the battle of Stiklestad. Adund, who died about 1050, according to Adam of Bremen, was succeeded by his brother Emund the Old, who had been previously passed over because his mother was unfree, the daughter of a Slav prince and captured in war. This king had become a Christian, but soon quarrelled with Adalhard, archbishop of Bremen, and endeavoured to secure the independence of the Swedish church, which was not obtained for another century. Under Emund there was a rectification of boundaries which assigned Blekinge to Denmark.

With his death in 1060, the old family of Swedish kings dies out. He was succeeded by his son-in-law Steinkel, a noble of Vestergötland, who was warmly attached to the Christian religion, though he refused to destroy the old sanctuary of idols at Uppsala. During his reign grants of land in Vermland made by the king to the Norse earl Haakon Ivarsson led to a successful invasion of Götaland by Harold Hardrada of Norway. Steinkel also had disputes with Denmark. His death in 1066 was followed by a civil war, and for the next fifteen years the history of Sweden is very obscure. In 1081 we find the sons of Steinkel, Inge and Halstan reigning. Inge's attachment to Christianity caused him to be expelled after a short time by his brother-in-law Sweyn or Blotsweyn, so called from his revival of the old sacrifices, described by Adam of Bremen. Sweyn retained the kingship only for three years before Inge returned and slew him.

Bibliography.—Tacitus, *Germania*, cap. 44; Claudius Ptolemaeus, *Geographica* ii., 11 *ad fin.*; Jordanes, *De origine actibusque Getarum*, cap. 3; Procopius, *De bello gothico*, ii. 15; *Beowulf*, Rimbertus, *Vita S. Ansgarii in monumenta Germaniae historica*, ii. (Hanover, 1829); King Alfred's translation of *Orosius* i. 1. Adam of Bremen, *Gesta hammaburgensis ecclesiae pontificum* iii. and iv.; *Ynglinga Saga*, with the poem *Ynglingatal* contained in the *Heimskringla; Olafs Sagan Tryggvasonar* and *Olafs Saga hins Helga*, both contained in *Heimskringla* and in *Fornmanna sögur; Saxo grammaticus, gesta Danorum;* a collection of later Swedish Chronicles contained in *Rerum suecicarum scriptores*, vol. iii. (ed. Annerstedt, Uppsala, 1871 and 1876); Thomsen, *The Relations between Ancient Russia and Scandinavia and the Origin of the Russian State* (1877); J. Stefansson, *Hist. of Denmark and Sweden* in *Story of the Nations* Series (1916); *Sveriges historia*, vol. i. (Montelius and Hildebrand, Stockholm, vol. 1. 1919, vol. 2. 1925).

Organization of the Kingdom.—Under Blotsweyn's grandson, King Sverker (1134–1155), who permanently amalgamated the Swedes and Goths (each of the two nations supplying the common king alternately for the next hundred years), Sweden began to feel the advantage of a centralized monarchical government. Eric IX. (1150–1160) organized the Swedish Church on the model prevalent elsewhere, and undertook a crusade against the heathen Finlanders, which marks the beginning of Sweden's overseas dominion. Under Charles VII., the archbishopric of Uppsala was founded (1164). But the greatest mediaeval statesman of Sweden was Earl Birger, who practically ruled the land from 1248 to 1266. To him is attributed the foundation of Stockholm; but he is best known as a legislator, and his wise reforms prepared the way for the abolition of serfdom. The increased dignity which the royal power owed to Earl Birger was still further extended by King Magnus Ladulås (1275–1290). Both these rulers adopted the dangerous expedient of creating a number of almost independent duchies in Sweden, but the danger of weakening the realm by partition was averted, though not without violent complications. In 1319, the severed portions of Sweden were once more reunited. Meanwhile the political development of the state was steadily proceeding. The formation of separate orders, or estates, was pronounced by Magnus Ladulås, who extended the privileges of the clergy and founded an hereditary nobility (Ordinance of Alsnö, 1280). In connection with this institution we now hear of a heavily armed cavalry as the kernel of the national army. The knights too became distinguishable from the higher nobility. To this period belongs the rise of a prominent burgess class, as the towns now began to acquire charters. At the end of the 13th century, and the beginning of the 14th provincial codes of laws appear and the king and his council execute legislative functions.

Union of Kalmar 1397.—The first union between Sweden and Norway occurred in 1319, when the three-year-old Magnus, son of the Swedish royal duke Eric and of the Norwegian princess Ingeborg, who had inherited the throne of Norway from his grandfather Haakon V., was in the same year elected king of Sweden (Convention of Oslo). A long minority weakened the royal influence in both countries, and Magnus lost both his kingdoms before his death. The Swedes, irritated by his misrule, superseded him by his nephew, Albert of Mecklenburg (1365). In Sweden, Magnus's partialities and necessities led directly to the rise of a powerful landed aristocracy, and, indirectly, to the growth of popular liberties. Forced by the unruliness of the magnates to lean upon the middle classes, the king summoned (1359) the first Swedish *Riksdag*, on which occasion representatives from the towns were invited to appear along with the nobles and clergy. His successor, Albert, was forced to go a step farther and, in 1371, to take the first coronation oath. In 1388, at the request of the Swedes themselves, Albert was driven out by Margaret, regent of Denmark and Norway; and, at a convention of the representatives of the three Scandinavian kingdoms held at Kalmar (1397), Margaret's great-nephew, Eric of Pomerania, was elected the common king, but the liberties of each of the three realms were expressly reserved and confirmed. The union was to be a personal, not a political union. (X.)

THE 15TH AND 16TH CENTURIES

Danish Plans for Union.—The Swedish nobles who were dissatisfied with the evil rule of Albrekt of Mecklenburg called in Margaret, Valdemar Atterdag's powerful daughter and successor on the Danish throne, and she became queen of Sweden also in

1389. Norway was already united with Denmark and Margaret's plan was to bring all the three kingdoms together into a single union under Denmark. An Act of Union was drawn up at Kalmar in 1397 but was not proceeded with as the Queen was dissatisfied with some of its clauses. At the same time her relative, Eric of Pomerania, was elected future king of the three kingdoms. After Margaret's death in 1412 he assumed the Government and proceeded to try to change Sweden into a vassal country with the help of a system of Danish bailiffs. The consequent oppression became so hard that the Swedish peasants rose in 1434 under the leadership of Engelbrekt Engelbrektsson, a noble from Bergslagen. The national movement spread swiftly and the Danish strongholds were conquered. In the course of this fight for freedom Engelbrekt called together at Arboga, in Jan. 1435, the first *Riksdag* of nobles, priests, burghers and peasants. The *Riksdag* has never been done away with since, so that in 1935 Sweden's parliament will commemorate its 5th centenary. In 1436 Engelbrekt was murdered. For several decades a Party in favour of the Union, made up of the more important nobles and the clericals, with Danish support, proceeded to contend against a National Democratic Party under native leaders taken from the nobles. Danish kings were on several occasions recognized as rightful sovereigns also of Sweden, among them, for instance, Christopher of Bavaria (1440–48) in whose reign there was enacted in 1442 a new general law which, with additions, held good until 1734, and Christian I. (1457–64). In between, a Swedish nobleman, Karl VIII. Knutsson, was recognized as king during the years 1448–57, 1464–65 and 1467–70 (being twice expelled and twice re-instated). During the years that followed no native-born sovereigns were set up against the Danish kings, but the National Party was under the leadership of *Riksföreståndare,* or Regents, in the persons of members of the Sture family. After *Riksföreståndare* Sten Sture the Elder (1470–97) came the Danish King Hans (1497–1501), then Sten Sture again, (1501–03), and then Svante Sture (1504–12) and Sten Sture the Younger (1512–20). The times were troubled and there were continual struggles with the Danes. Many Germans lived in the towns. After a Swedish victory over the Danes outside Stockholm in 1471 an old ordinance by which the Germans should have half the seats in the town councils was abolished. The country now became impoverished but the national feeling grew stronger than ever alongside a hatred of Denmark which inspired Sweden's foreign policy for 300 years and which was caused by Danish intrigues against Sweden. Things came to a climax when the Danish king Christian II. conquered the country and in 1520 had the foremost men of the National Party in Stockholm executed ("The Stockholm Blood-Bath"). Among noteworthy events in this period may be mentioned the founding of Sweden's first university in Uppsala in 1477.

Gustavus Vasa, 1523–1560.—The Scandinavian Union was represented by the Danish king living in Copenhagen. Denmark and Norway held the south, and foreign trade lay in the hands of the German Hanseatic League. Sweden was a land of peasants, divided by provinces, and inspired by all the local patriotism that troublous times evoke. The Uppsala university had deteriorated, and the affairs of the Catholic Church had long been neglected by the Holy See.

A young Swedish nobleman, Gustavus Eriksson Vasa, who had been treacherously carried off to Denmark as hostage and prisoner, in 1519 made his escape to Lübeck, where he won good friends. At the end of May 1520 he landed again in Sweden near Kalmar, and quickly learnt of the massacre in Stockholm, in which his father and brother-in-law had perished. He made his way up to Dalarna where he raised his first peasant troops. He had neither arms nor money, but one province after another came to his support. Archbishop Gustav Trolle was his foremost opponent but had to take flight from Sweden. Gustavus formed an engagement with Lübeck, which sent ships with arms and soldiers. In June 1523 Gustavus was elected king of Sweden by an assembly in Strängnäs, and Stockholm surrendered to him.

But it was not easy to guard what had been won. Lübeck had secured for herself a monopoly of Sweden's foreign trade as well as exemption from tolls and bonds for very considerable sums in payment for services rendered. Drastic taxation had to be imposed, and the churches and monasteries also were requisitioned for help. Archbishop Gustavus Trolle was a fugitive and the Swedish Church found itself in a state of dissolution. Gustavus Vasa's first appeals to the pope were for bishops of Swedish birth, a new archbishop, and church reformation. No favourable response came from Rome and in these circumstances the king was influenced by Lutherans. The New Testament was translated into Swedish. At the *Riksdag* held in Västerås in 1527 the church settlement decreed that the bishops had to hand over their castles to the king, and the chapters and canons, moreover, their superfluous incomes; that Peter's Pence should no longer be paid to the pope and that the pope's authority should not be invoked for the election of bishops. The year afterwards the king was crowned in the cathedral of Uppsala.

Gustavus Vasa had to defend the interests of the kingdom against the individual claims of the provinces. The peasants had become disturbed by the novelties of the Reformation, and an adventurer came upon the scene, declaring he was Sten Sture's son. Disturbances broke out but the king put them down with severity. Christian II. had been driven out of Denmark, also and this produced a rapprochement between Sweden and Denmark. Finally Christian was incarcerated in a Danish prison in 1532. Lübeck's privileges had come to be intolerable; on one occasion every church was called upon to hand over its largest bell to supply means for meeting the Lübeck liabilities. This caused a rising in Dalarna, and Lübeck declared war on Denmark and Sweden. They and their German allies took Copenhagen and Malmö. They could not hold out, however, and in 1536 peace was declared. In the following year a treaty was framed between Sweden and Lübeck regarding certain exemptions from tolls but without trade monopoly. Sweden's debts were declared to be settled.

King Gustavus had now to organize administration. He heard talk about Roman law as the basis of all law. He consequently called in a great number of Germans, so that the years 1538–44 came to be known as "the German period"; but the Germans were for the most part adventurers and the results were not satisfactory. The newcomers caused the king to distrust his earlier helpers. There was a dangerous outbreak in Småland, which was led by a peasant, Nils Dacke, who was killed in 1543. The influence of the Germans then ceased, and Gustavus ruled alone. He devoted great attention to mining, trade and agriculture. An influential landed nobility was restrained. At the *Riksdag* meeting of 1560 the king presented his testament. He died on Sept. 30 of that year, aged 63. He was the founder of the new Sweden.

Erik XIV., 1560–1568.—Gustavus Vasa's eldest son succeeded. Scholarly, display-loving, wayward, he ruled well at first but became insane. Gustavus had bestowed on his other sons dukedoms which entailed discords between them. On the occasion of his coronation Erik created the ranks of counts and barons but he was mistrustful of the nobles, upon whom he imposed great exactions. He entered into negotiations for marriage with Queen Elizabeth and afterwards with Mary Stuart, as well as with two princesses on the Continent, but met with refusals. Towards the close of his reign he married his low-born mistress, a good-hearted woman, Karin Månsdotter.

When the Teutonic Knights of Estonia and Livonia ceased to be, the town of Reval and the neighbouring region went over of their own accord to Sweden. This was the first step towards a Swedish sovereignty over the Baltic south of the Bay of Finland. The situation pointed ominously to coming conflicts, for Russia took Narva, the Danish Duke Magnus took Ösel, and Poland took a large portion of the Teutonic Knights' country.

A break with Poland resulted in internal dissensions, as Erik's brother, Johan, who was duke of Finland, married Katerina, the sister of the Polish king, Sigismund Augustus, and as security for a loan to his brother-in-law got some Polish castles in Livonia. A brief civil war took place. Erik's troops took Åbo, and Johan and Katerina were put in prison, after being tried and sentenced by the *Riksdag*. Negotiations were entered into with Ivan the

Terrible in Russia and ended with a proposal for a treaty containing the condition—a blot upon Erik's name—that Duke Johan's wife should be handed over to the tsar, evidently to be used as a means of enforcing concessions from the Polish king. The shameful clause may be ascribed to Erik's madness and was never enforced. A severe conflict ensued with Denmark who wished to have the Union preserved and kept Sweden's "Three Crowns" in her coat of arms. Erik wanted to break the cordon in the south and would not recognize Denmark's claims to supremacy over the Baltic. He ostentatiously added the Danish and Norwegian kingdoms' arms to his own. Other disputes followed, and war resulted in 1563. The Swedish fleet won victories but the Danes had the mastery in the war on land which was waged on both sides with grim ferocity. Lübeck and Poland allied themselves with Denmark. In 1567 Erik's insanity became manifest. He had some of the foremost nobles imprisoned, murdered one of them himself, and had others of them assassinated. He became penitent and set free Duke Johan, who, in alliance with the younger brother Karl and the nobles, dethroned and imprisoned Erik in 1568. He died in prison in 1577.

Johan III. (1568–92), an amiable man, learned in theology, but irresolute and weak, was acclaimed king. The Danish war died a natural death through the economic attrition of both Powers, and in Dec. 1570 peace was declared at Stettin through Polish and French mediation; the frontiers remained the same as before the war. Gottland was allotted to Denmark; Älvsborg on the west coast was to be surrendered by Sweden with a large sum of money; the question of the Three Crowns was left for later decision but in the meantime Denmark was free to incorporate them in her arms, whilst, on the contrary, the Danish and Norwegian arms were to be taken out of the Swedish coat of arms. Sweden's gain consisted in the fact that from this time forward she was to be considered Denmark's equal as a Baltic State. Between Sweden and Poland good relations sprang up at once but war broke out with Russia, waged with changing fortunes and occasionally interrupted by armistices. In the result the whole of Estonia, with Narva, was incorporated with Sweden.

The great religious struggle in Europe was followed with interest by Johan, who sought to take up a mediative rôle and entered into negotiations with the pope. Both papal and Spanish envoys came to Sweden, and it looked as though the king would go over to the Catholic church, but when the pope refused to accept his offer of mediation he changed his tone and entered into definite opposition to Rome. He had previously given out a liturgy which evoked general displeasure in Sweden by its approach to the Catholic form of religious services, and taken as a whole his religious measures caused great unrest. His son Sigismund adopted the Catholic faith and was elected king of Poland in 1587. The internal administration of the country was marked by continual lack of funds (despite high taxation) and at the same time by extravagance over new buildings. Falls in the currency made the matter worse. The nobles were rewarded by special privileges for their part in the overthrow of Erik—a departure from the more democratic policy of Gustavus and Erik. The nobles now showed a tendency to aggrandize their powers but the peasants never became serfs and the *Riksdag* of the four estates continued to be called together. There were serious complications when Johan died in 1592.

Charles IX.—The crown went to Sigismund, who was scantily gifted, obstinate, and a devoted servant of the Catholic Church; his uncle Charles on the other hand was a practical man of affairs, passionate and hard. The evangelical learning had taken still stronger root, and at a Church meeting in Uppsala in 1593 it was decided to abide by the Holy Scriptures, the three great symbols and the unmodified Augsburg Confession. Sigismund was forced to agree. On the day previously, however, he had protested to the papal nuncio against the undertaking and he considered himself entitled to disregard it. He returned to Poland in 1594. Duke Charles and the council soon fell out, with the result that the leading members of the council went off to see Sigismund. In 1598 Sigismund landed with a small Polish army. Sigismund suffered defeat, left hastily for Poland and this caused the Swedish *Riksdag* in 1599 to declare him dethroned. Charles took a sanguinary revenge. The captive members of the council were executed.

Duke Charles was not crowned until 1607. He aimed at a monarchical-democratic conception of Government. During the years 1561–93 the *Riksdag* or other estates were convened 15 times; during Charles's much briefer reign, 1594–1611 they were called together 16 times. New Church dissensions were caused by the fact that Charles cherished Calvinistic ideas while the clergy and the people expressed themselves more and more strongly in favour of evangelical tenets. By the peace with Russia concluded at Teusina in 1595 Sweden's ownership of Estonia and Narva had been recognised, but the troublous times in the East evoked new conflicts. Swedish troops marched into Moscow and the Russian crown was offered to one of Charles's sons. Novgorod was conquered. War with Poland was waged in Livonia, where the Poles won certain advantages without being able to turn them to account. Owing to Charles's endeavour to extend the region of Finnmark up to the Arctic under the rule of Sweden, and from other causes, war broke out with Denmark in 1611 and Kalmar was taken by the Danes. When Charles died in 1611 he left to his son, Gustavus Adolphus, an inheritance of three unfinished wars.

THE 17TH CENTURY

Gustavus Adolphus had been given a thorough classical education and spoke Latin and several modern languages. He was an organiser of great capacity alike in military and in internal administration. His personal influence was due to a strong and good character and a clear and far-sighted vision. In all his work he had assistance of extraordinary value from his Chancellor of State, Axel Oxenstjerna (*q.v.*).

Gustavus Adolphus.—Gustavus Adolphus was born in 1594 and was declared of age on his father's death. The Danes were successful in the war and took the harbours on the west coast. Through the mediation of King James I. of England peace was concluded in 1613: Älvsborg was to be handed back to Sweden in return for a payment of a million dalers within six years; the Finnmark region was given to Denmark-Norway, and the right of the Danish king to use the Swedish Three Crowns in his coat of arms was recognised. The peace conditions were hard.

Sweden next desired peace and a fixed frontier with Russia. The war was continued until the conclusion of peace at Stolbova—also with King James's mediation—in 1617. Sweden won Eastern Carelia and Ingermanland, whereby land-connection was obtained between Finland and Estonia, but gave up Novgorod. During and after these wars a great task of organisation was carried out in Sweden. The council acquired a stronger position as the king's advisers at the head of the administration. Ministerial offices were set up after the French-Burgundian model; a method of judicial procedure was instituted and courts of appeal were established. The nobility was incorporated in the social system as officials of the Government and much was done to improve local administration. The king promised not to begin war or conclude peace or make a treaty with other powers without the sanction of the *Riksdag*. The ransom of Älvsborg made heavy taxes necessary and even so the town of Amsterdam had to help with a loan; the financing of the State and the raising of the loan were based in a high degree on the copper-ore in the Falu mines. In Jan. 1619, the ransom-sum was paid and Älvsborg was returned to Sweden. Gustavus Adolphus endeavoured to promote commerce. New towns were founded, of which Göteborg on the west coast was the most prominent (1621). A source of future difficulties lay in the privileges of the nobles; their graduated freedom from taxes—the reward of the servants of the State—was to diminish thereby the State's revenue from taxation: this danger, however, did not present itself until later. The nobility secured the stability which it needed through the founding of the *Riddarhus*, or House of the Nobles, in 1626, in which records were inscribed of the noble families. Higher education was furthered. The University of Uppsala got from the king in 1624 a great donation of lands. Great attention was given to equipment of the army and navy.

Relations with Poland were settled by armistices until the year 1617 when negotiations led to no result. Sigismund had never abandoned his claim to the Swedish crown and therein lay a menace for the future. Open war began again and Gustavus Adolphus took personal part in it. Livonia and Riga were conquered and for several years the Swedes carried the war into Polish Prussia. Through the mediation of Brandenburg, France and England, a six years' truce was agreed to at Altmark in Sept. 1629; some Prussian seaports continued to be a Swedish possession, the Swedes retaining the right to levy tolls. While the Polish war was in progress the great conflict which was to be known as the Thirty Years' War (*q.v.*) started within the German Kingdom, and Sigismund's efforts were menacing to the religious peace of Sweden. The emperor's troops were sent to Prussia to help Poland. The royal houses of Sweden and Denmark were related to German princes who asked for help. Catholic France sought to check the emperor's increasing influence and negotiated with Sweden and Denmark: the English Government was working to the same end. Christian IV. of Denmark entered into the war but was completely defeated, and Wallenstein's imperial army took up its position on the Baltic; Wallenstein was made duke of Mecklenburg and imperial admiral over the Atlantic ocean and the Baltic; an imperial fleet was to be built. When Stralsund was threatened, Gustavus Adolphus sent help and after long and many deliberations with the council and the *Riksdag* he made his way with 13,000 men to Pomerania in June 1630; he preferred to have Germany as his theatre of war rather than to await an attack in Sweden. When success attended his invasion of the country, France concluded a subsidiary treaty with him at Bärwalde in Jan. 1631. The evangelical princes of Germany took up a dubious attitude at first, and the Swedes were blamed when they did not succeed in relieving the town of Magdeburg which was taken by the imperial general, Tilly. After various negotiations, a decisive victory was won at Breitenfeld in Sept. 1631.

A series of brilliant Swedish successes followed. Gustavus Adolphus held his Court in Mainz and Frankfurt, crossed the River Lech and made his entry into Munich. The emperor had dismissed Wallenstein in 1630, but now took him back into favour, and soon the latter was once again in the field with a strong army. The Swedes vainly stormed his fortified camp at Nuremberg and the brisk war which ensued led to the battle of Lützen in which Gustavus Adolphus met his death on Nov. 6, 1632.

It may be thought a matter for wonder that Sweden, a country with a population relatively so small, should have been capable of so great a political and military expansion as was shown in the Thirty Years' War. The explanation lies partly in an extraordinary national effort to avert an imminent danger. Sweden's armies were made up also in an increasing degree of foreign mercenaries, German, English, and Dutch. In the Polish war a number of excellent Swedish generals had learnt their business, and Gustavus Adolphus was one of the foremost military leaders of the time.

Christina.—The death of Gustavus Adolphus produced a crisis in Germany. His daughter Christina, still a minor, was recognized as queen (1632–54) and the Regency was undertaken by Axel Oxenstierna. It was well that a new treaty was concluded with France in 1633 and that Wallenstein was murdered in Feb. 1634, but in the autumn the Swedes suffered a defeat at Nördlingen which lowered their prestige. In 1635 Saxony concluded peace with the emperor and her example was followed by Brandenburg in 1636; both declared war against Sweden. John Banér (*q.v.*), restored the good name of the Swedish troops by victories at Wittstock in 1636 and Chemnitz in 1639. His successor, Torstensson (*q.v.*), thrice invaded the emperor's dominions and won the second battle of Breitenfeld in 1642. Almost everywhere Swedish interests were opposed by Denmark. Thus Torstensson was ordered, therefore, to leave Bohemia for Denmark in 1643, and Jutland was overrun by Swedish troops. Christian IV. was forced to conclude a peace at Brömesbro in 1645 by which Sweden won Jämtland, Härjedalen, Gottland, Ösel and, for 30 years Halland; exemption from the Öresund tolls was accorded for goods to Sweden and the Baltic provinces. By the Treaty of Westphalia (*q.v.*) Sweden acquired important German possessions—large portions of Pomerania, Wismar, the bishoprics of Bremen and Verden as fiefs of the German empire, and sums of prize-money, rewards for the soldiers. A great number of Swedes had in the course of the war amassed large fortunes; the influence of the nobles in this way had been increased and a chasm had grown between them and the unprivileged classes. This was intensified by the circumstance that many foreigners had entered into Swedish service and had been rewarded with landed estates. Through them, and through the impressions which Swedes had gathered in foreign countries, new ideas regarding the social status of the nobles had become widely prevalent.

The exercise of governmental power and the administration of the State in general were regulated by the constitution of the year 1634. Christina came of age in 1644, but laid down the crown ten years later. Richly endowed by nature, she had acquired much learning and many accomplishments but she was flighty and arbitrary, wont to overload with gifts those who were momentarily in her favour. She went over to the Catholic Church and died in Rome in 1689 after a life not lacking in excitement.

Charles X.—The new king was the son of Charles IX.'s daughter, the Count Palatine Karl Gustav (Charles X. 1654–60), who had been brought up in Sweden, becoming *generalissimus*. The costs of the court were cut down, and in the *Riksdag* of 1655 the nobles agreed that the endowed estates necessary for administration of the kingdom, for defence of the realm, and for working the mines, should return to the Crown, that certain estates bestowed as gifts should acquire the character of fiefs with right of return to a new king, while a fourth of such estates as had been bestowed after the year 1633 should be returned to the Crown. This measure was put into effect at once but ceased to operate during the strenuous war years that followed.

Charles X.'s short reign was occupied by war. With Poland there was as yet no peace; as the Russians had directed an attack against Poland, the king and the *Riksdag* decided to settle the matter by means of a war. Charles X. took Warsaw and Cracow (1655). Poland looked as though lost, but a national rising followed in favour of King John Casimir and two years of fruitless fighting resulted. Charles X. concluded peace with the rising power, Brandenburg, and the Swedish and Brandenburgian armies together won a three days' battle at Warsaw in 1656. In that year the Russians began war and the emperor joined Sweden's enemies, and the following year Denmark, Holland and Brandenburg followed suit. If all these powers could have co-operated closely Sweden's position would have been extremely perilous, but they could not. Charles turned resolutely upon Denmark, took Jutland and led his troops first over the ice to Fyen and then across the islands to Själland. The credit of this military exploit belongs chiefly to the quartermaster general of the army, Erik Dahlberg. Denmark was forced to make peace in 1658 at Roskilde, Sweden receiving Skåne, Halland, Blekinge and Bornholm, Bohuslän and Trondhjems Län. Both kingdoms undertook to make common cause to keep enemy fleets out of the Sound. The king now thought of confronting his other enemies, but as certain negotiations with Denmark did not quite take the turn he expected and the Dutch were busily agitating in Denmark, he guessed that hostilities from this country would follow the moment he had become engaged in the east. He resolved to avoid this danger by completely crushing Denmark and began war anew in Aug. 1658. His policy, however failed, as in Poland, through a contingency with which the statesmen of those days seldom reckoned—the kindling of a national patriotic movement. Copenhagen withstood his attack and Holland sent a fleet which after a fierce struggle with the Swedes relieved the Danish capital. The situation was anxious, and a *Riksdag* was called together at Göteborg. Charles Gustavus died on Feb. 13, 1660 during its session.

Charles XI.—Charles XI. (1660–97), a boy of four, became king at a moment when Sweden was surrounded by enemies. The widowed queen and five officials became regent. The first thing to do was to secure peace with Poland, the emperor and Brandenburg at Oliva in 1660, whereby Sweden's right to hold Livonia was recognized and John Casimir renounced all claim to the

Swedish throne; with Denmark the same year at Copenhagen, whereby Trondhjems Län and Bornholm went back to Denmark, compensation being given in the case of Bornholm; and with Russia in 1661 at Kardis, confirming the peace of Stolbova. Magnus Gabriel de la Gardie, the chancellor of State, was weak, and none took the lead in the way Axel Oxenstierna had done after the death of Gustavus Adolphus. The nation's defences were allowed to decline although its foreign policy was adventurous. It was desired to obtain subsidies from other powers and a rash treaty was concluded with France in 1672. In this year the king came of age, having reached his 17th year. His education had been neglected and he grew up awkward in his bearing, but he was an ardent patriot and extremely industrious.

The general decadence of Sweden became manifest when her foreign policy led to war with Brandenburg (1674) and Denmark (1675). The war with Brandenburg was ill-managed, and Sweden's military prestige was lowered by a defeat at Fehrbellin in 1675; most of her German possessions were lost. The Danes invaded Skåne where they continued to have many friends. The king took the leadership. On the sea the Danes were successful, but victories at Lund in 1676 and other places saved the southern provinces for Sweden. Peace treaties were signed in 1678 and 1679 with the different enemies. France accepted terms which in some respects were humiliating for Sweden. Some smaller regions in Germany were lost, but there was no question of any cessions of land to Denmark.

Great portions of the country had been laid waste, the fleet had been destroyed, trade and commerce had suffered, and finances were in disorder. A great task lay before the young king and he accomplished it, but it was by the methods of an absolute monarchy. Several *Riksdags* were called—1680, 1682–83, 1686, etc.—but on each occasion its attitude towards the king was more complaisant and it gradually came to leave practically all the questions of legislation and taxation in his hands. An enquiry was held into the conduct of the members of the Regency, who were sentenced to restore or pay large sums of money; and a very drastic confiscation of private estates was taken in hand whereby land and incomes were made to fall to the Treasury. Charles then put the army and navy in good trim. The officers were remunerated by small farms; cavalry were raised by a certain number of assessed farms and the infantry by the landowners. In the year 1681 the Swedish national debt amounted to 44,000,000 dalers in silver, but on Charles' death it was only 11,500,000. Charles married the Danish Princess Ulrika Eleonora, but the two northern States soon fell apart again. In 1681 Sweden entered into treaties with Holland at The Hague with a view to safeguarding the frontiers fixed by the peace treaties of Westphalia and Nijmwegen. The emperor gave his signature to the compact the following year. Sweden wanted to draw Holstein into its sphere of interest so as to secure less interrupted communications between her different German possessions. For Denmark it was still more important to hinder the Holstein plans of expansion lest she should be hemmed in on the South. The duke of Holstein-Gottorp was Charles XI.'s uncle (his mother's brother) and had his support against Denmark. He died in 1697, leaving one son, Charles, and two daughters.

THE 18TH CENTURY

Charles XII.—For the third time in the 17th century a regency was called on to act, but already Nov. 1697, the *Riksdag* declared the 15-year old Charles XII. (1697–1718) of age. At the coronation he placed the crown on his own head and gave no *Kungaförsäkring* (lit. King's guarantee). Charles was a gifted but precocious youth who had been grounded in book-learning and military science. He had high morality, but was inclined to obstinacy. In his early youth he was addicted to wild pranks and perilous sports.

Poland, Denmark and Russia were united against Sweden. In March, 1700, the Poles marched on Riga and the Danes against Holstein. The young king showed unusual power and decision. Protected by the English and Dutch fleets he landed on Själland and enforced on Denmark the peace of Traventhal in Aug. 1700. In November the Swedes, under the personal leadership of Charles, won a momentous victory over the Russians at Narva. In the summer of 1701 Charles marched south, drove the Russians and the Saxons back over the Duna and invaded Poland. Charles called upon the Poles to dethrone Augustus who had begun the war. This idea stirred up the national feeling of Poland and won Augustus help from other States. Charles' route went through Kovno in Lithuania to Warsaw and Cracow which he took (1702). After continual but fruitless victories for the Swedes a Polish parliament, not constitutionally formed, declared Augustus dethroned and elected as his successor Stanislaus Leszczynski, a weak man who lacked the strength to defend his own status as king. The Polish parliament concluded peace with Sweden in 1705. In this way Poland became a kind of subject State to Sweden, but Charles miscalculated Sweden's capacity for maintaining such a relationship. During these Polish conflicts the Tsar Peter took town after town in Livonia and Ingermanland, among them Dorpat and Narva. Charles, in the meantime, held that the most important thing was to force Augustus to conclude peace before he took up his stand against Peter, and he carried war into Saxony. The Swedish army was now one of the most famous in Europe, and Charles's power was very great. Leipzig was taken, and Augustus by the peace signed at Altranstädt in Sept. 1706, renounced the Polish throne and allowed Charles to remain some time in Saxony with his army. Augustus was in Lithuania and sought by intrigue to overrule the peace treaties but failed. From different quarters came efforts to benefit by Swedish aid; nearly a dozen German princes sought Charles out and he was visited by some 30 envoys from various courts. The most notable of them was Marlborough, who took note that the Swedish king did not intend to place himself on the side of France in the Western European wars as rumour had declared. Quarrels with the emperor began, but with the help of English and Dutch mediation a peace was concluded in 1707 which secured for Protestants in Schleswig the Church rights promised them in the Peace of Westphalia.

Charles was anxious to come to conclusions with Russia, but he had given the tsar too long to prepare. The Russians had forced their way into Poland but were driven out again, and after a victory at Holovszyn Charles crossed the Dnieper. Adam Ludwig Lavenhaupt was to have come with an army from Livonia to the king's support, but he was delayed and experienced a severe defeat, arriving eventually with a diminished force and without commissariat. Owing to devastations by the Russians it became difficult for the Swedes to provide themselves with necessaries, and when the Cossack, Mazeppa, offered his co-operation Charles concluded a treaty with him in Oct. 1708. Mazeppa did not manage to get his Cossacks to join with him, but Charles advanced into the Ukraine. In an unusually hard winter thousands of Swedish soldiers perished. Charles began to lay siege to Poltava: the battle which followed (June 28, 1709) ended in a Swedish defeat, largely owing to the fact that Charles was wounded in the foot and that his generals were not united. Charles made his way as a fugitive to Turkey and his proud army capitulated at Perevolatschna on July 1, 1709.

The unfortunate Russian campaign made an immense impression both in Sweden and in other countries. Augustus declared the peace with Sweden invalid and marched into Poland. The Danes crossed the Sound and sought to overrun Skaane. The Government in Stockholm put forth all its powers to defend Southern Sweden and Magnus Stenbock won a decisive victory at Helsingborg in Feb. 1710. The Danish troops were taken back to Denmark. The Russians occupied the Baltic provinces completely after they had taken Riga. Meanwhile Charles was busying himself in Bender trying eagerly to bring about a war between the Turks and Russia. His stay in Turkey is difficult to explain; probably he did not want to return until the Russians had been either conquered or weakened. Thrice the Turks began war but without any gain to Sweden. Meanwhile Stenbock made his way to Germany, but though he defeated the Danes at Gadebusch (1712) he was forced to capitulate with his army at Tönningen in 1713. The German possessions, apart from

Stralsund, were taken by the enemy, who was joined by Prussia and Hanover, and the Russians swarmed over Finland.

From Feb. 1713 Charles was held captive by the Turks but after a swift journey in Dec. 1714, he arrived in Sweden. The country was in a sad plight. The population was only 1,250,000 and the burden of the great war was too heavy. The people were oppressed by heavy taxes and services imposed by the State, and worn out by conscription.

During the years that followed Charles XII. strengthened Sweden's defences against the Danes, who received help from a Russian army and threatened an invasion of Sweden. The plan was not carried out, and Charles turned towards Norway to force the Danish king to make peace. While there he was shot on Nov. 30, 1718. In Stralsund Charles had made acquaintance with the Holstein Baron von Görtz who afterwards became his confidant and associate. Unscrupulous and resourceful, Görtz discovered new means of taxation; simplified the State administration and lowered the value of the currency and conducted an adventurous policy abroad. The poverty thus brought about evoked a hatred against him which after Charles' death led to his being tried and executed. With Charles the Swedish supremacy over the Baltic came to an end.

The Swedish forces were withdrawn at once from Norway, one brigade which was sent against Trondhjem experiencing terrible losses in the mountains. The *Riksdag* assembled for the special purpose of putting an end to the absolute power of the sovereign. Charles' sister, Ulrika Eleonora, married to the hereditary Prince Frederick of Hesse, was declared not to be the successor to the throne, but was elected queen (1718–20) on condition that the *Riksdag* alone should have the right to draw up the constitution. The changes effected in the constitution drawn up in 1719 and 1720 and in the *Riksdag* decrees of 1723 were drastic. When the *Riksdag* was not in session the council ruled together with the king who on most questions only had two votes. While the *Riksdag* was sitting decisions on foreign affairs and other matters were made by a secret committee which was formed of members of the three higher estates, the nobles, the clergy and the burghers. The peasants were left in the background but they had to be heard on questions of taxation. Each estate chose its own speaker; in the house of nobles the speaker was called *Landmarskalk*. The membership of the council could only be revoked by law, and this made parliamentary government very primitive because it led to political law-suits.

In 1719 peace was concluded with Hanover on the basis of Sweden's giving up Bremen and Verden and receiving a sum of money in return. In 1720 an arrangement was come to with Prussia, which acquired a large part of Pomerania and also paid up a sum of money. In 1720 also peace was made with Denmark which renounced the regions it had conquered in return for Sweden's undertaking to agree to Denmark's retaining possession of Schleswig. Russian fleets were harrying the coasts of the Baltic and an attack upon Stockholm was with great difficulty warded off. Peace was not concluded until 1721 at Nystad, when Sweden gave up Livonia, Estonia, Ingria and parts of Finland; northern and western Finland was restored to Sweden.

Frederick I.—In 1720 the crown was transferred to the queen's consort Frederick I. (1720–51). The leading statesman down to the end of the 'thirties was Count Arvid Horn, who pursued a prudent peace policy. The State's debts amounted to 60 or 70 million silver dalers, and the emergency currency (*nödmynten*) was working much harm. A State bankruptcy was inevitable, and after this the emergency currency disappeared. With the English Navigation Act as a model, a proclamation was issued in 1724 prohibiting foreign vessels from conveying to Sweden anything except the produce of the countries to which they belonged. The Swedish commercial fleet increased, an East Indian company was formed in 1731 (which caused bad blood in England), new manufactories were founded with support from the State, in particular the textiles industry, thanks to Jonas Alströmer who created the manufactory at Alingsås. A new general law was framed in 1734.

During the first years following the Peace of Nystad Russia sought to intervene in Sweden's internal affairs and Horn therefore in 1726–27 made Sweden a member of the alliance between England, France and Prussia. Indeed, foreign subsidies began to have their ill effects in Sweden. Against Horn's prudent leadership there grew up an opposition which gained ground in 1734 and became victorious in the *Riksdag* of 1738–39. Horn gave up office in Dec. 1738. The victorious party was called *Hattar*, "the Hats" in contradistinction from *Mössorna*, "the Caps."[1] The programme of the Hats favoured war with Russia with a view to winning back the Swedish provinces and power and a more intensive industrial policy; Sweden was to become a great Power politically and economically.

The party of the Hats controlled the fortunes of the country until the '60s, although sometimes strongly opposed by the Caps. They dominated the council from 1739 onwards with Count Karl Gyllenborg as their leader. Conditions seemed favourable for a war with Russia in 1741 and war began. The campaign was badly conducted and the Swedish troops took to flight. Discontented thousands of peasants marched to Stockholm and could only with difficulty be dispersed. At the beginning of the *Riksdag* session in 1742 the Caps were in power, and the peasants now won for themselves a place in the secret committee. An enquiry was set on foot into the actions of the instigators of the war, and two of the generals were condemned to death and executed. The Hats now raised the question of the succession to the throne, the royal couple being childless, and the question soon became bound up with that of the Russian peace as the Russian Empress Elizabeth wished to see Duke Adolphus Frederick of Holstein elected. The peasants particularly wanted to have the Danish crown prince, and a great conflict raged in *Riksdag* circles, much bribing being done by foreigners. In June 1743 peace was concluded at Åbo. Russia retained only a small portion of her conquests in Finland, and Adolphus Frederick was chosen as heir to the Swedish throne. Denmark threatened war and Sweden's impotence became manifest when a Russian army came to the country to protect her against the Danes. While the *Riksdag* was in session there was a split among the Caps, and the council came to include both Hats and Caps. Adolphus Frederick came to Sweden and in 1744 married Louisa Ulrika, sister of the Prussian King Frederick II. Russia's disposition to control the destinies of the country now took on a singularly offensive aspect. Foreign gold filled the coffers of the parties before the *Riksdag* of 1746–47 assembled. The Hats opposed the Russian proceedings resolutely and in this were supported by many of the Caps. Through new elections to the council, the Hats now came definitely into power again, with Anders Johan von Höpken as head of the Government. Some members of the Caps party were charged with treason and the matter was investigated by a commission. This had the effect of diminishing their opposition to the Hats. An alliance was contracted in May 1747 with Prussia and France which improved the situation. The successful party rewarded its friends lavishly and came down heavily upon its foes.

The years which followed were comparatively quiet. The brilliant young noble, Count Carl Gustav Tessin, was president of the council, which was the strongest known within the period of the *Riksdag's* predominance; National defences were strengthened, custom tolls were raised to help industry which was also supported by loans and premiums; agriculture was supported also by loans on easy terms. The improvement secured by these measures was in part apparent only and great credits were extorted from the *Riksbank* which had to increase its issue of notes. Notes depreciated in value and exchange offices were set up to keep the currency at the desired height.

Adolphus Frederick.—King Frederick died in 1751 and was succeeded by Adolphus Frederick (1751–71) who was under the influence of his stronger-minded wife. Controversial pamphlets and journals came out in numbers. Tension between the king and the council increased. A rash effort at a *coup d'état* was made during the *Riksdag* of 1755–56; the royal couple were humiliated and an autograph stamp was introduced in order to dispense with the king's personal intervention in the Government. Count Axel von Fersen came to the front as the foremost man in the Hats Party; he was chosen as *Landmarskalk* (*see* above), leading the bureaucracy of the nobles.

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[1] These party names originated in the Progressives nicknaming their opponents—who sacrificed everything to perpetuate an inglorious peace—the "Nightcaps," they themselves receiving their name from the three-cornered hats that they wore as officers.

Opposition grew therefore among the unprivileged classes against the nobility and the bureaucracy. The State's finances were in a bad way, yet in spite of this the country was let in for a war, on the side of France and Austria, against Frederick II. of Prussia (1757), largely owing to the French subsidies. The war was badly managed, but peace was made with Prussia without loss of territory in May 1762. The Caps took office in the *Riksdag* of 1765–66. Russia and Prussia decided in union to support the Swedish constitution, prolong her general state of weakness, and at the same time to work against the French influence. A Russo-Danish alliance was also formed with the purpose of maintaining the Swedish constitution. England was on the same side and it is calculated that these powers spent 3,000,000 silver dalers in order to ensure the victory of the Caps, while France's contribution to the Hats amounted to 2,000,000. The corruption was shameful. Against the wishes of the royal couple, the Crown Prince married the Danish Princess Sofia Magdalena.

The court had helped the Hats during the *Riksdag* and by the king's direct intervention the council was obliged to call together the *Riksdag* which sat from 1769 till 1770. The Caps were now in a minority and their men were left out of the council which was controlled by the Hats. The court had been promised that the king's power would be increased but the Hats did not keep their word. Nor did the *Riksdag* succeed in solving the great financial problems. In Feb. 1771 Adolphus Frederick died. Somewhat previously Russia and Denmark had come to an agreement that, should any change be made in the Constitution of Sweden in the direction of increasing the king's power, they would uphold the existing Constitution (December, 1769) by force of arms. Sweden's Constitution therefore seemed to be held in greater value by her enemies than by her own people.

Gustavus III. (1771–92) was in Paris at the time of his father's death. He returned home to meet the *Riksdag*. The Hats and the court party were receiving money from France, the Caps from Russia and England. The parties were of about equal strength. At this juncture the king decided to precipitate a change of the constitution. Col. Jakob Magnus Sprengtporten (*q.v.*) crossed to Finland to stir up a rising, in which he succeeded but not so quickly as had been expected. Johan Kristoffer Toll (*q.v.*), a superintendent of forests, went to Skaane and won over the garrison at Kristianstad. Prince Charles, the brother of the king, also busied himself in Skaane. The council got wind of the danger and the king had to act speedily. On Aug. 19, 1772, he collected round him the officers of the Guard and arrested the council in the royal castle. The Stockholm troops declared for him and the people acclaimed him in the streets. The king became again head of the government, with the right to appoint officials. It was an attempt to divide the balance of power between the sovereign and the *Riksdag*.

Russia and Denmark were furious but did not begin war, being much influenced by the resolute attitude of France. Gustavus surrounded himself with capable men. He was unusually gifted, but too much of a visionary. He had a real passion for the theatre but took up his business as king with honest intent; an enquiry into the conditions of governmental offices was set on foot and a number of reforms in the administration were instituted as a result. In order to help the finances distilling was decreed a State monopoly and a number of distilleries were founded on behalf of the Crown. This displeased the peasants who wanted to be free to distil and it increased drunkenness. Another cause for dissatisfaction lay in the king's efforts to transform the nobility into a court nobility and to manage promotion so as to break the power of the old bureaucracy.

Foreign Policy.—A dispute with his mother discouraged the king. He set out for Italy and Paris. A subsidy treaty was concluded with France but he had no great success there. During the *Riksdag* of 1786 the situation became worse; most of the king's measures were rejected. Gustavus turned to foreign policy and Turkey's war with Russia in 1787 seemed to offer favourable conditions. He began war with Russia in June 1788.

War with Russia.—The king took command. A sea-fight at Hogland was undecisive and among officers a conspiracy came to be known as the Anjala League. The conspirators opened negotiations with the Russian empress, to bring about peace. News came that Denmark had entered the war as Russia's ally and Gustavus was obliged to hurry back to Sweden. The Swedish people became animated by patriotism and the king talked to the peasants as Gustavus Vasa had done of old. England and Prussia brought pressure to bear on Denmark to leave Sweden in peace and a truce was concluded. By the beginning of the following year, 1789, Gustavus was strong enough to have the leaders of the Anjala League imprisoned. The *Riksdag* was called together at the beginning of February. The meeting was a stormy one, the king, supported by the unprivileged estates, driving through the so-called Act of Union and Security which embodied a number of far-reaching constitutional innovations: the council ceased to exist; the king acquired full powers over the administration of the State and the appointing of officials; and the *Riksdag* lost its initiative in legislation. Once again the authority of the king became dominant. The *Riksdag* became responsible for the national debts, the management of which was placed in the hands of the *riksgäldskontor*, which was dependent on the *Riksdag* and which was given the right to take up new loans and to issue credit notes. A number of the leaders of the opposition had been imprisoned in the course of the session. Such was the king's second revolution. (*See* GUSTAVUS III.; WALLQVIST, OLAF.)

The Russian war became a war of exhaustion on land. During the years 1789–90 there were several sea-fights, the second of which, at Svensksund in 1790, constituted a fine victory under the king's command. In Aug. 1790, peace was concluded without modification of frontiers. But Sweden's finances were destroyed and the internal strife brought to a head. One result was a conspiracy against the king's life. He died on March 29, 1792, from the effects of a murderous attack by Captain J. J. Anckarström at a ball in the Opera House on March 16, 1792.

Gustavus IV.—At the age of 13 Gustavus IV. Adolphus (1792–1809) became king of Sweden with his uncle Duke Charles as Regent. Duke Charles's closest associate was Gustav Adolf Reuterholm (*q.v.*), a man of great powers of work, but pedantic and of little intelligence. The Regency brought order into the higher grades of Government service and sought above all to further the prosperity of agriculture. Reuterholm was not lacking in appreciation of the latest reforms: the freedom of the press was at first increased, but when the horrors of the French Revolution broke out it was restricted, and the repute of the Regency did not stand very high. It wavered between a French and a Russian alliance. The king, the duke and Reuterholm visited the Russian court in order to arrange a marriage between the king and a Russian princess, but the whole thing fell through when the king refused to give a guarantee of the princess's religious freedom. On the basis of a treaty concluded in 1794 between the two countries, the fleets of both Denmark and Sweden sought to protect neutral trade against privateers of England and other nations.

In 1796 Gustavus Adolphus took over the Government himself. He was scantily gifted but he knew how to make himself felt and combined obstinacy with passionate temper. So bad were the finances that the town of Wismar had to be mortgaged to Mecklenburg in 1801. In the course of a long journey in Germany in the years 1803–04 Gustavus Adolphus came into touch with French emigrants, and was filled with hate of Napoleon. He took part in the coalition against France in 1805–07, with the result that Pomerania and Stralsund were lost. In the Treaty of Tilsit Napoleon and the Emperor Alexander agreed to attack Sweden unless she were willing to declare war against England and to prevail on Denmark to do the same. The army in Finland gave way before the Russians. The strong fortress of Sveaborg was treacherously surrendered without any real struggle. In the Spring the Swedes marched again to the south of Finland and won several fine victories, afterwards immortalized by the poet Runeberg. In Dec. 1808 the Swedish forces vacated Finland. Gustavus Adolphus's measures became more and more thoughtless and he annoyed even England, his only ally. The feeling grew that the king must be dethroned. Lieut. Colonel Adlersparre started a revolutionary movement in Värmland, but before he reached Stockholm Adjutant General Karl Johan Adlercreutz had secured possession of the king's person (March 13, 1809). The king died in exile in 1837.

The *Riksdag* was called together on May 1 by the provisional Government and it decided to draw up a new constitution and elect a king. A form of Government resulted which in its fundamental parts still (1928) holds good and which is based on a division of power between the ministry, the representatives of the people and the judicature. The king was to be advised by a ministry the members of which were to be appointed by the king but to be answerable to the *Riksdag*. General legislature was to be the work of the king and the *Riksdag*, and the *Riksdag's* control over taxation was confirmed. As soon as this constitution had been adopted Charles XIII. was recognized as king (1809–18). The credit of drafting the new constitution belongs in the first place to Hans Järta.

King Charles was childless and it was necessary to choose a successor to the throne. Public opinion in Sweden at this period occupied itself with Norway's union with Sweden as a compensation for Finland. The *Riksdag* chose as successor to the throne Prince Christian Augustus of Augustenburg who was commander-in-chief in Norway, manifestly in the hopes that the choice would help to bring this union about. The prince declared that he could accept this offer only after a declaration of peace. During the late summer of 1809 the Russian war was extended to the north of Sweden and the Swedish forces met with two defeats. The Russians in the meantime had become weary of the war and in September peace was declared at Fredrikshamn; Sweden lost Finland and Åland. Soon treaties of peace followed with her other enemies. Pomerania was returned to Sweden.

The heir to the throne, who took the name of Charles, died suddenly in 1810, and a *Riksdag* at Örebro had again to deal with the question of a successor. Opinions were divided when a suggestion was made that they should elect one of Napoleon's marshals, Jean Bernadotte, prince of Ponte Corvo. It seemed certain that Napoleon would approve and accordingly Bernadotte was chosen and assumed the name of Charles John. He is the founder of the present Swedish dynasty, the succession to the throne having been provided for in an ordinance passed in 1810. The old King Charles XIII. had shown courage and patriotic feeling during Gustavus III.'s war with Russia, but he was not very intelligent and he lacked strength of character. The crown prince therefore began to exert considerable influence, with stimulating and beneficent results.

In 1811 Napoleon prepared to break down Russia's resistance. A great war began, and the crown prince perceived that Sweden could not possibly go into it with France against England and Russia. He seems early to have thought out his plans for the conquest of Norway, and in 1812 he brought about a complete change in Swedish policy with this goal in view. Napoleon's occupation of Swedish Pomerania without declaration of war facilitated this change, and Russia and England favoured the idea that Norway should pass over to Sweden from Napoleon's ally Denmark. After the defeat of the French armies in Russia Charles John took part as commander of the northern army in the final conflict and there were Swedish troops also under him. With these the crown prince now made a movement against Denmark, who by the Peace of Kiel (1814) was forced to hand over Norway in return for Pomerania. Herewith begins a new order of foreign policy in Swedish history.

UNION WITH NORWAY: 1814–1905

The project of uniting the Scandinavian peninsula into one kingdom now became a reality. The interests of Sweden's foreign policy lay now more to the west and she was less dependent upon Russia, more dependent upon the western Powers. The Norwegians themselves desired independence for their country and an assembly held at Eidsvold in 1814 framed a constitution and elected Prince Christian Frederick of Augustenburg as king. The Norwegians were forced as the result of a short war to surrender; the prince laid down his crown and a *Storting* which was called together endorsed the union with Sweden. Special conditions affecting the union were framed in the "act of union" passed by the parliaments of both countries in 1815 ("riksakt").

Charles XIV.—More than 100 years of peace followed upon the riksact. The industrial economic revolution proceeded in Sweden as in other countries evolving new classes, which claimed their share in the Government of the country and burst asunder the old methods of representation. The break between the new and the old began during the reign of Charles XIV. and embittered his later years. He was a strong personality capable and lovable, but distrustful of new ideas and apprehensive of too great changes. A Liberal Opposition was formed in the *Riksdag*, above all among the burghers, and took a strong line against the Government's prosecution of newspapers which even amounted to suppression, against bureaucratic formalities, and against the king's tendency to disregard the advice of his ministers. From the '30s onwards there was question of reforms in the matter of the representation of the people and a great many bills were put forward without accomplishing more than a few small reforms. In 1840 the State council was changed by the creation of special departments. With the king's active co-operation the State's foreign debts were paid while internal debts were diminished and in 1834 a regulation of the exchange was affected. Much was done for the canal system; in 1822 one section of the Götha canal was opened and in 1832 the rest of it. In 1842 the board school system was changed.

Oscar I. (1844–59).—Charles was succeeded by his son, a man of gifts and of more open mind but of less strength of will than his father. During the earlier years of his reign he stood for a policy of reform but later he changed noticeably towards conservatism. During the last two years of his life he was ill, and the administration was taken in hand by his son Charles. The restrictions on agriculture and commerce were relaxed; the gild system was done away with in 1846; the old rules for only allowing trade to the towns were removed. By decisions reached in the *Riksdag* for 1844–45 the right to suppress newspapers was definitely abrogated. In 1847 an important poor law system was introduced. One of the greatest questions of that period was that of communication; railways had to be built, but there were differences of opinion as to the laying down of the main lines through the sparsely inhabited land. In the *Riksdag* of 1853–54 it was decided that the main lines should be built by the State and the direction of the work was placed in the hands of Col. Nils Ericson. Friends of reform concentrated more and more on the demand for a thorough-going change in the formation of the *Riksdag* and many proposals were submitted without any of them being accepted. The revolutionary movement which marked the year 1848 on the continent set brains on fire also in Sweden and some street disturbances occurred in Stockholm. The Government produced a new scheme of representation, which, however, was rejected by the *Riksdag* of 1850. A strong Scandinavian movement manifested itself especially in Denmark and Sweden, although the Norwegians also took part in it; great meetings of students were held, but no programme for the unity of the Scandinavian countries with any real life in it was ever framed. When the Schleswig question led to war between Denmark and the German States, a Swedish army was collected together in Skaane and troops were carried over to Fyen, in case Jutland should be invaded; but they never had occasion to come into action. During the Crimean War Sweden and Norway maintained neutrality. In Nov. 1855 they reaped the benefit: a treaty was concluded with England and France by which the Union States undertook not to cede any portion of their territories to Russia while the two other powers undertook to prevent any Russian efforts in that direction (the November treaty). Side by side with the peace treaty in Paris there was concluded a separate agreement between Russia, France and England in which Russia undertook not to fortify the Åland Islands.

The increasing consumption of spirits due to the right to distil for household needs, called forth anxiety and led to a temperance movement conducted by warm-hearted individuals like Peter Wieselgren, a pastor. Private distilleries were done away with by the *Riksdag* of 1853–54 and the distilling of spirits was regulated by the State. Ever since the middle of the 19th century the question of temperance had affected parties.

Charles XV.—The crown prince had conducted the Government for two years when he became king under the name Charles XV. (1859–72). He was a fascinating man who by his liveliness of mind, personal friendliness and artistic temperament won great popularity, but he lacked the thoroughness and perseverance in work and the seriousness which are called for in a statesman. His undeniable gifts were bound up with an extravagant imagination which in certain situations was a danger. This became most noticeable in the German-Danish war of 1863–64, when he gave the Danes distinctly to understand that they could count on an alliance between Denmark and Sweden-Norway, an idea which had never had the sanction of the State councils of either of the Union countries and which was never to be realized. A number of Swedes did however enter the Danish army as volunteers.

The social changes which had come about in the life of Sweden necessitated a new form of electoral representation and increasingly the general feeling was that it must be solved by giving up the division into four estates and that a *Riksdag* with two chambers should be founded instead. The minister of justice, Louis De Geer (*q.v.*) took the lead in the matter and the Government submitted a bill in the *Riksdag* of 1862–63.

The new constitution was finally accepted by all four estates in the *Riksdag* of 1865–66; this consisted of two chambers, which, unlike the English houses of parliament, have in most respects similar powers and also exercise a veto on each other in questions of legislation; in the event of conflicting divisions on questions of finance a joint vote is taken. Members of the first chamber were elected by the provincial assemblies (*landsting*) together with the town councillors of the larger towns for nine years; the second chamber was elected by collective vote (without any division of the electors into classes), a certain census being necessary for the right to vote. In Jan. 1867 the first *Riksdag* of this kind was assembled and it soon became evident that it was the peasants who had benefited most by the reform; within a couple of years they dominated the second chamber and their party—the so-called Lantmanna party—was a power to reckon with. The *Riksdag* now meets every year.

Through the influence of the finance minister, Baron J. A. Gripenstedt, Sweden was led more in the direction of free trade, and its treaty of commerce with France in 1865 was an epoch-making event in the development. All duties on grain were done away with. The right of trading was extended in 1864. Among more important reforms may be mentioned the new criminal law and the new maritime law of 1864. The wars which were in progress on the continent caused the *Riksdag* to grant large sums for armaments but the Government's proposal for a reorganization of the national defences was rejected. After a prolonged illness Charles XV. died in Sept. 1872 and was succeeded by his brother Oscar II. (1872–1907). The most noteworthy event in the latter's reign was the dissolution of the Union with Norway.

Dissolution of the Union.—The Union plans of 1815 were never quite clear, and great doubts had always existed regarding the documents in question and their precise bearing. The Norwegians, apprehensive of Swedish domination, had sought always to give the narrowest possible application to the provisions of the Act of Union, while the Swedes, generally speaking, sought to give them a wider application, although with increased powers for Norway.

The first great crisis arose over the question of the post of Ståthållarc, or Governor, of Norway. At first this post had been held by Swedes, but as this had invited opposition they were succeeded by Norwegians. In 1859 the *Storting* resolved to abolish the post altogether but in Sweden it was contended that as the post was provided for in the Act of Union it could not be done away with by Norway alone. The question was shelved for a time and in 1873 Oscar II. sanctioned the resolution of the *Storting*. The first great union committee met in the '40s and was followed by several smaller committees and in the year 1865–67 by a great committee which worked out a plan for a new agreement between the two kingdoms. This was rejected however by the *Storting* in 1871. The position of the sovereign of the two kingdoms was now becoming extremely difficult, because modern parliamentarianism had progressed much further in Norway than in Sweden and the powers of the sovereign had consequently become much less extensive in Norway. Thus the king had been forced to make continual concessions to the Norwegians. In the year 1835 it had been decided that the premier or another member of the Norwegian Government should be called into the Swedish Norwegian ministerial council whenever questions concerning the foreign affairs of Norway alone or both kingdoms should be under discussion. In the '80s a dispute arose about this joint ministerial council. From 1891 onwards the *Storting* demanded Norwegian consulates for Norway. Also, it reduced the annual grant for the court. Owing to the protectionist demand of Sweden a Swedish-Norwegian joint law (dealing with reciprocal freedom from customs duties) ceased to exist in 1897, and in 1898 the king ratified a decision of the *Storting* to remove the Joint Union emblem in the upper right hand corner of the Norwegian flag; it disappeared afterwards from the Swedish flag. A small union committee put forward in 1902 a proposal for separate consular services but joint Foreign Office. Negotiations took place and in 1903 understanding seemed to be in sight. The Swedish plan provided that the foreign minister might be either a Norwegian or a Swede. But from both sides there came charges of breach of faith and in Norway all parties demanded dissolution of the union. The Swedes were astonished when on June 7, 1905, the *Storting* declared the union with Sweden to be dissolved. The *Riksdag* acquiesced in the dissolution of the Union upon certain conditions, such as that Norway should destroy certain frontier fortresses erected near the Swedish frontier, that the regions adjoining the frontier should constitute a neutral zone without fortifications and military manoeuvres, etc. King Oscar laid down the Norwegian crown on Oct. 26, 1905.

Oscar II. (1872–1907).—During the first years of King Oscar's reign the question of national defence was the dominant one, the first chamber contending for an improved system and the peasant members in the second chamber making demands which could not for a long time be conceded. A number of army organization proposals were rejected, and during the '80s the question of customs duties caused bitter disputes. The increasing exportation of grain from the United States and Russia together with the strong industrial competition between all countries resulted in a protectionist movement in Germany and France which extended also to Sweden. The second chamber was protectionist and the first in favour of free trade; in 1887 the majority in the first chamber was so small that it would have been possible to bring about a protectionist system by the collective vote of the two chambers. The king then dissolved the second chamber which returned with a majority in favour of free trade. The *Riksdag* of 1888 on the other hand accepted the customs system as the general election in the autumn of 1887—through a technical mistake in the election of the free trade candidates in Stockholm—had given the Protectionists a small majority. This issue had profound consequences both in the formation of parties in the second chamber and in other respects. New men came forward, the most conspicuous of whom was the landed proprietor E. G. Boström, premier from 1891 to 1900 and 1902 to 1905. The question of the national defences was provisionally settled by the *Riksdag's* decisions in the autumn of 1891 (at an extraordinary session) and in 1901. In the latter year the Swedish military tenure established was completely abolished; the training time of the men liable for military service was increased from 90 to 240 days in the infantry and a longer period in the case of the navy and special branches of the army.

At this period new legislation was necessitated by industrial development and the great increase in the number of industrial workers. In 1881 the conditions of labour for children in all factories were regulated and in 1889 a law was passed on providing against injury while at work; the former law was amplified in 1900 by one dealing with the condition of industrial work for women and children. Trade unions were formed and collective agreements governing labour conditions were arranged between employers and workers. In 1889 a Social Democratic Party was formed and in the autumn of 1896 Hjalmar Branting was elected to the second chamber as its first Social Democratic member. The Liberals and Social Democrats demanded an extension of the suffrage for the second chamber, but it was not until the severance of the union with Norway had given a strong impetus to a closer national union on new lines that the question came to be decided. The severance of the union led to the formation of the coalition ministry of Christian Lundeberg, a manufacturer, whose task it was to carry out the dissolution of the union. He was followed at the close of the year 1905 by a Liberal ministry with Karl Staaff, a solicitor, as premier. The *Riksdag* of 1906 rejected his suffrage bill, and the ministry resigned. Rear Admiral Arvid Lindman succeeded, with a conservative ministry and succeeded in 1907 in solving the suffrage question on the basis of universal and equal suffrage (with certain exceptions) together with the democratization of the communal scale of voting and proportional voting for both chambers. Among other important decisions may be mentioned the monopoly in the issuing of bank notes accorded to the *Riksbank* in 1897, the restriction of the right of companies to acquire land in Northern Sweden in 1906, and the part ownership of the State in the Grängesberg Company which owned the Lappland iron-ore mines.

Gustav V.—When Oscar II. died on Dec. 8, 1907, the crown fell to his eldest son Gustav V., who still (1928) wears it. Modest and simple in his character, avoiding needless display, but capable of bearing himself with the dignity required by his position, he has been a true king in a democratic epoch. Reforms were carried through, as, for instance, the laws on civil marriages in 1908 and for the protection of the peasants in Norrland in 1909. In the summer of 1909 the country witnessed a great trial of strength between the industrial workers' trade unions and employers' associations, accompanied by strikes, lock-outs and a general strike. The idea of the workers was to set society rocking and the situation was somewhat like that which resulted in England in 1926. But society won the battle; the general strike failed. In the autumn of 1911 the election for the second chamber was held with a doubled electorate and the Lindman ministry gave up office. Karl Staaff formed his second ministry which lasted until Feb. 1914. In the Autumn of 1911 a great committee was set up to enquire into temperance. The Lindman ministry had approved a cruiser of a new type but Staaff's Government set aside their decision. A movement to cover the costs of its construction by private subscription produced a sum of 17,100,000 kr., and the ship was built. The people had been disquieted by the way the Russians were arming in Finland, and with widespread espionage by the Russians in Sweden. A new workman's protection law was passed in 1912, and an Old Age Pension scheme was founded in 1913.

In Feb. 1914, 30,000 peasants met in Stockholm to request the king that the whole question of national defence should be handled simultaneously. The king's answer was favourable, and the Liberal ministry resigned. The king commanded the *landshövding* Hjalmar Hammarskjöld (*q.v.*) to form a new ministry. K. A. Wallenberg became minister of foreign affairs. The second chamber was dissolved and the *Riksdag* reassembled after the election of May 1, 1914. The new Government had a majority in the first chamber but not in the second.

THE WORLD WAR

The World War broke out. To meet the needed expenditure a war tax was levied on all incomes above a certain amount. It was widely, but quite erroneously, believed that Sweden had entered into a treaty with Germany. Sweden issued a declaration of neutrality. The fleet endeavoured to prevent any military operations within Swedish territorial waters.

The Problem of Neutrality.—As the blockade against Germany was intensified, an increasing amount of Swedish goods were detained in England. The black lists of the belligerents, trade espionage and the attempt to force extensive undertakings from importers in neutral countries induced the Swedish Government to put a proposal for a War Trade Law before the 1916 *Riksdag*, under which no undertakings with belligerent Powers could be made without the sanction of the official Swedish authority (Trade Commission). (If this officially recognized undertaking were broken the culprit was severely punished.) Special arrangements were made with the belligerent countries regarding compensation for permission to transport goods. Britain desired to transport over Sweden goods necessary to Russia, and Sweden granted transport licences in return for permission from Britain to import certain foodstuffs and other goods from the west. In Jan. 1915 the Government forbade the transport over Sweden of arms and other war material. Pourparlers between the Swedish and British Governments with the object of improving trade communications between the two countries led to no result. Disputes arose over the British postal censorship and the closing by Sweden of a channel in Öresund. The difficulties brought the three Scandinavian countries into closer touch. In Dec. 1914, King Gustav invited the kings of Norway and Denmark to a conference in Malmö which inaugurated a period of greater friendship.

Many legal and administrative innovations were made. In 1914 a moratorium for debts was introduced, but was soon abolished. Special laws empowered the Government to fix a maximum price for food and other necessities and if necessary to commandeer them. A War Insurance Commission was set up to give state-aided insurance against loss at sea, a Food Commission to take over the import of grain, etc., an Industry Commission to report on industry and later to ration raw materials, etc., an Unemployment Commission, and a Trade Commission to carry out the war trade laws. In Nov. 1915 the first maximum prices were fixed (for grain). A bad fodder harvest and the difficulty of importing maize and other foodstuffs necessitated a great slaughter and export of cattle.

Some circles sympathized with Britain, others with Germany, but nearly all desired neutrality. A little group of "activists" urged intervention on the side of Germany.

The Blockade.—On July 7, 1916 Britain and France ceased to apply the regulations of the Declaration of London regarding neutral trade. The German U-boat warfare was intensified; the closed areas in the North Sea and the blockade of the Central Powers by the Allies created a situation little in accord with international law. During the war 280 Swedish merchant vessels were sunk, chiefly by German submarines, but also by mines and from other causes. The English ports were crowded with confiscated goods. After the Russian revolution in 1917, Britain no longer needed to transport goods over Sweden to Russia; so this means of bargaining fell away.

Negotiations with Britain for import licences led in the spring of 1917 to a temporary agreement whereby Sweden was guaranteed certain imports (including grain) in return for the release from the Baltic of a number of imprisoned vessels belonging to the Entente. Swedish vessels were requisitioned (or were only allowed to sail in Swedish interests on condition that they were replaced by other vessels when required). Finally a commercial agreement was concluded in the spring of 1918, which enabled Sweden to import large consignments of goods in return for handing over merchant vessels up to 400,000 tons dead weight; a certain proportion of the Swedish iron ore export; longer credit for goods purchased in Sweden, and stricter regulations regarding exports to Germany. The increasing difficulties of nagivation in the North sea and the insignificant export from Britain to Sweden, led to an expansion of trade with Germany. Before the War Sweden obtained 91% of her coal from England but during 1916–17 only 27–26%. The remainder was almost entirely supplied by Germany. The dislocation of trade thus largely influenced Sweden's policy.

Import difficulties necessitated still more stringent State measures. In Oct. 1916 sugar was rationed. In 1917 bread cards were introduced together with State control of the whole grain trade. Before the war an average of 183 kilogrammes of wheat and rye were consumed per head. The harvest of 1917–18 produced only 84·4 kilogrammes per head. Finally, potatoes and many other commodities were rationed. There was a great shortage of meat and bacon, and milk was reserved for children and invalids. The price of food rose rapidly and large sums of money were set aside to provide the poorer classes with goods at cheap rates. As the import of coal decreased, special arrangements were made for procuring wood from the forests. All kinds of raw materials, especially lubricants, were scarce.

Government Changes.—The Hammarskjöld ministry was formed against the wishes of the Liberals and the Social Democrats, and these parties commanded a majority in the second chamber of the *Riksdag*. The Government only remained in power so long thanks to its firm neutral policy. Criticism of its trade policy increased, however, and in spite of a huge vote of confidence from 750,000 people, it was unable to co-operate further with the parties of the Left and resigned at the end of March 1917. A new Conservative ministry carried on up to the new elections to the second chamber in the autumn. Carl Swartz, a manufacturer, was prime minister and Admiral Arvid Lindman, a former prime minister, was minister of foreign affairs. The food shortage caused considerable unrest and led to a demand for a constitutional reform of a democratic nature. At the autumn elections the Conservatives suffered several losses and Swartz resigned. The Liberal leader, Prof. Nils Edén, formed a ministry. He himself became prime minister and Lord Justice Johannes Hellner, minister of foreign affairs. The ministry included five other Liberals and four Social Democrats. Among them were Hjalmar Branting as minister of finance, and Baron E. Palmstierna, afterwards Swedish minister to London, as minister of marine. Branting soon resigned on account of illness.

Finland and the Åland Islands.—In Jan. 1918, Sweden recognized Finland as an independent State. The civil war in Finland created a critical situation. There was a demand for military support of the lawful Finnish Government; yet Sweden feared she might be drawn into the war if she assisted the Finns against the Russians. The Government acted with a circumspection which was rather resented by the Finnish "Whites." When the conflict was transferred to Åland, whose inhabitants had voted for adherence to Sweden, Sweden sent a warship to the islands, and a small body of troops to maintain peace. These were recalled when the Germans made the islands their centre for sending assistance to the "Whites" in Finland (*see* ÅLAND ISLANDS).

Swedish Relief Work.—The Swedish Red Cross was active in the adjacent belligerent lands, and Prince Charles, a brother of the king, took a prominent part in the work. Swedish delegates inspected the prison camps of Russia, Germany and Austria and distributed numerous gifts to the prisoners from their respective countries. Arrangements were made for the exchange of invalided prisoners and their transport over Sweden. After the war large numbers of German and Austrian children spent some time in Sweden renewing their health and strength, and Swedish help was given to the impoverished countries. When the great famine broke out in Russia a Swedish relief expedition was sent to Samara. The sum total of relief given by Sweden to the various countries amounted to 36,500,000 kroner.

MODERN DEVELOPMENTS

The repercussions of the revolution in Central Europe reached Sweden. The *Riksdag* was sitting when the war ended and in order to keep in power, the Government hastened to put forward a programme embodying a far-reaching constitutional reform, which was carried, thanks to the close co-operation of the Government parties (1918–1919). The graduated scale at the communal elections was abolished and equal and universal suffrage introduced. As the first chamber is based on the communal vote, it became automatically more democratic. Women received full political franchise. The Social Democratic party acquired a relative but not an absolute majority in each Chamber.

Growth of Democracy.—The advance made in the political democratization of Sweden is shown by the following table, in which the number of qualified voters and their proportion to the population together with the number of actual voters and their proportion to the number of qualified voters are given for the years 1905, 1911 (after the Lindman Suffrage Reform bill) 1921 (after the application of the suffrage system of 1918, including the introduction of votes for women) and—for the sake of comparison—1924:—

Year	Number qualified to vote	Number qualified to vote in proportion to population	Number of actual voters	Number of actual voters in proportion to those qualified to vote
		%.		%
1905 . .	402,099	8·2	217,759	50·4
1911 . .	1,066,200	19·3	607,487	57·0
1921 . .	3,222,917	54·3	1,747,553	54·2
1924 . .	3,338,892	55·3	1,770,607	53·0

It will be noticed at once that an immense democratic wave has swept over the country and carried public opinion with it. Dissensions among the middle-class parties—the Conservative, Liberal and the new Bondeförbund (Farmers' League)—further increased the power of the Social Democrats; but lacking an absolute majority, they were obliged to act rather as a Radical middle-class party. The Edén ministry remained in office until March 1920. The liquidation of war-time restrictions and the work of reform continued. A provisional law adopting an eight-hour day in industry and certain other branches of labour, not including agriculture, was passed. The Liberal and Social Democratic members of the Government disagreed on the reform of communal taxation, and the ministry resigned after Sweden's entry into the League of Nations.

Branting now formed his first purely Social Democratic ministry with Palmstierna as minister of foreign affairs. This ministry set on foot investigations into projects of socialisation, industrial democracy and control over trusts and cartels. At the second chamber elections the Conservatives and the *Bondeförbund* gained several seats; Branting therefore dissolved his ministry on Oct. 22, 1920. Baron Louis de Geer formed a moderate Conservative ministry, at the head of which Oscar von Sydow replaced him in Feb. 1921. The Government granted large sums for relief work and the support of the unemployed. To carry out the new constitutional reforms fresh elections for both Chambers took place in the autumn.

The result favoured the Socialists, especially in the first chamber and in October Branting formed his second purely Social Democratic ministry, in which he himself was both premier and minister of foreign affairs. The economic crisis and the problem of unemployment were the vital questions at the moment, and at the instance of the Government the 1922 *Riksdag* granted what were, according to Swedish ideas, enormous sums of money for the relief of the unemployed. The Government finally fell over this question of unemployment. Swedish policy was to provide relief work whenever possible, otherwise to give monetary assistance. Wages for relief work were to be less than ordinary wages and assistance still less. Help was not to be given to workers involved in any conflict (strike or lock-out). The Government and the *Riksdag* interpreted this last clause differently, and Branting resigned in April 1923. During 1922 a referendum on the total prohibition of all alcoholic drinks was defeated.

Controversy on Defence.—Lord Justice Ernest Trygger, the old Conservative leader, now formed a new ministry, whose special task was the solution of the national defence question. The 1914 army regulations had not been entirely carried out when the war ended, and the Socialists, especially, felt strongly that the creation of the League of Nations and the fall of the tsardom justified a reduction of armaments. During the 1924 *Riksdag* the Government had brought in a bill for this purpose, but it was not sufficiently drastic for the Social Democrats and the *folkfrisinnade* (the Radical half of the Liberal Party; the rest still called themselves Liberals). The *Riksdag* threw out the bill, but the Government remained in office until after the second chamber elections in September. As the result did not strengthen the Government, it went out, and Branting formed his third ministry on Oct. 18, 1924, with Prof. Östen Undén as minister of foreign affairs. The Government and the Social Democratic Party suffered a severe loss in the death of Branting (*q.v.*) on Feb. 24, 1925. Rickard Sandler, minister of commerce, succeeded him as prime minister. A Government measure, introducing shorter military service and a reduction of the army, was passed by the 1925 *Riksdag*.

At the close of the session of the 1926 *Riksdag* the ministry fell over the unemployment question after a sharp conflict regarding the *Riksdag's* instructions to the Unemployment Commission and the latter's manner of carrying them out. C. G. Ekman, member of the Board of Directors in the State Bank, had led the Opposition in the *Riksdag* and he now was invited by the king to form a ministry, which remained in office till Oct. 1928. It was made up of *folkfrisinnade,* to which Party the premier belongs, and Liberals, with Eliel Löfgren, the foreign minister, as their foremost man. Both parties together constitute but a small proportion of the number of members of the *Riksdag* but their position in the Centre has made it possible for them to assume the responsibilities of the Government. During the *Riksdag* of 1927 there were undertaken a number of additions to the fleet and a thoroughgoing Radical reform of the Higher School system. In the *Riksdag* of 1928 a measure of reform in respect of communal taxes was carried through. In June 1928 King Gustav's 70th birthday was celebrated with great circumstance. In commemoration of the day a collection of nearly 9,000,000 Kr. was made for use in accordance with the King's decision for the campaign against cancer, just as a similar collection was used in King Oscar's time as a fund to be used in fighting against tuberculosis. At the beginning of October a new Conservative Government was formed by Admiral Lindman.

Foreign Affairs.—When the question of the entry of Sweden into the League of Nations was broached there was considerable opposition, one reason being the non-entry of the United States. The decision to join was, however, carried by a large majority and in March 1920 her entry into the League was officially announced. Among the Swedish representatives at the League Assemblies were Branting, Trygger and Undén. In Sept. 1922 Sweden was given a seat on the council and held it to 1926. The Åland (*q.v.*) question was decided by the League in favour of Finland (June 1921) but the islands received guarantees for the preservation of their Swedish culture. An international convention prohibited any fortification of the islands.

BIBLIOGRAPHY.—A modern and scholarly exposition of the history of Sweden is available in *Sveriges historia till våra dagar,* ed. E. Hildebrand, of which 14 volumes have appeared namely I. O. Montelius, *Forntiden* (1919); II. S. Tunberg, *Äldre medeltiden* (1926); III. G. Carlsson, *Senare medeltiden* (in preparation); IV. E. Hildebrand, *Gustav Vasa* (1920); and V. *Gustav Vasas Söner* (1923); VI. G. Wittrock, *Gustav II. Adolf* (1927); VII. E. Hildebrand and G. Jacobson, *Kristina och Karl X. Gustav* (1926); VIII. R. Fåhraeus, *Karl XI. och Karl XII.* (1921); IX. L. Stavenow, *Frihetstiden* (1922); and X. *Den Gustavianska Tiden* (1925); XI. S. Clason, *Karl XIII. och Karl XIV. Johan* (1923); XII. C. Hallendorff, *Oscar I. och Karl* XV. (1923); XIII. S. J. Boëthius, *Oscar II.;* XIV. K. Hildebrand, *Gustav V.* (1926); vol. xv. has yet to appear, namely, S. E. Bring, *Källor och Litteraturförteckning,* containing a good account of Sweden's older historical literature and index. *See* also K. Setterwall, *Svensk historisk bibliografi,* 1875–1900, 1900–20 (1907 and 1923); H. Schück, H. Almquist, A. Stille and C. Hallendorff, *Svenska Folkets historia* (1914, etc.); C. Grimberg, *Svenska folkets underbara öden,* I.–IX. (1913–24); Emil Hildebrand, *Svenska statsfirfattringens historia* (1896). (K. Hi.)

SWEDENBORG or **SWEDBERG, EMANUEL** (1688–1772), Swedish scientist, philosopher and mystic, was born at Stockholm on Jan. 29, 1688. His father, Dr. Jesper Swedberg, subsequently professor of theology at Uppsala and bishop of Skara, was under suspicion of heterodoxy, as he placed more emphasis on the cardinal virtues of faith, love and communion with God than on dogma. On completing his university course at Uppsala, in 1710, Emanuel travelled in England, Holland, France and Germany, studying natural philosophy and writing Latin verses, a collection of which he published in 1710. In 1715 he returned to Uppsala, devoting himself to natural science and engineering. From 1716 to 1718 he published a scientific periodical, *Daedalus hyperboreus,* a record of mechanical and mathematical inventions and discoveries. In 1716 Charles XII. appointed him assessor-extraordinary on the Swedish board of mines. Two years later he distinguished himself at the siege of Frederikshall by the invention of machines for the transport of boats overland from Stromstadt to Iddefjord, a distance of 14 m. At the death of Charles XII. Queen Ulrica gave him a patent of nobility, by which his name was changed from Swedberg to Swedenborg, the "en" corresponding to the German "von." In the Swedish House of Nobles he spoke on economic subjects—the currency, the decimal system, the balance of trade and the liquor laws (where he was the pioneer of the Gothenburg system). He strongly opposed a bill for increasing the power of the crown. The next years were devoted to his official duties, which involved the visitation of the Swedish, Saxon, Bohemian and Austrian mines. In 1724 he declined the chair of mathematics in the university of Uppsala, on the ground that it was a mistake for mathematicians to be limited to theory. As early as 1721 he was seeking a scientific explanation of the universe, when he published his *Prodromus principiorum rerum naturalium,* and had already written his *Principia* in its first form. In 1734 appeared in three volumes *Opera philosophica et mineralia,* the first volume (his *Principia*) containing his view of the first principles of the universe, a curious mechanical and geometrical theory of the origin of things. The other volumes dealt with (*a*) iron and steel, (*b*) copper and brass, their smelting, conversion and assaying, and chemical experiments thereon.

Swedenborg's voluminous writings were not properly collected and examined until towards the end of the 19th century; it was then seen that in almost every department of scientific activity he was ahead of his time. His work on palaeontology shows him the predecessor of all the Scandinavian geologists. He was also a great physicist and had arrived at the nebular hypothesis theory of the formation of the planets and the sun long before Kant and Laplace; he wrote a lucid account of the phenomena of phosphorescence, and adduced a molecular magnetic theory which anticipated some of the chief features of modern hypotheses. The French chemist, Dumas, credits him with the first attempt to establish a system of crystallography. He was the first to employ mercury for the air-pump, and devised a method of determining longitude at sea by observations of the moon among the stars.

In 1734 he published *Prodromus philosophiae ratiocinantis de infinito et causa finali creationis,* which treats of the relation of the finite to the infinite, and of the soul to the body, seeking to establish a nexus in each case as a means of overcoming the difficulty of their relation. From this time he applied himself to discovering the nature of soul and spirit by means of anatomical studies. He travelled in Germany, France and Italy, in search of anatomical knowledge and, as a result, published his *Oeconomia regni animalis* (London, 1740–41) and *Regnum animale* (The Hague, 1744–45; London, 1745). In no field were Swedenborg's researches more noteworthy than in physiological science. In 1901, Max Neuberger of Vienna called attention to certain anticipations of modern views made by Swedenborg in relation to the functions of the brain, and the university of Vienna appealed to the Royal Swedish Academy for a complete issue of the scientific treatises. Swedenborg showed (150 years before any other scientist) that the motion of the brain was synchronous with the respiration and not with the action of the heart and the circulation of the blood, a discovery the full bearings of which are still unrealized. He arrived at the modern conception of the activity of the brain as the combined activity of its individual cells. The cerebral cortex, and, more definitely, the cortical elements (nerve cells), formed the seat of the activity of the soul, and were ordered into departments according to various functions. His views as to the physiological functions of the spinal cord are in agreement with recent research, and he anticipated modern research on the functions of the ductless glands.

At middle age, Swedenborg left the domain of physical research for that of psychical and spiritual inquiry. Late in life he wrote to Oetinger that "he was introduced by the Lord first into the natural sciences, and thus prepared, and, indeed, from the year 1710 to 1745, when heaven was opened to him." Before his illumination he had been instructed by dreams, and enjoyed extraordinary visions, and heard mysterious conversations. According to his own account, the Lord filled him with His spirit to teach the doctrines of the New Church by the word from Himself; He commissioned him to do this work, opened the sight of his spirit, and so let him into the spiritual world, permitting him to see the heavens and the hells, and to converse with angels and spirits for years; but he never received anything relating to the doctrines of the church from any angel but from the Lord alone while he was reading the word (*True Christian Religion,* No. 779). He elsewhere speaks of his office as principally an opening of the spiritual sense of the word. In 1747 he resigned his post of assessor of the board of mines, took up afresh his study of Hebrew, and began his voluminous works on the interpretation of the Scriptures. His life thenceforth was spent alternately in Sweden, Holland and London, in the composition of his works and their publication, till his death, which took place in London on March 29, 1772. He was buried in the Swedish church in Princes Square, St. George's-in-the-East, and on April 7, 1908, his remains were removed at the request of the Swedish government to Stockholm.

Swedenborg never attempted to preach or to found a sect. He believed that members of all the churches could belong to the New Church without forming a separate organization. His theosophic system is most briefly and comprehensively presented in his *Divine Love and Wisdom.* The point of view from which God must be regarded is that of His being the Divine Man. His *esse* is infinite love; His manifestation or body is infinite wisdom. Divine love is the self-subsisting life of the universe. From God emanates a divine sphere, which appears in the spiritual world as a sun, and from this spiritual sun proceeds the sun of the natural world. The spiritual sun is the source of love and intelligence, or life, and the natural sun the source of nature or the receptacles of life; the first is alive, the second dead. The worlds of nature and spirit are perfectly distinct, but they are intimately related by analogous substances, laws and forces. In God there are three infinite and uncreated "degrees" of being, and in man and all things corresponding three degrees, finite and created. They are love, wisdom, use; or end, cause and effect. The final ends of all things are in the Divine Mind, the causes of all things in the spiritual world, and their effects in the natural world. By a love of each degree man comes into conjunction with them and the worlds of nature, spirit and God. The end of creation is that man may have this conjunction and become the image of his Creator and creation. In man are two receptacles for God—the will for divine love and the understanding for divine wisdom—that love and wisdom flowing into both so that they become human.

Swedenborgianism is based on the belief in Swedenborg's claims to have witnessed the last judgment, or the second advent of the Lord, with the inauguration of the New Church, through the new system of doctrine promulgated by him and derived from the Scriptures, into the true sense of which he was the first to be introduced. The "doctrines" of the New Church as given in the *Liturgy* (which also contains the "Creed" and "Articles of Faith") are as follows:—

1. That there is one God, in whom there is a Divine Trinity; and that He is the Lord Jesus Christ.
2. That a saving faith is to believe on Him.
3. That evils are to be shunned, because they are of the devil and from the devil.
4. That good actions are to be done, because they are of God and from God.
5. That these are to be done by a man as from himself; but that it ought to be believed that they are done from the Lord with him and by him.

Swedenborgians now constitute a widely spread and considerable society, with a regularly constituted ecclesiastical organization and a zealous missionary activity (*see* New Jerusalem Church).

Bibliography.—Lithographed facsimiles of the mss. of Swedenborg's works were edited by R. L. Tafel, 10 vols. (Stockholm, 1869–70); another edition in 18 vols. was published at the same place (1901–16). Various editions of the single works have appeared, and about forty are available in English, *Heaven and Hell, The Divine Providence* and *The Divine Love and Wisdom* being published in the Everyman series. There are also translations into most European languages as well as into Arabic, Hindu and Japanese.

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SWEDISH LANGUAGE AND LITERATURE. Old Swedish was spoken in (1) Sweden, except the most northerly part (Lappish and Finnish), the most southerly (Skåne, Halland and Blekinge) and certain parts of western Sweden; (2) maritime tracts of Finland, Estonia and Livonia, with their surrounding islands; and (3) certain places in Russia. A number of words, almost exclusively personal names (nearly 100), were introduced into the Russian language at the foundation of the Russian realm by Swedes (in 862), and preserved in two Russian documents of the years 911 and 944, though for the most part somewhat influenced by Russian phonetic laws. Of about the same date, are the runic inscriptions, amounting in number to about 2,000 cut on stones (rarely wood, metal or other materials) almost all over Sweden, most frequently (about half of the total number) in the province of Uppland. For the most part they occur on tombstones or monuments in memory of deceased relatives; rarely they are public notices. Their form is often metrical, in part at least. These inscriptions vary in age, belonging to all centuries of Old Swedish, but by far the greatest number of them date from the 11th and 12th centuries. The oldest are perhaps the Ingelstad inscription in Östergötland, the Sparlösa inscription in Västergötland, and the Gursten one found in the north of Småland, all probably from the end of the 9th century. The rune-stone from Rök in Östergötland probably dates from about A.D. 900. Its inscription surpasses all the others both in length (more than 750 runes) and in the importance of its contents; it is a fragment (partly in metrical form) of an Old Swedish heroic tale. From the beginning of the 12th century is the remarkable inscription on the door-ring of the church of Forsa in Helsingland, containing the oldest Scandinavian statute now preserved, as well as other inscriptions from the same province, written in a particular variety of the common runic alphabet, the so-called "staflösa" (staffless, without the perpendicular staff) runes, as the long genealogical inscription on the Nalstad-stone. Of runic literature nothing has been preserved to our days. The literature in the Latin letters is in quality and extent inferior to Old Icelandic, though it, in quantity, considerably surpasses Old Norwegian. In age, it begins only in the 13th century. The oldest of the extant manuscripts is a fragment of the Older Västgötalaw, written about the year 1250. A complete codex (Cod. Holm. B 59) of the same law dates from about 1285. The very numerous Old Swedish charters, from 1343 downwards, are also of great importance.

Form of the Language.—Old Swedish, during its earliest preliterary period (800–1225), retains quite as original a character as contemporary Old Icelandic and Old Norwegian. The formal changes of the language during this period are, generally, such as appear about the same time in all the members of the group—as the change of soft ʀ into common *r* and the change of *sþ* into *st* (in the 10th century *raisþi,* later *ræisti,* raised); or are, at least, common to it with Norwegian—as the dropping of *h* before *l, n* and *r* (in the 10th century *hrau*ʀ, younger, *rør,* cairn), and the changing of nasal vowels (the long ones latest) into non-nasalized. But during the classical period of Old Swedish (1225–1375), the time of the later runic inscriptions and the oldest literature, the language is already distinctly separate from the (literary) Icelandic-Norwegian (though not yet very much from Danish). As innovations in Swedish:—*d* is inserted between *ll* (*nn*) and a following *r* (as *b* between *m* and *l*, *r*, and *p* between *m* and *t*, *n*); an auxiliary vowel is inserted between final *r* and a preceding consonant; *a* in terminations is often changed into *æ*; a *u* in the final syllable causes no change of a preceding *a*; the present tense takes the vowel of the infinitive (and the preterite subjunctive that of preterite indicative plural). There were other important changes.

The borrowed words are chiefly ecclesiastical and of Latin and Greek origin. At the middle of the 14th century the literary language develops to a *"rikssprâk,"* a uniform language, common to a certain degree to the whole country. The language at this period is deluged with borrowed words of Low German origin, mostly social and industrial terms. Towards the end of the period a powerful Danish influence extends also to phonetics and etymology, so that nearly all the terminal vowels are supplanted by the uniform Danish *e*, the hard consonants *p*, *t*, *k* by *b*, *d*, *g* as in Danish, the second person plural of the imperative ends in *–er*, besides *–en* (as *tagher*, for *taghen*, older *takin*).

Dialects.—Dialectical differences occur in the runic inscriptions and in the literature. One distinct dialect, that of the island of Gottland, differs so essentially from the Old Swedish of the mainland that it has been characterized, under the name *Forngutniska*, as in a sense a separate language. Materials for its study are abundant: more than 200 runic inscriptions, and, in literature a runic calendar from 1328, the law of the island (the oldest manuscript is from about 1350), and a piece of traditional history. The language is distinguished from the Old Swedish of the mainland by the following characteristics:—the old diphthongs are preserved and a triphthong has arisen by the change of *iu* into *iau*; the long vowels *æ* and *ø* have passed into *ē* and *ȳ* (as *mēla*, to speak, *dȳma*, to deem); short *o* rarely occurs except before *r*, being in other positions changed into *u*; *w* is dropped before *r* (as *raiþi*, wrath); the genitive singular of feminines in *–a* ends in *–ur* for *–u* (as *kirkiur*, of the church).

LITERATURE

While the definite beginnings of Swedish literature can hardly be set back to a period farther distant than the 13th century, there is evidence, in the shape of runic inscriptions in which Sweden is extraordinarily rich—the most interesting being the *Rökstene* in East Gotland—that she had her share in the imaginative life of Scandinavia which finds its fullest expression in the early poetry of Iceland. But the Swedish middle ages were veritably dark ages; they are illumined only fitfully by light reflected from the mainland of Europe. The Church did not become a vital force until the middle ages were far advanced, while the orders of knighthood found their way too late to Sweden, and were too ill adapted to conditions there, to take any real root. From 1200 on, however, Swedish students visited in surprising numbers the great centres of European learning, and on their return home founded schools.

The great figure of mediaeval Sweden is St. Brigitta (1303–73), the founder of the monastery of Vadstena on Lake Vener. Her writings, which are exclusively in Latin and consist of accounts of her visions and revelations, were printed at Lübeck in 1492. Her confessor, Mattias (d. 1350), compiled a Latin Bible concordance, which is lost, and he may also have been the author of a paraphrase of part of the Old Testament. Swedish mysticism in the 13th century had a prominent representative in Petrus de Dacia (*c.* 1235–89), and Swedes contributed to the Latin hymn-poetry of the middle ages. There are Swedish versions—the so-called *Eufemiavisor*—of Crestien de Troyes' *Chevalier au lion* (1302), of a now lost German romance of Duke Frederick of Normandy (1308) and of *Flores and Blanscheflor;* not until 1380 do we find another romance of this type, *Konung Alexander.* These, to which should be added some prose romances of the later time (*Didrikssagan, Historia Trojana, Karl Magnus*), are practically all Sweden's contribution to the literature of chivalry.

The most pleasing aspect of Swedish mediaeval literature is the folksong or *folkvisa.* This she shares with the other Scandinavian lands, particularly the songs on mythic themes and the so-called *kämpavisor* of presumably historical origin. Particularly interesting are the Swedish *riddarvisor,* while the dance-songs, so characteristic of the North, seem to have been cultivated in Sweden long after they had died out in Denmark. The early prose literature consists here, as in other lands, of legal codes and chronicles. The Elder West Göta Law (*Äldre Västgötalagen*) is preserved in a ms. of the end of the 13th century; and other similar codes (*Upplandslagen, Södermannalagen,* etc.) date from the 14th. Much the most interesting juridical work of the early time is *Um styrilsi kununga ok höfthinga* (*On the Conduct of Kings and Princes*), which dates from the 13th century, although not printed until 1634. Besides Latin chronicles there is one in the vernacular, *Erikskrönika,* dealing with the period from about 1250 to 1319; this was followed by others and finally by the three *Sturekrönikorna,* which bring the record of events down to 1496. The oldest work which may be definitely described as history is the *Prosaiska krönikan* of the 15th century and the Latin *Chronica Regni Gothorum* of Erik Olai (d. 1486), the father of Swedish historiography.

The Renaissance.—The 16th century added but little to Swedish literature, and that little is mostly connected with the newly-founded university of Uppsala. The Renaissance scarcely made itself felt in Scandinavia, and even the Reformation failed to waken the genius of the country. The most prominent writers were two brothers, Olavus Petri (1493–1552) and Laurentius Petri (1499–1573), Carmelite monks who adopted the Lutheran doctrine while studying at Wittenberg, and came back to Sweden in 1518 as apostles of the new faith. Olavus became chancellor to Gustavus Vasa, but his reforming zeal soon brought him into disgrace, and in 1540 he was condemned to death. Two years later he was pardoned, and allowed to resume his preaching in Stockholm. He wrote a *Svensk krönika,* which is the earliest prose history of Sweden, a mystery-play, *Tobiae comedia,* which is the first Swedish drama, and three psalm-books. Laurentius Petri, who was a man of calmer temperament, was archbishop of all Sweden, and edited or superintended the translation of the Bible published at Uppsala in 1540. He also wrote many psalms. Laurentius Andreae (d. 1552), had previously prepared a translation of the New Testament, which appeared in 1526. He was a polemical writer of prominence on the side of the Reformers. Finally, Petrus Niger (Peder Svart), bishop of Västerås (d. 1562), wrote a chronicle of Gustavus I. up to 1533, in excellent prose.

With the accession of Charles IX. literature began to assert itself in more vigorous forms. The long life of the royal librarian, Johannes Bure or Buraeus (1568–1652), formed a link between the age of the Petri and that of Stiernhielm. A patient antiquary, Buraeus advanced the knowledge of ancient Scandinavian mythology and language; nor was it without significance that two of the greatest Swedes of the century, Gustavus Adolphus and the poet Stiernhielm, were his pupils. The reign of Charles IX. saw the rise of secular drama in Sweden. The first comedy was the *Tisbe* of Magnus Olai Asteropherus (d. 1647), a coarse but witty piece, acted by the schoolboys of the college of Arboga in 1610. A greater dramatist was Johannes Messenius (1579–1636), who, having been discovered plotting against the Government during the absence of Gustavus in Russia, was condemned to imprisonment for life—that is, for 20 years. Before this disaster he had been professor of jurisprudence in Uppsala, where his first historical comedy *Disa* was performed in 1611 and the tragedy of *Signill* in 1612. The design of Messenius was to write the history of his country in 50 plays of which only six were completed. Messenius was a genuine poet, a fact that is more apparent in the lyrics he introduced into his plays than in the plays themselves. He was imitated by a little group of playwrights. Nikolaus Holgeri Catonius (d. 1655) wrote a tragedy on the Trojan War, *Troijenborgh;* Andreas Prytz (d. 1655) several religious chronicle plays from Swedish history; and Jacobus Rondeletius (d. 1662) a curious "Christian tragi-comedy" of *Judas redivivus.* Another interesting play was an anonymous *Holofernes and Judith* based on German models. These were all acted by schoolboys and university youths, and when such performances went out of fashion the drama in Sweden almost ceased.

Stiernhielm and His Followers.—The greatest literary name of the 17th century was that of Georg Stiernhielm (*see* STJERNHJELM) (1598–1672), a man of many-sided intellectual attainment. His chief literary work, and the greatest Swedish poem of the century, is the epic—or rather didactic allegory—*Hercules* (publ. 1658), written in excellent hexameters.

The claim of Stiernhielm to be the first Swedish poet may be contested by a younger man, but a slightly earlier writer, Gustaf Rosenhane (1619–84), known to literature as Skogekär Bärgbo. If Stiernhielm studied Opitz, Rosenhane took the French poets of the Renaissance for his models, and in 1650 wrote a cycle of 100 sonnets, the earliest in the language (*Venerid*, 1680). Most of the young poets followed Stiernhielm rather than Rosenhane. As personal friends and pupils of the former, the brothers Columbus deserve special attention. Each wrote copiously in verse, Johan (1640–84) almost entirely in Latin, while Samuel (1642–79), especially in his *Odae sueticae,* showed himself an apt imitator of the Swedish hexameters of Stiernhielm, to whom he was at one time secretary, and whose *Hercules* he dramatized. Urban Hiärne (1641–1724) introduced the new form of classical tragedy from France, his best play being *Rosimunda* (1665). Lars Johansson (1638–74), who called himself "Lucidor," was a misanthropic, melancholy poet whose adventurous, unhappy life ended in his being stabbed, like Marlowe, in a midnight brawl at a tavern. His *Flowers of Helicon* bear witness occasionally to a very genuine poetic feeling. Haquin Spegel (1645–1714), the famous archbishop of Uppsala, wrote a long didactic epic in alexandrines, *Guds Verk och Vila* (*God's Labour and Rest,* 1685), with an introductory ode to the Deity in rhymed hexameters. He also takes a high place as a writer of hymns. Another ecclesiastic, the bishop of Skara, Jesper Svedberg (1653–1735), wrote sacred verses, but is better remembered as the father of Swedenborg. Peter Lagerlöf (1648–99), professor of poetry at Uppsala, cultivated a pastoral vein in his ingenious lyrics *Elisandra* and *Lycillis.* Gunno Eurelius, afterwards ennobled with the name of Dahlstjerna (*q.v.*) (1661–1709), early showed an interest in the poetry of Italy. In 1690 he translated Guarini's *Pastor Fido,* and in or just after 1697 published his *Kunga-Skald,* an epic in *ottava rima* in honour of Charles XI.; it is not without real merits, richness of language, flowing metre and a genuine poetic enthusiasm. Johan Runius (1679–1713) has, on the one hand, points of contact with Lucidor, and on the other, often seems a forerunner of Bellman. His poetry appears in a collection entitled *Dudaim.*

In prose the 17th century produced but little of importance in Sweden. Gustavus Adolphus (1594–1632) was the most polished writer of its earlier half, and his speeches take an important place in the development of the language. The most original mind of the next age was Olof Rudbeck (1630–1702), the famous author of *Atland eller Manhem,* usually known as *Atlantikan.* A man of encyclopaedic interests, he spent nearly all his life in Uppsala, expending ceaseless energy on the practical improvement of the university. His *Atland* which appeared in Latin and Swedish, between 1679 and 1702 contains his antiquarian studies; it was an attempt to summon the past, all the sages of Greece and the bards of Iceland, to prove that Scandinavia was the lost Atlantis. Olof Verelius (1618–82) had led the way for Rudbeck, by his translations of Icelandic sagas, a work which was carried on with greater intelligence by Johan Peringskjöld (1654–1720) the editor of the *Heimskringla* (1697). The French philosopher Descartes, who died at Christina's court at Stockholm in 1650, found his chief disciple in Andreas Rydelius (1671–1738), bishop of Lund, who was the master of Dalin, of the next epoch. His *Nödiga förnuftsöfningar* (5 vols.), appeared in 1718–22.

The 18th Century.—A more brilliant period followed the death of Charles XII. The influence of France and England took the place of that of Germany and Italy. The taste of Louis XIV., tempered by the study of Addison and Pope, gave its tone to the academical court of Queen Louise Ulrica, who founded in 1758 the academy of literature, history and antiquities. Two writers in verse connect this Augustan period in Sweden with the school of the preceding century: Jacob Frese (1691–1729), a native of Finland, whose poems were published in 1726, was an elegiacal writer with an often strangely modern appreciation of nature; while Samuel von Triewald (1688–1743) was the first Swedish satirist; he introduced Boileau to his countrymen. Both in verse and prose Olof von Dalin (*q.v.;* 1708–63) took a higher place than any writer since Stiernhielm. He was inspired by the study of his great English contemporaries. His *Svänska Argus* (1733–34) was modelled on Addison's *Spectator,* his *Thoughts about Critics* (1736) on Pope's *Essay on Criticism,* his *Tale of a Horse* on Swift's *Tale of a Tub.* Dalin's style, whether in prose or verse, was of a finished elegance. As a prose writer Dalin is chiefly memorable for his history of Sweden, *Svea rikes historia* (1747–61). His allegoric epic *Svenska friheten* (*Swedish Freedom,* 1742) is in polished alexandrines. When in 1737 the new Royal Swedish theatre was opened, Dalin led the way to a new school of dramatists with his *Brynhilda,* a regular tragedy in the French style, and in his comedy *Den afundsjuke* (*The Envious Man*) he introduced the manner of Molière, or more properly that of Holberg. His songs and satires enjoyed great popularity in their time.

The only poet of importance who contested the laurels of Dalin was a woman. Hedvig Charlotta Nordenflycht (1718–63), "The Shepherdess in the North," was the centre of a society which took the name of *Tankebyggare Orden* and included among its members Creutz and Gyllenborg. She wrote with facility and grace; and her collection of lyrics *Den sörjande turturduva* (*The Sorrowing Turtledove,* 1743), in spite of affectation, expressed her deep sorrow for the death of her husband after a brief happy married life. In 1744 she settled in Stockholm and opened her famous literary salon. Count Gustaf Philip Creutz (*q.v.*) (1731–85) was a Finlander who achieved an extraordinary success with his idyllic poems, and in particular with the beautiful pastoral of *Atis och Camilla* (1759), long the most popular of all Swedish poems. His friend Count Gustaf Fredrik Gyllenborg (1731–1808) was a more rhetorical and artificial poet. His epic *Tåget över Bält* (*The Expedition across the Belt,* 1785) is an imitation, in 12 books, of Voltaire's *Henriade,* and deals with the prowess of Charles X. He wrote fables, allegories, satires, and a successful comedy of manners, *Den svenska sprätthöken* (*The Swedish Fop*). Anders Odel (1718–73) wrote in 1739 the famous *Song of Malcolm Sinclair,* the *Sinclairsvisa.* In spite of all the encouragement of the court, drama did not flourish in Sweden. Among the tragic writers of the age we may mention Dalin, Gyllenborg and Erik Wrangel (1686–1765). In comedy Reinhold Gustaf Modée (1698–1752) wrote three good plays in rivalry of Holberg.

In prose, as was to be expected, the first half of the 18th century was rich in Sweden as elsewhere. The first Swedish novelist was Jakob Henrik Mörk (1714–63). His romances have some points of resemblance with those of Richardson. *Adalrik och Göthilda,* which appeared between 1742 and 1745, is the best known; it was followed, between 1748 and 1758, by *Thecla.* Jakob Wallenberg (1746–78) described a voyage he took to the East Indies and China under the odd title of *Min son på galejan* (*My Son on the Galley*), a work full of humour and originality. Johan Ihre (1707–80), professor at Uppsala, was a philologist of distinction. His masterpiece is the *Glossarium sueogothicum* (1769), a historical dictionary with many valuable examples from the ancient monuments of the language. The chief historians were Sven Lagerbring (1707–87), Olof Celsius (1716–94) and Karl Gustaf Tessin (1695–1770) who wrote on politics and on aesthetics. Tessin's *Old Man's Letters to a young Prince* were addressed to his pupil, afterwards Gustavus III.

The two Swedes of widest European reputation in the 18th century were Carl von Linné or Linnaeus, the great botanist, (*q.v.*; 1707–78), and the learned and many-sided mystic Emanuel Swedenborg (*q.v.;* 1688–1772). Linné in his books of travel (*Lapplandska resa, Skårska resa,* etc.) pointed the way to a new interpretation of nature, and Swedenborg's mystic communings deeply influenced the imagination of the after-time.

The Gustavian Period.—What is called the Gustavian period commences with the reign of Gustavus III. in 1771 and closes with the abdication of Gustavus IV. in 1809. This period of less than 40 years was particularly rich in literary talent; journalism began to develop; the drama flourished and literature began to take a characteristically national shape. Gustavus III. (1746–92) was himself a playwright of no mean ability. One of his prose dramas, *Siri Brahe och Johan Gyllenstjerna,* held the stage for many years. But his best work was his national drama of *Gustaf Vasa* (1783), written by the king in prose, and afterwards versified by Kellgren. In 1773 the king opened the national theatre in Stockholm, and on that occasion an opera of *Thetis och Pelée* was performed, written by himself. In 1786 Gustavus created the Swedish Academy, on the lines of the French Academy, but with 18 members instead of 40.

The principal writers are classical and academic. But Carl Michael Bellman (*q.v.;* 1740–95), an improvisatore of the first order, had nothing academical in his composition. His *Fredmans epistlar* (1790) and *Fredmans sångar* (1791), with their riot of bacchanalian humour and fine characterization, are among the greatest of Swedish song books, and unique in the literature of their age. Of the Gustavians in the narrower sense, Johan Gabriel Oxenstjerna (1750–1808) was a graceful idyllist (*Skördarne, The Harvests; Dagens stunder, The Hours of the Day*); Johan Henrik Kellgren (*q.v.;* 1751–95), who assisted the king with his dramas, was a poet and critic of high distinction; while Carl Gustaf af Leopold (1756–1829), another of the king's favourites, carried the Gustavian tradition far into the 19th century. He wrote *Erotiska Oder* (1785), a satire, *Enebomiad* (1795), and two classic tragedies, *Oden* and *Virginia* (1790, 1802). The chief dramatist of the age was, however, Gudmund Göran Adlerbeth (1751–1818) who also made translations of the classics, of Racine and Voltaire and of old Norse poetry. D. G. Björn (1757–1810), C. Envallsson (1756–1806) and Olof Kexél (1749–96) supplied the Gustavian theatre with its comedy. Anna Maria Lenngren (1754–1817) was a very popular writer of graceful domestic verse, chiefly between 1795 and 1800, and a forerunner of modern literary developments.

Two writers of the academic period were definite precursors of the Romantic revival. Bengt Lidner (1757–93), a melancholy and elegiac writer of real poetic inspiration, led a disordered, wandering life which began with an adventurous voyage to the Cape, and died in poverty. He wrote two dramas, *Erik XIV,* and *Medea,* but only a narrative poem, *Grefvinnan Spastaras död* (*The Death of the Countess Spastara,* 1783), has retained its popularity. Thomas Thorild (1759–1808) was a much stronger nature, and led the revolt against prevailing taste with far more vigour. His best poem, *Passionerna,* in hexameters, appeared in 1785, but it is mainly as a prose writer that he is now remembered. He settled in Germany and died as a professor in Greifswald. Karl August Ehrensvärd (1745–1800) may be mentioned here as a critic whose aims somewhat resembled those of Thorild. Among critics of taste may be mentioned Nils Rosén von Rosenstein (1752–1824), the first secretary of the Swedish Academy, who exercised great influence over Swedish literature and thought. His writings include an eloquent argument against Rousseau's theory of the injurious influence of art and letters.

The Romantic Movement.—The excellent lyric poet Frans Mikael Franzén (*q.v.*) (1772-1847), who was deeply influenced by English poetry, and a belated academician Johan David Valerius (1778–1852), fill up the space between the Gustavian period and the domination of Romantic ideas from Germany. It was Lorenzo Hammarsköld (1785–1827) who in 1803 introduced the views of Tieck and Schelling and founded the society in Uppsala called "Vitterhetens Vänner." His chief work was *Svenska vitterheten* (1818, etc.) a history of Swedish literature. Hammarsköld's society was succeeded in 1807 by the famous "Auroraförbundet," founded by two youths of genius, Per Daniel Amadeus Atterbom (1790–1855) and Vilhelm Fredrik Palmblad (1788–1852). These young men formulated the Romantic doctrine in their journals, *Polyfem* and *Fosforos* (1809–13), the latter giving the name "Fosforistena" ("Phosphorists") to their school. Atterbom is the greatest of the purely Romantic poets of Sweden. His chief work is a poetic drama in two parts, *Lycksalighetens ö* (*The Isle of Bliss,* 1824–27) which, although over-long, contains scenes of striking imaginative beauty. Palmblad is the chief novelist of the group. Other leading Phosphorists were Samuel Hedborn (1783–1859); Clas Livijn (1781–1844), author of a remarkable novel, *Spader Dame* (*Queen of Spades,* 1824), and, as a dramatist, a pioneer of Shakespearian influence in Sweden; Adolph Törneros (1794–1839), and Carl Frederik Dahlgren (1791–1844), the last-mentioned a humorist who owed much to the example of Bellman. Fru Julie Nyberg (1785–1854), "Euphrosyne," a poetess of some distinction, was the muse of the school. On the part of the academy the Phosphorists were vigorously attacked by Per Adam Wallmark (1777–1858), to whom they replied in a satire which was the joint work of several writers, *Markalls sömnlösa nätter* (*Markall's Sleepless Nights,* 1820). The most cultured woman of this Uppsala circle was Malla Montgomery-Silfverstolpe (1782–1861), whose exceedingly interesting *Memoarer* was only published in 1908–11.

In 1811 certain young men in Stockholm founded a society for the elevation of literary taste by means of the study of Scandinavian antiquity. This was the "Götiska förbundet" ("Gothic Society"), and its organ was the journal *Iduna* (1811–24). Of its patriotic editors the most prominent were Erik Gustaf Geijer (*q.v.*) (1783–1847); and Esaias Tegnér (*q.v.*) (1782–1846); afterwards bishop of Vexio, and usually regarded as the greatest of all Swedish writers. Eminent as a historian and critic, Geijer has also added, with his *Vikingen, Odalbonder* (*The Peasant Freeholder*) and *Psalmer,* to the treasures of Swedish poetry. Tegnér's copious verse is filled with a noble idealism—at times, perhaps, too rhetorical in its expression—which has closer affinities with the classic tradition of the 18th century than with the Romanticism of his own time. His *Frithiofs saga* (1825), although its sentimentalism is little to the taste of the modern world, was long the most famous of all Swedish poems. To the Gothic Society belonged also Per Henrik Ling (1776–1839), an extreme enthusiast for the Scandinavian past, but now better remembered as the father of gymnastic science than as a poet; Arvid August Afzelius (1785–1871), the first editor of Swedish folk-songs; Benard von Beskow (1796–1868), lyric poet and dramatist; and Carl August Nicander (1799–1839), a poet of distinction who to some extent represents a compromise with the Phosphorists. With the two latter was associated Carl Wilhelm Böttiger (1807–78), a poet influenced in turn by all the greater Romanticists; his unfinished autobiography, *Ungdomsminnen* (*Memories of Youth*), written in his last years, is a masterpiece in its way. Johan Olof Wallin (1779–1839) may be mentioned in the same category, although he is really independent of all schools. He was archbishop of Uppsala and in 1819 published *Den svenska psalmboken,* the national hymn-book of Sweden, a great collection of sacred poetry; 126 of the hymns were written by Wallin himself.

From 1810 to 1840 was the supreme age of Swedish poetry. Second only to Tegnér in genius is Erik Johan Stagnelius (1793–1823). His life and mysterious death have given a romantic interest to all that is connected with his name. His first publication was an epic, *Vladimir den store* (*Vladimir the Great,* 1817), which was followed by a romantic poem, *Blenda.* His dramas, *Bacchanterna* (*The Bacchantes,* 1822), *Martyrerna* (*The Martyrs,* 1821) and the posthumous *Sigurd Ring* are among his most original productions. His mystical lyrics include *Liljor i Saron* (*Lilies in Sharon,* 1812) and his sonnets are the best in Swedish.

Rise of Realism.—Romance began to yield to realism. The first place here belongs to C. J. L. Almqvist (*q.v.*) (1793–1866), whose influence and chequered life recall that of Strindberg. His novels and sketches are collected (14 vols.) under the title *Törnrosens bok* (1832–51). The new realism also appears in Samuel Ödman (1750–1829), and in the descriptions of nature—which recall Linné—of Petrus Laestadius (1802–41) and Nils Lovén (Nicolovius, 1796–1858). Fredrik Cederborgh (1784–1835) revived the comic novel in his *Uno von Trasenberg* (1809–10) and *Ottar Tralling* (1810); and Swedish history supplied themes for the romances of Count Per Georg Sparre (1790–1871) and of Gustaf Herik Mellin (1803–76).

The most popular novelist was Fredrika Bremer (*q.v.*) (1801–65), a native of Finland. Her stories of domestic life owed much to English models, and enjoyed a European reputation inferior only to that of Tegnér's *Frithiofs saga.* Another woman novelist, Sofia von Knorring (*née* Zelow, 1797–1848) wrote about the same time a long series of aristocratic novels. A polemical writer of great talent was Magnus Jakob Crusenstolpe (1795–1865); while in history, besides Geijer, Jonas Hallenberg (1748–1834) and Anders Magnus Strinnholm (1786–1862) prepared the way for the most widely read of all Swedish historians, Anders Fryxell (1795–1881): *Berättelser ur svenska historien* (1823–80).

With Tegnér the greatest poet of Swedish literature is the Finn, Johan Ludvig Runeberg (*q.v.*) (1804–77). Between 1832 and 1844 Runeberg published a series of splendid epics, *Elgyskyttarne* (*The Elk Hunters*), *Hanna, Nadeschda* and *Julgräften* (*Christmas Eve*); in 1848 and 1860 followed the two volumes of *Fänrik Ståls sägner* (*Ensign Stål's Tales*). They achieve wonderful portraits and vigorous metrical swing.

Bernhard Elis Malmström (1816–65) produced in 1840 a volume of elegies, *Angelika;* with two later volumes of poems (1845, 1847). In his literary history he showed himself to be a discriminating critic.

Johan Börjisson (1790–1866) was the last of the Phosphorists, author of several romantic dramas; Vilhelm von Braun (1813–60), a writer of humorous verse; "Talis Qualis," a poetical poet and translator of Byron whose real name was Carl Vilhelm August Strandberg (1818–77); Oscar Patrick Sturzen-Becker (1811–69), better known as "Orvar Odd," a lyrical poet who was also the author of a series of excellent sketches of everyday life; and August Blanche (1811–68), the most popular dramatist of the period. Fredrik August Dahlgren (1816–95) gained a great reputation with his *Värmlänningarna* (1846), a national drama interspersed with songs and dances, and with his poems in the Värmland dialect. Other notable dramatists of the period were Johan Jolin (1818–84) and Frans Hedberg (1828–1908), who in his old age adapted himself in a remarkable degree to modern tastes. A popular novelist of this period was Emilie Flygare-Casten (*née* Smith, 1807–92); indeed, in respect of popularity she entered into Fredrika Bremer's heritage. Her best books deal with the life of the Swedish west coast. The stories and sketches of Karl Anton Wetterbergh (1804–69), known as "Onkel Adam," were much loved in their day, as were the novels of Auguste Blanche and Marie Sofie Schwartz (1819–94). But the most poetically gifted novelist of the later 19th century was the patriotic Finn, Zakris Topelius (1818–98). His long series of romances dealing with Finno-Swedish history appeared between 1850 and 1867. Lyric poetry was represented by Johan Nyborn (1815–89), the poet of Uppsala student-life; Carl Herman Sätherberg (1812–97); Gunnar Wennerberg (1817–1901), the genial improvisator of *Gluntarna* (*The Students,* 1847–50) with its memories of Bellman; and A. T. Getterstedt (1836–1914), an architect by profession and a poet of fine quality, if of limited range. The dominant force in Swedish philosophy in this period was Kristoffer Jakob Boström (1810–66); the leading journalist Lars Johan Hierta (1801–72), editor of *Aftonbladet* from 1830, a newspaper which marks an epoch in the history of the Swedish press. The aesthetic critic and poet, Carl Ruprecht Nyblom (1832–1907) helped materially to mould Swedish taste.

The serenity of Swedish literature was rudely shaken about 1884 by an incursion of modern realism, and an embittered controversy raged between the older generation and the new. The leader of the older school was Viktor Rydberg (*q.v.*) (1828–95), a writer of many-sided activities, but chiefly remembered as the author of the five novels *Fribytaren på Östersjön* (*The Freebooter on the Baltic,* 1857) *Den siste Athenaren* (*The Last Athenian,* 1859), *Singoalla* (1865) and *Vapensmoden* (*The Armourer,* 1891). He was ably supported by Carl Snoilsky (*q.v.*) (1841–1903), the greatest of Swedish lyric poets at the close of the 19th century.

Strindberg.—Four influences combined to release Swedish literature from the old hard-bound conventions. These were English thought in the writings of Darwin, Herbert Spencer and John Stuart Mill; French realism in the doctrine and practice of Zola; Norwegian drama as represented by Ibsen and Björnson; and Danish criticism in the essays and monographs of Georg Brandes. Unquestionably the greatest name in recent Swedish literature is that of Johan August Strindberg (*q.v.*) (1849–1912). The significance of his genius may be still under debate, but of one aspect of it there can be no question: he is the master of modern Swedish prose and dramatic dialogue.

Of those who worked side by side with Strindberg the most prominent was Gustaf Geijerstam (1858–1909), who began in 1884 by publishing realistic studies of peasant-life, *Fattigt folk* (*Poor People*) and a novel of Uppsala, *Erik Grane* (1885), which awakened wide interest. These were followed by a long series of popular novels in which psychological problems became increasingly predominant. But before Geijerstam, two women writers had inaugurated the new novel of unidealized actuality. These were Anne Charlotte Edgren-Leffler, subsequently duchess of Cajanello (1849–92), who, from 1882 onwards, published a series of stories (*Ur livet, From Life*) which emphasized the demand for the equality of the sexes; and Victoria Benedictsson ("Ernst Ahlgren," 1850–88), who committed suicide in Copenhagen after achieving marked success with her sketches of humble life in *Från Skåre* (*From Skåre,* 1884) and with the more ambitious novels *Pengar* (*Money,* 1885) and *Fru Marianne* (1887). Of similar tendency are the stories of Alfhild Agrell (b. 1849). Associated with Ernst Ahlgren was Axel Lundgård (b. 1861) whose novel, *Röde prinsen* (*The Red Prince,* 1889), marks a stage in the development of Swedish fiction. He subsequently turned to the historical novel to which two women, Sofie Elkan (1853–1921) and Matilda Malling (b. 1864) have also contributed books which enjoyed a wide popularity. In the '90s descriptive realism in the novel gave place to a finer psychological realism, and a more idealistic—even romantic—tendency. The change is to be seen in Geijerstam, and also in the work of Tor Hedberg (b. 1862), son of Frans Hedberg already mentioned. Of his novels, *Judas* (1886) and *På Torpa gård* (1888) may be specially mentioned. The idealistic tendency is most prominent in the novels of the representative Swedish writer at the beginning of the 20th century, Verne von Heidenstam (b. 1859), *Endymion* (1889), *Hans Alienus* (1892), *Karolinerna* (*King Charles's Men,* 1897–98) and *Heliga Brigittas pilgrimsfärd* (*St. Brigitta's Pilgrimage,* 1901); and also in the delicate short stories of Per Hallström (b. 1866), a writer who passed a considerable part of his youth in America. With Hallström may be associated Ernst Josephson (1857–1906). The greatest of Sweden's living novelists is Selma Lagerlöf (b. 1858), whose masterly *Gösta Berlings Saga* appeared in 1891, and was followed by *Antikrists mirakler* (1897), *Jerusalem* (1901–02), and the delightful journey of *Nils Holgersson* through Sweden on the back of a wild swan (1906–07). In a long series of admirable short stories she has brought world-fame to her native province of Värmland. The poetry of the northern districts of Sweden has been finely expressed in the stories of Pelle Molin (1864–96) and Ludwig Nordström (b. 1882), and that of the "Skärgård"—the Stockholm archipelago—discovered for literature by Strindberg, in the writings of Albert Engström (b. 1869). A place must also be found for the fine novels of Sven Lidman (b. 1882), *Ätten Silfverstååhl* (*The Silfverstååhls*), and the polished and essentially French talent of Hjalmar Söderberg (b. 1869) whose ironic novel, *Martin Bircks ungdom,* appeared in 1901. Of the many contemporary novelists who make a more popular appeal Hilma Angered-Strandberg (b. 1855), Henning Berger (1872–1925), Hjalmar Bergman (b. 1883), Gustaf Jansson (1885–1913), Sigfrid Siwertz (b. 1882) and Elin Wägner seem to have the most serious claim for an abiding place in Swedish literary history. Many of the writers just mentioned, notably Fru Agrell, Fru Edgren-Leffler and Tor Hedberg, have also written for the theatre. To these may be added as dramatists of talent, Harald Johan Molander (1858–1900) and Ernst Didring (b. 1868). But the drama has never been a strong feature in Sweden.

Recent Lyric Poetry.—The particular glory of the last phase of Swedish literature is its lyric poetry. A forerunner of this lyric revival was Albert Ulrik Bååth (1853–1912), in whom the revolt against tradition and conventions is first apparent. His earliest poems appeared in 1879. But the real starting-point for the new lyric was Heidenstram's *Vallfart och vandringsår* (*Pilgrimage and Wanderings,* 1888), which was followed in later years by other volumes of conspicuously beautiful verse. Then, in 1891, appeared *Gitarr och dragharmonika* (*Guitar and Accordion*), the first collection of poems by Sweden's greatest modern lyricist, Gustaf Fröding (1860–1911). It was followed by other collections—notably *Stänk och flikar* (*Sprinklings and Snippets*)—of extraordinary originality, variety and haunting beauty. His later life was overshadowed by mental derangement, which left its mark on his latest work. Another of the leading lyric poets of modern Sweden is Erik Axel Karlpeldt (b. 1864), and indeed, in many respects the most subtle and delicate of them all. His *Friddins visor* (1898), *Fridolins lustgård* (*Fridolin's Garden,* 1901), and *Flora och Pomona* (1906) are the greatest contributions to Swedish poetry of his native province, Dalecarlia. The poetry of Oscar Levertin (1862–1906) introduces an exotic note and recalls in some measure our English Preraphaelites, by whom he was influenced. Of the many eminent lyric talents of modern Sweden, mention can only be made here of Ola Hansson (b. 1860) whose early work (*e.g., Sensitiva amorosa,* 1887) provided an antidote to the harshness of Strindberg's realism; Daniel Fallström (b. 1858); F. Vetterlund (b. 1865); Emil Kleen (1868–98); Bo Bergman (b. 1869); Viktor Ekelund (b. 1880); Per Hallström; Sven Liden; K. G. Ossiannilsson (b. 1875); Gustaf Ullman (b. 1881), and Anders Österling (b. 1884).

Amongst recent literary historians and critics, the most prominent are Oscar Levertin, Henrik Schück, Karl Johan Warburg, Fredrik Böök, Anton Blanck and Martin Lamm; while of writers dealing with social and educational problems, Ellen Key (1849–1926) has, with her *Tankebilder* (*Thought Pictures,* 1898), *Människor* (*Men and Women,* 1899), and *Livslinjer* (*Life Lines,* 1903–06), achieved an international reputation.

BIBLIOGRAPHY.—Of older books on Swedish literary history the following have still real value: P. D. A. Atterbom, *Svenska, siare och skalder* (Uppsala, 1841–55); B. E. Malmström, *Granddragen av svenska vittshateus historia* (1866–68); C. R. Nyblom, *Estetiska Studier* (1873–84). The standard history of Swedish literature is H. Schück and K. Warburg, *Svensk litteraturhistoria* (1885, *seq.;* 2nd ed., 1911–16; a 3rd ed. begun in 1926). Excellent is also the *Svenska litteraturens historia* by several collaborators and edited by O. Sylwan (3 vols., 1919–23); in German, Ph. Schweitzer, *Geschichte der skandinavischen Literatur* (Leipzig, 1886–89). There are smaller histories by R. Steffen (5th ed., 1919); H. Schück, *Histoire de la littérature suédoise* (1923); H. de Boor, *Schwedische Literatur* (Breslau, 1924). Indispensable are the many volumes of Oscar Levertin's critical works. An invaluable anthology is provided by the series of 25 vols., *Sveriges nationallitteratur,* edit. by H. Schück and R. Gφrson Berg (Stockholm, 1907–12), and, in smaller compass, R. Steffen, *Översikt av svensk litteraturen* (4 vols., 1918 *seq.*).

(E. G.; J. G. R.)

The Period Since 1910.—Among the more notable novelists of the present day we find on the whole more originality among the women than among the men, some of whom still reflect the influence of Strindberg in certain aspects of their work. Hildur Dixelius-Brettner in her trilogy of three generations, *Prästdottern* (1920), *Prästdotterns Son, Sonsonen* (1922) achieved an admirable unity of feeling, essentially tragic, but tempered by the humour of real life. Elin Wägner came to the fore with *Pennskaftet,* a bright and witty novel of feminist Stockholm; she later established a more permanent reputation with *Åsa-Hanna* (1918) and *Den namnlösa* (1922) which show a deep human sympathy.

The novels of Sigfrid Siwertz are studies in degeneration, marked by sure psychological insight. The most remarkable of them, *Selambs* (1920), Eng. trans. *Downstream* (1922), is a family history of the now classical Rougon-Macquart type, but concentrated in a single generation; the workmanship is of high order, but the picture suffers somewhat from lack of relief. His later novel, *Hem från Babylon,* by drawing on the bizarre and fantastic, gives the impression of a paucity of human material. Among retrospective novels of Swedish life Erik Fahlman's *Firman Åbergson* (1914) stands out as the work of a true artist. The hero is a self-made provincial of the mid-19th century with all the virtues and limitations of his race and time. The texture of the book is extraordinarily light, and the subtlety with which the author has created his atmosphere is altogether admirable. K. G. Ossiannilsson, who began (in a way that is almost a tradition with Swedish writers) as a lyricist, later published a number of novels of contemporary life. He is a writer of originality who has the courage of his opinions and has not shrunk from exposing himself to attack and political isolation by his frankness. His *Bondlandet* (1919), a novel of country life, is a good character study, clearly treated. In *Förtrollningen* (1924) he deals with modern hysteria.

Less clear in his method, but full of vivacity, is Ludvig Nordström, most of whose work bears the general title *Skildringar ur Svenska Nationens Lif.* He is most successful in *Landsorts-bohême* (1912), a thoroughly amusing satire on provincial bohemians, with the editor of a local paper for its central figure. A later work, *Döda världar i Samhällsrymden* (1920), is an ambitious attempt to deal in a fantastically satirical vein with the industrial evolution of Sweden.

Hjalmar Bergman in his best work, *Markurells i Wadköping* (1919), Eng. trans. *God's Orchid* (1924), has succeeded in blending together tragedy, high comedy and farce while never outraging our sense of fitness and psychological probability. This book, the action of which is concentrated into a single day in the life of a provincial town, is something of a *tour de force,* but at the same time a remarkably trenchant study of character. Henning Berger (1872–1925) was a realist of pessimistic outlook, whose strength lay in the delineation of the life of great cities. His best work is the *Dreamland* trilogy, in which he depicts with great variety of treatment the loss of illusions suffered by Swedes of the educated class in America and the brutalising effect of standardisation on the mental and moral character of the individual. Returning to Stockholm in *Fata Morgana* (1911), his banker hero has renounced his ideals and settled down to a comfortable epicurean view of life.

While contemporary literature affords an admirable retrospect of 19th century life and manners, the future historian will only find in it fragmentary and distorted material for a picture of the 20th. Writers in their dread of the commonplace have exaggerated the fantastic, thereby detracting from the documentary value of their work—a fault not peculiar to Sweden.

BIBLIOGRAPHY.—Fredrik Böök, *Sveriges moderna litteratur* (1921); Gunnar Jörn, *Svenska diktarporträtt* (Uppsala, 1924). (A. G. CH.)

SWEELINCK or **SWELINCK, JAN PIETER** (also known as JAN PIETERSZOON) (1562–1621), Dutch organist and composer, was probably born at Amsterdam, although his family came from Deventer. It has been persistently stated that he was a fellow pupil with Giovanni Gabrieli and Leo Hassler of the great Andrea Gabrieli in Venice, but this has been disproved by F. H. J. Tiedeman in the *Vereeniging voor Nederlandsche Muziekgegeschiedenis* (Amsterdam 1876). Sweelinck was the son of the organist of the Old Church, Amsterdam, and lived in Holland from about 1577 onward. At a date not later than 1581 he was appointed organist to the Old Church, his father having died in 1573, and this post he held until his death on Oct. 16, 1621.

A complete edition of his works, edited by Max Seiffert with prefaces, was brought out by Breitkopf & Härtel in 1894–1901. *See* also Grove, *Dictionary of Music & Musicians.*

SWEET, HENRY (1845–1912), English philologist, was born in London on Sept. 15, 1845. Educated at King's college, London, Balliol College, Oxford, and Heidelberg university, he was a recognized authority on phonetics, and a readership in phonetics was specially created for him in 1901 by the University of Oxford. He died at Oxford on April 30, 1912.

His works include *Anglo-Saxon Reader* (1866); *Student's Dictionary of Anglo-Saxon* (1897); *A Short Historical English Grammar* (1866); *The History of Language* (1900); and many editions of Old and Middle English texts. The *Collected Papers of Henry Sweet* were edited by H. C. Wyld (1913).

SWEETBREAD, a popular term for certain glands of animals, particularly when used as articles of food; these are usually the pancreas, the "stomach-sweetbread" of butchers, and the thymus, or "breast sweetbread." The term is also sometimes used to include the salivary and lymphatic glands (*see* DUCTLESS GLANDS, PANCREAS and LYMPHATIC SYSTEM).

SWEETBRIER (*Rosa Eglanteria* or *R. rubiginosa*), a tall, stiff-stemmed rose, called also eglantine, native to Europe, widespread in Great Britain, and extensively naturalized in eastern North America. The erect, somewhat branching stem, armed with stout hooked prickles, grows usually from 5 to 8 ft. high. It bears fragrant leaves, of 5 to 7 leaflets, and solitary white or pinkish flowers, 1 to 2 in. across. While the sweetbrier is infrequently grown for ornament, various hybrids with other roses are in cultivation. (*See* Rose.)

SWEET CLOVER, the popular name for plants of the leguminous genus *Melilotus*, called also melilot, comprising about 20 species, natives of the Old World. They are annual or biennial, sweet-smelling, erect herbs, with pinnate leaves of three usually small, narrow leaflets and small yellow or white flowers, borne in slender axillary clusters (racemes). The white sweet clover (*M. alba*), 3 to 10 ft. high, and the similar but larger flowered yellow sweet clover (*M. officinalis*) occur in the British Isles and are widely naturalized in the United States and Canada. A yellow-flowered Eurasian species (*M. indica*), $1\frac{1}{2}$ to 3 ft. high, with minute flowers only about $\frac{1}{12}$ in. long, has become extensively naturalized in California and other western States. Since about 1900 agricultural varieties of the white sweet clover, as Bukhara clover and Hubam clover (var. *annua*), and also of *M. indica* have been grown as forage, cover and soiling crops in various parts of the United States.

For details regarding cultivation, *see* "Sweet Clover," *Leaflet No. 23, U.S. Department of Agriculture.*

SWEET CORN: *see* Maize; Vegetable; Vegetable Culture in the United States.

SWEET-GALE (*Myrica Gale*), a shrub of the family Myricaceae, called also gale, sweet willow, bog myrtle and Dutch myrtle, widely distributed in the north temperate zone. It grows usually from 2 to 4 ft. high, with numerous twiggy branches; narrow, short-stalked, fragrant leaves; inconspicuous, unisexual flowers, borne in short spikes, and small, waxy-resinous, drupe-like fruits attached to the persistent flowering bracts. The sweet-gale occurs extensively on bogs and moors in the British Isles and widely also throughout the northern United States and Canada. The leaves are used as tea and as a country medicine. (*See* Myrica.)

SWEET GUM (*Liquidambar Styraciflua*), a handsome North American tree of the witch-hazel family (Hamamelidaceae), called also red gum, liquidambar (*q.v.*) and bilsted, found from Connecticut to Missouri and southward to Florida and Mexico. It has a straight trunk, sometimes 140 ft. high and 5 ft. in diameter, with rough bark, corky-winged branches, large deeply lobed leaves, and drooping, spiny, globose fruiting heads containing winged seeds. The hard reddish-brown wood is known to the lumber trade as red gum or satin-walnut. In 1925 the cut of red gum lumber in the United States amounted to 1,100,648,000 bd.ft., valued at the mill at $34,549,341. The tree yields liquidambar, called also copalm-balsam, a fragrant gum-resin very similar to the storax produced by *L. orientale* of Asia Minor.

SWEET POTATO, a food plant, known botanically as *Ipomaea batatas*, a member of the family Convolvulaceae (*q.v.*). It is widely cultivated in tropical and warm countries for its tuberous root, which is a valuable article of diet. It is a climbing perennial with entire or palmately-lobed leaves very variable in shape, borne on slender twining stems. The flowers are borne on long stalks in loose clusters or cymes, and have a white or rosy funnel-shaped corolla like that of the common bindweed of English hedges. The edible portion is the root, which dilates into large club-shaped masses filled with starch. The plant is not known in a truly wild state. A. de Candolle believes that it is of American origin, where it has been cultivated from prehistoric times. The allusions in the *Merry Wives of Windsor* and other of Shakespeare's plays probably refer to the sweet potato.

The sweet potato is an important food crop in the southern United States where among the root crops its rank is second to the common potato, the total production in 1927 being estimated at 93,928,000 bu., valued at $77,020,960; Texas, Georgia, North Carolina and Louisiana, produced 45% of the total crop.

For an account of its cultivation in India, *see* Sir George Watt, *Dictionary of Economic Products of India* (1890). *See* also W. W. Robbins, *The Botany of Crop Plants* (Philadelphia, 1924); L. H. Bailey, *Standard Cyclopedia of Horticulture* (1914–27).

SWEET-SOP or **SUGAR APPLE,** botanical name *Anona squamosa* (family Anonaceae), a small tree or shrub with thin oblong-ovate leaves, solitary greenish flowers and a yellowish-green fruit, like a shortened pine cone in shape with a tubercle corresponding to each of the carpels from the aggregation of which it has been formed. The fruit is 3 to 4 in. in diameter and contains a sweet creamy-yellow custard-like pulp. It is a native of the West Indies and tropical America; it is much prized as a fruit, and has been widely introduced into the Eastern Hemisphere. *A. muricala* is the sour-sop (*q.v.*). *A. reticulata* is the custard apple (*q.v.*), and *A. palustris* the alligator apple.

SWEETWATER, a city of western Texas, U.S.A., on Federal highway 80; county seat of Nolan county. Pop. (1920) 4,307 (91% native white), local estimate, 10,000 in 1928. The district specializes in blooded Hereford stock, and has gas and oil fields. Sweetwater was founded in 1882 and chartered as a city in 1897. It has a commission-manager form of government, a board of city development, and a tax-supported chamber of commerce. South of the city are the ruins of Fort Chadbourne, built in 1853.

SWELLENDAM, town, situated in the valley of the Breede river, 192 m. E. by S. of Cape Town by rail; 33° 59′ S., 20° 23′ E.; altitude 500 feet. It dates from 1745. In 1795 the people rebelled against the Dutch East India company, proclaimed a free republic and demanded "the absolute and unconditional slavery of all Hottentots and Bushmen." In September of that year Cape Town surrendered to the British, and Swellendam quietly accepted British rule. The town has lost much of its former importance. The population in 1926 included 1,814 whites, and probably a greater number of "coloured" people.

SWETCHINE, MADAME (1782–1857), Russian mystic, whose maiden name was Soymanof, was born in Moscow, and under the influence of Joseph de Maistre became a member of the Roman Catholic Church in 1815. In the following year she settled in Paris, where, until her death, she maintained a famous salon remarkable no less for its high courtesy and intellectual brilliance than for its religious atmosphere. Her *Life and Works* (of which the best known are "Old Age" and "Resignation") were published by M. de Falloux (2 vols., 1860) and her *Letters* by the same editor (2 vols., 1861).

See Sainte-Beuve, *Nouveaux lundis*, vol. i.; and E. Scherer, *Études sur la littérature contemporaine*, vol. i.

SWETE, HENRY BARCLAY (1835–1917), English theologian, was born at Bristol on March 14, 1835, and educated at King's College, London, and Caius College, Cambridge. He was ordained in 1858, and became in 1865 dean of Caius College. In 1877 he accepted the college living of Ashdon, Essex, and in 1882 was made professor of pastoral theology at King's College, London. In 1890 he succeeded Westcott as regius professor of divinity at Cambridge, retiring with the title of emeritus professor in 1915. He died at Hitchin on May 10, 1917.

Swete's works on Biblical texts are of the highest importance. In 1887 he published the first volume of his edition of the Greek text of the Old Testament, completing the series in 1894 (3rd ed., 1901–07); in 1898 the Greek text of the Gospel of St. Mark with notes and introduction (2nd ed., 1902), and in 1906 that of the apocalypse of St. John (2nd ed., 1907). He was the editor of *Cambridge Theological Essays* (1905) and *Cambridge Biblical Essays* (1909), and contributed to Smith and Wace's *Dictionary of Christian Biography* (1882–87) and Hastings's *Dictionary of the Bible* (1899–1900). His historical and critical works include *The Apostles' Creed in Relation to Primitive Christianity* (1894; 3rd ed., 1899); *Church Services and Service Books before the Reformation* (1896); *Patristic Study* (1902); *The Appearances of our Lord after the Passion* (1907, 2nd ed., 1908), and *The Last Discourse and Prayer of Our Lord* (1913).

SWEYN I., King of Denmark (d. 1014), son of Harold Bluetooth, the christianizer of Denmark, by his peasant mistress Aesa, according to the Jomsvikinga Saga, though more probably his mother was Queen Gunild, Harold's consort. The lad was a born champion and buccaneer. His first military expedition, in alliance with the celebrated Jomsborg Viking, Palnatoke, was against his own father, who perished during the struggle (*c.* 986). Six years later he conducted a large fleet of warships to England, which did infinite damage, but failed to capture London. During his absence, Denmark was temporarily occupied by the Swedish king, Eric Sersel, on whose death (*c.* 994) Sweyn recovered his patrimony. About the same time he repudiated his first wife Gunild, daughter of duke Mieszko of Poland, and married King Eric's widow, Sigrid. This lady was a fanatical pagan of a disquieting strength of character. Two viceroys, earlier wooers, were burned to death by her orders for their impertinence, and she refused the hand of Olaf Trygvessön, king of Norway, rather than submit to baptism, whereupon the indignant monarch struck her on the mouth with his gauntlet and told her she was a worse pagan than any dog. Shortly afterwards she married Sweyn, and easily persuaded her warlike husband to unite with Olaf, king of Sweden, against Olaf Trygvessön, who fell in the famous sea-fight off Svolde (1000) on the west coast of Rügen, after a heroic resistance immortalized by the sagas, whereupon the confederates divided his kingdom between them. After his first English expedition Sweyn was content to blackmail England instead of ravaging it, till the ruthless massacre of the Danes on St. Brice's day, Nov. 3, 1002, by Ethelred the Unready (Sweyn's sister was among the victims) brought the Danish king to Exeter (1003). During each of the following eleven years, the Danes, materially assisted by the universal and shameless disloyalty of the Saxon ealdormen, systematically ravaged England, and from 991 to 1014 the wretched land is said to have paid its invaders in ransoms alone £158,000. Sweyn died suddenly at Gainsborough on Feb. 13, 1014. His memory has suffered from the fact that the chief chroniclers of his deeds and misdeeds were ecclesiastics.

See *Danmarks riges historie. Oldtiden og den aeldre middelalder,* pp. 364–381 (Copenhagen, 1897–1905). (R. N. B.; X.)

SWIFT, JONATHAN (1667–1745), dean of St. Patrick's, Dublin, British satirist, was born at No. 7 Hoey's Court, Dublin, on Nov. 30, 1667, a few months after the death of his father, Jonathan Swift (1640–1667), who married about 1664 Abigaile Erick, of an old Leicestershire family. His grandfather, Thomas Swift, vicar of Goodrich near Ross, appears to have lost his possessions by taking the losing side in the Civil War and died in 1658 before the restoration could bring him redress. He married Elizabeth, niece of Sir Erasmus Dryden, the poet's grandfather. The young Swift was supported by his uncle Godwin, a Tipperary official; at the age of six he entered Kilkenny school, where Congreve was a fellow student, and he completed his education at Trinity college, Dublin. Here he exhibited few signs of precocious genius, and it was only by special act of indulgence that he obtained his degree; then, on the death of his uncle, he left Ireland and sought counsel of his mother in Leicester.

His first employment commenced towards the close of 1689, when he became secretary to Sir William Temple, who was living in retirement at Moor Park, near Farnham. His ability gradually won him the confidence of his employer, and he was entrusted with some important missions. In 1694, however, Swift (who had in the meantime obtained the degree of M.A. *ad eundem* at Oxford) quitted Temple, who had, he considered, delayed too long in obtaining him preferment; but it was only after five months' delay, when Swift had unwillingly begged the favour of a testimonial from his discarded patron, that he was able to obtain the small prebend of Kilroot near Belfast (Jan. 1695).

In the meantime he had grown tired of Irish life and was glad to accept Temple's proposal for his return to Moor Park, where he continued until Temple's death in Jan. 1699. His *Pindaric Odes*, written at this period or earlier, indicate the rudiments of a real satirist, but of more importance was his first essay in satiric prose, *The Battle of the Books;* this arose out of a dispute originated in England by Temple's *Essay upon Ancient and Modern Learning*, which argued the superiority of the Ancients over the Moderns. Swift's aim was limited to co-operation in what was then deemed the well-deserved putting down of Bentley by Boyle. Though written in 1697, the satire remained unpublished until 1704, when it was issued with *The Tale of a Tub.*

After Temple's death, Swift suffered several disappointments in attempting to find employment, but he eventually secured the rectory of Agher in Meath with the united vicarages of Laracor and Rathbeggan, to which was added the prebend of Dunlavin in St. Patrick's—the total value being about £230 a year. He was now often in Dublin, at most 20 m. distant, and through Lady Berkeley and her daughters—Lord Berkeley was now a lord justice of Ireland—he became the familiar and chartered satirist of the fashionable society there. But he very soon began to grow tired of Ireland again and to pay visits in Leicester and London. His resolution to exchange divinity for politics must appear fully justified by the result. The *Discourse on the Dissensions in Athens and Rome* (Sept. 1701), written to repel the tactics of the Tory commons in their attack on the Partition Treaties "without humour and without satire," and intended as a dissuasive from the pending impeachment of Somers, Orford, Halifax and Portland, received the honour of being generally attributed to Somers himself or to Burnet, the latter of whom found a public disavowal necessary. In April or May 1704 appeared a more remarkable work. Clearness, cogency, masculine simplicity of diction, are conspicuous in the pamphlet, but true creative power told the *Tale of a Tub.* Although it lacks coherence and attains no conclusion, it is the most strikingly original of Swift's satirical works.

In Feb. 1701 Swift took his D.D. degree at Dublin, and before the close of the year he had taken a step destined to exercise a most important influence on his life, by inviting two ladies to Laracor. Esther, daughter of a merchant named Edward Johnson, a dependant, and legatee to a small amount, of Sir William Temple's (born in March 1680), whose acquaintance he had made at Moor Park in 1689, and whom he has immortalized as "Stella," came over with her companion Rebecca Dingley, a poor relative of the Temple family, and was soon permanently domiciled in his neighbourhood. Meanwhile the sphere of his intimacies was rapidly widening. He had been in England for three years together, 1701 to 1704, and counted Pope, Steele and Addison among his friends. In 1708 he wrote the finest example of his irony, the *Argument to prove that the abolishing of Christianity in England may, as things now stand, be attended with some inconveniencies,* and about this time, too (Nov. 1707), he produced his best narrative poem, *Baucis and Philemon.*

The next few months witnessed one of the most amusing hoaxes ever perpetrated against the quackery of astrologers, the victim being a Protestant alarmist and plot vaticinator styled John Partridge. In Jan. 1708, Swift, under the name of Isaac Bickerstaff, issued a solemn prediction that the notorious almanac maker, Partridge, would die at 11 o'clock P.M. on March 29, and on March 30 he published a letter confirming this prophecy. Partridge's fatuous denial and reply to Bickerstaff elicited Swift's amusing *Vindication of Isaac Bickerstaff, Esq.*, in April 1709. The episode has left a permanent trace in literature, for when, in 1709, Steele was to start the *Tatler*, it occurred to him that he could secure the public ear in no surer way than by adopting the name of Bickerstaff.

From Feb. 1708 to April 1709 Swift was in London, urging upon the Godolphin administration the claims of the Irish clergy to the first-fruits and twentieths ("Queen Anne's Bounty"), already granted to their brethren in England. His having been selected for such a commission shows that he was not yet regarded as a deserter from the Whigs, although the ill success of his representations probably helped to make him one. By Nov. 1710 he was again domiciled in London, and writing his *Journal to Stella*, that unique exemplar of a giant's playfulness. In the first pages of this minute record of a busy life we find him depicting the decline of Whig credit and complaining of the cold reception accorded him by Godolphin, whose penetration had doubtless detected the precariousness of his allegiance. Within a few weeks he had become the lampooner of the fallen treasurer, the bosom friend of Oxford and Bolingbroke, and the writer of the *Examiner*, a journal established as the exponent of Tory views (Nov. 1710). He was now a power in the State and the associate of ministers on a footing of perfect cordiality and familiarity. For a brief time he seemed to resume the whole power of the English press in his own pen and to guide public opinion as he would—his services to his party as writer of the *Examiner*, which he quitted in July 1711, were even surpassed by those which he rendered as the author of telling pamphlets. We need not suppose that he was consulted respecting the great Tory strokes of the creation of the twelve new peers and the dismissal of Marlborough (Dec. 1711), but they would hardly have been ventured upon if *The Conduct of the Allies* and the *Examiners* had not come first.

Generous men like Oxford and Bolingbroke cannot have been unwilling to reward so serviceable a friend, especially when their own interest lay in keeping him in England. Swift still had formidable antagonists in the archbishop of York, whom he had scandalized, and the duchess of Somerset, whom he had satirized. Anne was particularly amenable to the influence of priestly and female favourites, and it must be considered a proof of the strong interest made for Swift that she was eventually persuaded to appoint him to the deanery of St. Patrick's, Dublin. In June 1713 he set out to take possession of his dignity, and encountered a very cold reception from the Dublin public. The dissensions between the chiefs of his party speedily recalled him to England. He found affairs in a desperate condition. The queen's demise was evidently at hand and public opinion was turning towards the Whigs when the Tories manifestly could not be trusted to maintain the Protestant succession. Bolingbroke's brain teemed with the wildest plans. Swift's mediation was unavailing.

When the discord of Oxford and Bolingbroke had become patent to all the nation, Swift, foreseeing, as is probable, the impending fall of the former, retired to Upper Letcombe, in Berkshire, and there spent some weeks in the strictest seclusion. This leisure was occupied in the composition of his remarkable pamphlet, *Some Free Thoughts on the Present State of Affairs,* which indicates his complete conversion to the bold policy of Bolingbroke. The utter exclusion of Whigs as well as Dissenters from office, the remodelling of the army, the imposition of the most rigid restraints on the heir to the throne—such were the measures which, by recommending, Swift tacitly admitted to be necessary to the triumph of his party.

Bolingbroke's daring spirit, however, recoiled from no extreme, and, fortunately for Swift, he added so much of his own to the latter's ms. that the production was first delayed and then, upon the news of Anne's death, immediately suppressed. This incident only just anticipated the revolution which, after Bolingbroke had enjoyed a three days' triumph over Oxford, drove him into exile and prostrated his party. Almost the first acts of Bolingbroke's ephemeral premiership were to order him £1,000 from the exchequer and despatch him the most flattering invitations. The same post brought a letter from Oxford, soliciting Swift's company in his retirement; and, to the latter's immortal honour, he hesitated not an instant in preferring the solace of his friend to the offers of Bolingbroke. When, a few days later, Oxford was in prison and in danger of his life, Swift begged to share his captivity; and it was only on the offer being declined that he finally directed his steps towards Ireland, where he was very ill received. The draft on the exchequer was intercepted by the queen's death.

During these four busy years of London life, Swift had entered deeply into the literary life of the period. He was treasurer and a leading member of the Brothers, a society of wits and statesmen which recalls the days of Horace and Maecenas. He promoted the subscription for Pope's *Homer*, contributed some numbers to the *Tatler, Spectator,* and *Intelligencer,* and joined with Pope and Arbuthnot in establishing the Scriblerus Club, contributing to *Martinus Scriblerus,* his share in which can have been but small, as well as *John Bull,* where the chapter recommending the education of all blue-eyed children in depravity for the public good must surely be his. His miscellanies, such as *A Meditation upon a Broomstick,* and the poems *Sid Hamet's Rod, The City Shower, The Windsor Prophecy, The Prediction of Merlin,* and *The History of Vanbrugh's House,* belong to this period. A more laboured work, his *Proposal for Correcting, Improving and Ascertaining the English Tongue* (1712), in a letter to Harley, suggesting the regulation of the English language by an academy, is chiefly remarkable as a proof of the deference paid to French taste. His *History of the Four Last Years of the Reign of Queen Anne* is not on a level with his other political writings.

To Swift the change from London to Dublin meant for the time the fall from unique authority to absolute insignificance. All share in the administration of even Irish affairs was denied him; every politician shunned him; and his society hardly included a single author or wit. Before and after his elevation to the deanery of St. Patrick's, Esther Johnson and Mrs. Dingley continued to reside near him, and superintended his household during his absence in London. He had offered no obstacle in 1704 to a match proposed for Stella to Dr. William Tisdall of Dublin. Whatever the cause, his conduct proved the fatal embitterment of his life and Stella's and yet another's. He had always been unlucky in his relations with women. Esther Vanhomrigh, "Vanessa" (b. Feb. 14, 1690), the daughter of a Dublin merchant of Dutch origin, had become known to Swift at the height of his political influence. He lodged close to her mother, and Vanessa insensibly became his pupil, while he became the object of her impassioned affection.

But Swift was devoid of passion. Of friendship, even of tender regard, he was fully capable, but not of love, and Vanessa's ardent and unreasoning display of passion was beyond his comprehension. Yet Vanessa assailed him on a very weak side. The strongest of all his instincts was the thirst for imperious domination. Vanessa hugged the fetters to which Stella merely submitted. Flattered to excess by her surrender, yet conscious of his binding obligations and his real preference for Stella, he could neither discard the one beauty nor desert the other. When Vanessa's mother died (1714), she followed him to Ireland, taking up her abode at Celbridge within ten miles of Dublin. Unable to marry Stella without destroying Vanessa, or openly to welcome Vanessa without destroying Stella, he was thus involved in the most miserable embarrassment; he continued to temporize. Had the solution of marriage been open Stella would undoubtedly have been Swift's choice, but some mysterious obstacle intervened.

Meanwhile Swift's efforts were directed to soothe Miss Vanhomrigh, to whom he addressed *Cadenus* [*Decanus*] *and Vanessa,* the history of their attachment and the best example of his serious poetry, and for whom he sought to provide honourably in marriage, without succeeding either in his immediate aim or in thereby opening her eyes to the hopelessness of her passion. Worn out with his evasions, she at last (1723) took the desperate step of writing to Stella or, according to another account, to Swift himself, demanding to know the nature of the connection with him, and this terminated the melancholy history as with a clap of thunder. Stella sent her rival's letter to Swift, and retired to a friend's house. Swift rode down to Marley Abbey with a terrible countenance, petrified Vanessa by his frown, and departed without a word, flinging down a packet which only contained her own letter to Stella. Vanessa died within a few weeks. She left the correspondence for publication, but it was suppressed until it was published by Sir Walter Scott. Five years after Vanessa's death Stella died, on Jan. 28, 1728.

Between the death of Vanessa and the death of Stella came the greatest political and the greatest literary triumph of Swift's life. Although he was not an Irish patriot in the strict sense of the word, his pride and sense of equity alike revolted against the stay-at-home Englishmen's contemptuous treatment of their own garrison, and he delighted in finding a point in which the triumphant faction was still vulnerable. His *Proposal for the Universal Use of Irish Manufactures,* published anonymously in 1720, urging the Irish to disuse English goods, became the subject of a prosecution, which at length had to be dropped. A greater opportunity was at hand. A patent for supplying Ireland with a coinage of copper halfpence was accorded to William Wood on such terms that the profit accruing from the difference between the intrinsic and the nominal value of the coins, about 40%, was mainly divided between him and George I.'s favourite duchess of Kendal, by whose influence Wood had obtained the privilege. Swift now had his opportunity, and the famous six letters signed M. B. Drapier (April to Dec. 1724) soon set Ireland in a flame. Every effort was used to discover, or rather to obtain legal evidence against, the author, but none could be procured; the public passion swept everything before it; the patent was cancelled.

The noise of the *Drapier Letters* was followed by the anonymous publication of *Travels Into Several Remote Nations of the World,* in four parts, by Lemuel Gulliver, first a surgeon and then a captain of several ships (Benjamin Motto, Oct. 1726), the work being well advanced, it would seem, by 1720. The keenness of the satire on courts, parties and statesmen certainly suggests that it was planned while Swift's disappointments as a public man were still rankling and recent. Although he was afraid of the reception the book would meet with, especially in political circles, the world chose to be diverted by it. In the first two parts the misanthropy is quite overpowered by the fun. The third part, equally masterly in composition, is less felicitous in invention; and in the fourth Swift has indeed carried out his design of vexing the world at his own cost.

Swift's grave humour and power of enforcing momentous truth by ludicrous exaggeration were next displayed in his *Modest Proposal for Preventing the Children of Poor People from being a Burden to their Parents or the Country,* by fattening and eating them (1729). The *Directions to Servants,* a satire on domestics, was first published in 1745, while *Polite Conversation,* written in 1731 was published in 1738. Little beyond occasional verses—trivial and often indecent—followed, but the delightful *Hamilton's Bawn,* and the verses on his own death (1731) are exceptions, and in *The Legion Club* of 1736 he composed the fiercest of all his verse satires. His popularity remained as great as ever (he received the freedom of Dublin in 1729), and he governed his cathedral with great strictness and conscientiousness; but the attacks of giddiness to which he had always been subject increased upon him, and he grew more and more capricious and morbidly suspicious. In March 1742 it was necessary to appoint guardians of Swift's person and estate. In September of the same year his physical malady reached a crisis, from which he emerged a helpless wreck, with faculties paralysed rather than destroyed, and he eventually sank into the dementia which preceded his death on Oct. 19, 1745. He was interred in his cathedral at midnight in the same coffin as Stella, with an epitaph written by himself.

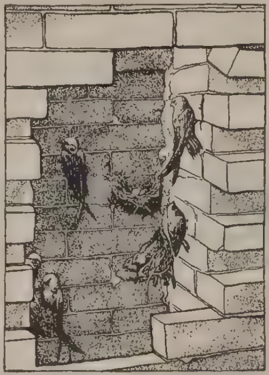
An object of pity as well as of awe, Swift is one of the most tragic figures of English literature. His master passion was imperious pride—lust for despotic dominion; place, profit and literary fame were comparatively indifferent to him. Contemptuous of the opinion of his fellows, he hid his virtues, paraded his faults, affected some failings from which he was really exempt, and, since his munificent charity could not be concealed from the recipients, laboured to spoil it by gratuitous surliness. "To think of him," says Thackeray, "is like thinking of the ruin of a great empire." Among those influenced by Swift may be mentioned Chesterfield, Smollett, Cobbett, Hazlitt, Scott, Borrow, Newman, Belloc.

BIBLIOGRAPHY.—The contemporary lives of Swift, most of which contain a certain amount of apocrypha, are those of Lord Orrery (1751); Dr. Delany's *Observations on Orrery* (1754); Dean Swift's *Essay upon the Life of Swift* (1755); and Thomas Sheridan's *Life* (of 1785). Dr. Hawkesworth, in the life prefixed to his edition of the *Works* in 1755, adds little of importance. Dr. Johnson's *Life* is marred by manifest prejudice. Dr. Barrett produced an *Essay upon the Early Life* of some value (in 1808). Six years later came the useful biography of Sir Walter Scott, and (in 1819) appeared the elaborate *Life* by W. Monck Mason in the form of an appendix to his ponderous *History of St. Patrick's.* A new epoch of investigation was inaugurated by John Forster, who began a new scrutiny of the accumulated material and published his first volume in 1875. Invaluable in many respects, it exhibited the process as well as the result of biography, and never got beyond 1711. The *Life* by Sir Henry Craik (1882 and reissues) now holds the field. Valuable monographs have been produced by Sir Leslie Stephen (Men of Letters and the Memoirs, in the *Dict. Nat. Biog.*), by Thackeray, in his *English Humourists,* by W. R. Wilde, in his *Closing Years of Dean Swift's Life,* by Lecky, in his *Leaders of Public Opinion,* by G. P. Moriarty, J. Churton Collins (1893), Max Simon (1893), Henriette Cordelet (1907) and Sophie Shilleto Smith (1910). The anecdotes of Swift related in Spence, *Laetitia Pilkington,* Wilson's *Swiftiana,* Delany's *Autobiography,* etc., though often amusing, can hardly be accepted as authentic.

The collective editions of Dr. Hawkesworth (various issues, 1755–79), T. Sheridan (1785), John Nichols (1801, 1804, 1808), Scott (1814 and 1821) and Roscoe (2 vols., 1849) have been in most respects superseded by the edition in Bohn's Standard Library in 14 volumes (including the two subsequently issued volumes of *Poems*) (1897–1910); arranged as follows: I. Biog. Introduction by W. E. H. Lecky; *Tale of a Tub; Battle of the Books; Critical Essay upon the Faculties of the Mind; The Bickerstaff Pamphlets,* etc., ed. Temple Scott. II. *Journal to Stella,* ed. F. Ryland (two portraits of Stella). III. and IV. *Writings on Religion and the Church,* ed. Temple Scott. V. *Historical and Political Tracts—English,* ed. Temple Scott. VI. *Historical and Political Tracts—Irish,* ed. Temple Scott. VII. The *Drapier's Letters,* ed. Temple Scott. VIII. and XI. Literary Essays, including *Gulliver's Travels* (ed. G. R. Dennis); *A Proposal for Correcting, Improving and Ascertaining the English Tongue; Hints towards an Essay on Conversation; Character; Directions to Servants;* and *Autobiographical Fragment,* ed. Temple Scott. IX. Contributions to the *Examiner, Tatler, Spectator,* etc., ed. Temple Scott. X. Historical Writings, including the *Four Last Years; Abstract of English History;* and *Remarks on Burnet,* ed. Temple Scott. XII. Essays on the Portraits, etc., Bibliography by W. Spencer Jackson, and Index. Twelve portraits of Swift are included in the work, in addition to two portraits of Stella and one of Vanessa. XIII. and XIV. Poems, ed. W. Ernst Browning.

Translations and editions of *Gulliver's Travels* have been numerous. "Valuable Notes for a Bibliography of Swift" were published by Dr. S. Lane Poole in *The Bibliographer* (Nov. 1884). (R. G.; X.)

SWIFT, a bird so called from the speed of its flight. Despite its appearance, the swift (*Apus apus*) is in no way related to the swallow and is not even a Passerine bird, its affinities being with the humming birds. The common swift is a summer visitor to Europe, arriving in May and returning to Africa at the end of August. It nests in holes in buildings, less frequently in cliffs and quarries. On the wing it gives the idea of a bow and arrow; it is a larger bird than the swallow and its flight is swifter and steadier. Except for a greyish-white patch under the chin, the plumage is entirely sooty black. Near sunset the birds often sweep round in screaming bands, and sometimes then ascend out of sight. It has been stated that they may spend the night on the wing at great heights; further observation on this point is needed, as also on the assertion that swifts actually pair in mid-air. A larger species, *A. melba,* with white under parts, inhabits the mountains and cliffs of southern Europe and is very numerous in the old water tower at Lucerne.



BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

CHIMNEY SWIFTS (CHAETURA PELAGICA), SHOWN WITH NESTS AND EGGS

The allied genus *Collocalia* construct nests of saliva and these are used by the Chinese for soup. The birds breed in caves, and range from north Madagascar to the Marquesas, one species occurring in the hill country of India. The chimney swallow of the United States (*Chaetura pelagica*) is also a swift, cementing its nest with saliva. It is migratory.

SWIFT AND COMPANY. The packing business which became Swift and Company in 1885 was founded in 1868 by Gustavus F. Swift. Swift began his business career as a Cape Cod meat retailer and live-stock dealer, but in 1875 moved to Chicago and entered the packing business. Almost immediately he began to make experimental refrigerator-car shipments of dressed beef to New England. Because of his part in making the western dressed beef trade a year-round commercial success, he is regarded as one of the true pioneers of the modern packing industry.

The rapid growth of the Swift business brought about the incorporation of Swift and Company in 1885 with a capital of $300,000. By the time of Swift's death in 1903, the company had become one of the two largest packing concerns in the United States. The business has continued to grow steadily. In 1928 its sales amounted to more than $970,000,000. In 1928 the company was capitalized at $150,000,000 and was owned by more than 47,000 shareholders, of whom 13,000 were employees. The employees numbered about 55,000.

Swift and Company slaughters live stock and sells meat and by-products. It also prepares and merchandizes butter, eggs, poultry, cheese, gelatin, vegetable shortening, soap, glue, animal feeds and fertilizer. The company operates 38 slaughtering and meat-packing plants; more than 70 poultry, butter and egg plants; 7 cotton oil mills; 21 shortening refineries; 2 soap factories; and 17 fertilizer plants. To distribute its products, Swift and Company maintains over 6,000 refrigerator-cars, which supply nearly 500 branch-selling houses, which in turn sell to retailers. Direct refrigerator-car shipments also serve retailers in more than 7,000 of the smaller American towns and villages. Over 100 foreign sales agencies are maintained abroad. (L. F. Sw.)

SWIMMING, the action of self-support and self-propulsion on or in water; though used by analogy of inanimate objects, the term is generally connected with animal progression and specially with the art of self-propulsion in water as practised by man. Natation (the synonym derived from Lat. *natare*) is one of the most useful of the physical acquirements of man. There have been cases in which beginners have demonstrated some ability in the art upon their first immersion in deep water, but generally speaking it is an art which has to be acquired. For many years Great Britain held the supremacy in this particular form of athletics, but continental, Australian and American swimmers have so much improved and have developed such speedy strokes, that the claim can no longer be maintained.

The teaching of swimming has been taken up in schools, and where the work is well done it is customary to use a form of land drill so as to impress upon the pupils some idea of the motions which have to be made in order to progress through the water. This drill is the preliminary practice to the teaching of the *breast stroke.*

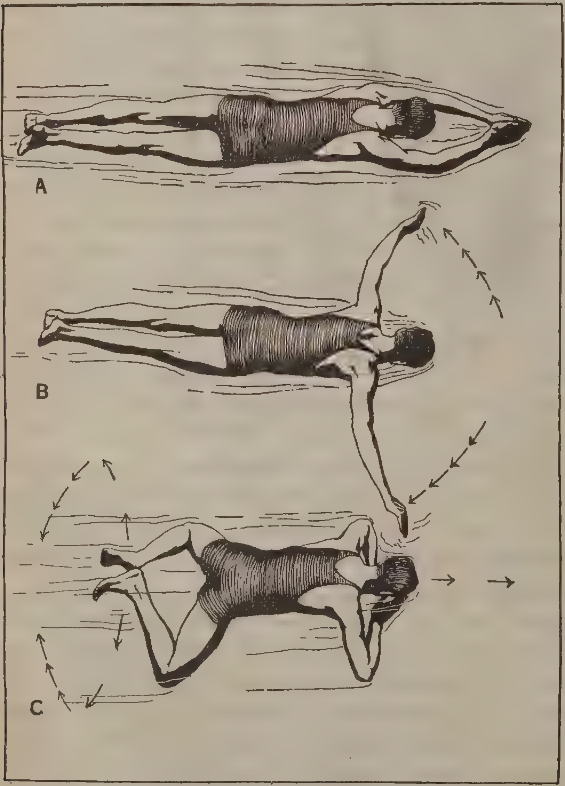


FIG. 1.—THE BREAST STROKE

A. Position at start and finish of stroke. B. First arm movement. C. Second movement of drawing up legs and bringing hands under chin. Arrows indicate continuation of stroke

The Breast Stroke.—When learning the *breast stroke,* the first thing to avoid is undue haste and rapidity in the movements. It is this fault, probably born of nervousness, which causes many to aver that though eager to do so, they have never been able to learn to swim. Rapid action of the arms only exhausts the learner, whose breathing then becomes hurried and irregular, and as a consequence he fails to preserve the buoyancy necessary for carrying him along the surface. When starting for the first stroke, the beginner should draw the elbows nearly to the side, at the same time bringing up the forearm and hands to the front of the chest with the palms of the hands downwards near to the surface of the water, the fingers being extended and closed and the forefingers and thumbs nearly touching. The hands are then pushed forward in front of the body to the full extent of the arms, the palms of the hands are turned slightly outward, and the arms swept round until in a right angle with the shoulders, when the elbows are dropped and the hands come up in front of the chest for the next stroke. The arms should not be kept rigid, but allowed to work gracefully. As the arms are swept backward the legs are drawn up, the knees being turned outward to the right and left and the heels nearly touching. The legs are then kicked outward and swept round as the arms are being pushed forward to their fullest extent, a "flip" being given with each of the feet which must be kept loose at the ankles and in the same position as when standing.

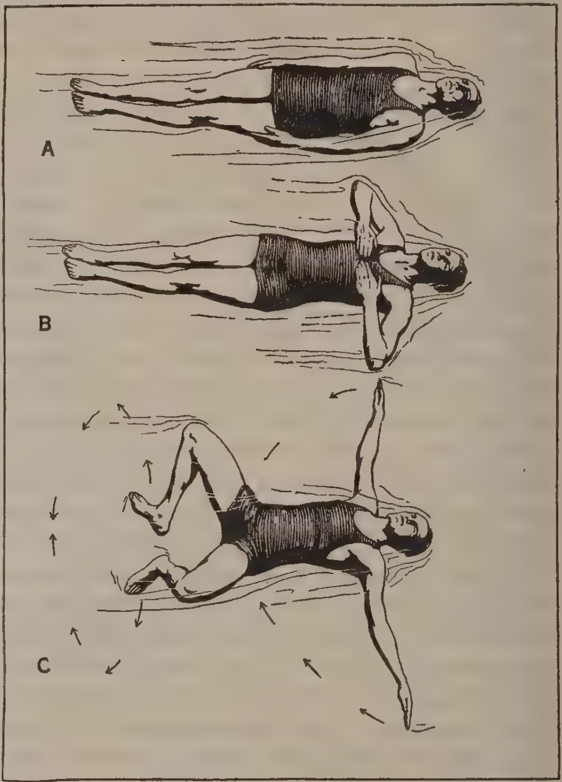


FIG. 2.—THE BACK STROKE, ONE OF THE EASIEST FORMS FOR THE BEGINNER

A. Start and finish position. B. First arm movement. C. Arm pull combined with "frog" kick

The Back Stroke.—A knowledge of the *back stroke* can easily be acquired by those who are able to swim on the breast, for the leg action is very similar and the principles relating to the use of the arms are almost the same. The arms, instead of being moved through the water, are lifted in the air and carried out to beyond the head with the palms upwards. The palms are then slightly turned and the arms swept round. Just as this action is being made the legs are drawn up as in the breast stroke, the body being allowed to travel on with the force of the kick as the arms are extended beyond the head. The great difficulty that a back swimmer has to contend with in open water is that of steering, and the best way to overcome it is to take an object for a guide before starting and hold the head slightly to the side so as to steer by it. An adaptation of the *crawl stroke* is now used by most back swimmers in short distance races.

At one time the *side stroke* was the great racing stroke; the body being placed on the side, the upper arm worked from the head to the upper side of the body, the lower arm taken downwards through the water to the underside of the body and a scissor-like kick made with the legs; but this has now been generally given up in favour of the *over-arm, trudgen* and *crawl strokes.*

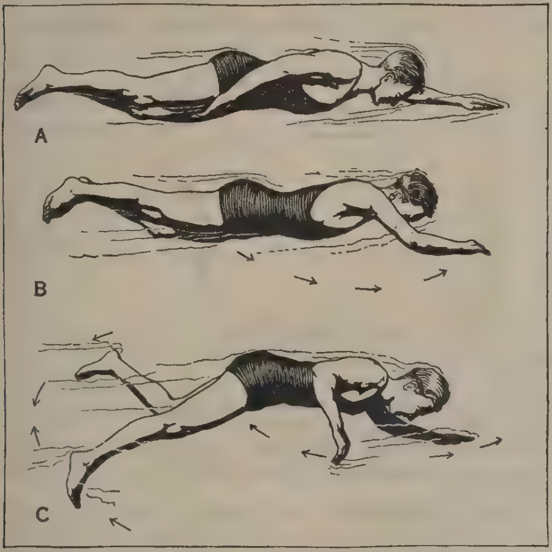


FIG. 3.—SIDE STROKE, THE BASIC STROKE FOR ADVANCED METHODS OF SWIMMING
A. Position at start and finish of stroke. B. Arm reach. C. Combination of arm pull and scissors kick

The Over-arm Stroke.—In the *over-arm* stroke the body is usually turned on the right side. At the start the lower arm is pulled downwards towards the hips, the fingers being kept closed and the hand flat, so as to present a large surface to the water. When the stroke is finished the hand is turned quickly palm upwards, so that together with the lower part of the arm it cuts the water sideways, the arm being almost bent double. Then, as it is shot forward, the hand is gradually turned from palm upwards to palm downwards, until, when it arrives at its position beyond the head, it is ready for the next stroke. The recovery and the pull ought to be effected as quickly as possible. The upper arm stroke is started when the downward stroke of the under or right arm is finished. It is started in front of the forehead, the arm being slightly bent and the fingers pointing downwards. The hand is pulled past the face and chest with the arm bent at right-angles and swept back in front of the body, the arm gradually straightening as it leaves the water opposite the hip. When the hand is opposite the hip it should be brought quickly out of the water and sent forward for the next stroke. When the upper arm is opposite the shoulder in its pull through the water the legs are kicked wide apart and closed again at the moment when the hand leaves the water. The kick is completed and the legs straightened before the left hand is replaced ready for the next stroke. As the legs are opened the upper leg is kicked forward with the knee slightly bent, and the foot kept in its ordinary position. The lower leg is bent double until the heel approaches the thigh, which is brought backwards slightly. In the actual kick the upper leg is sent forward, and as it is straightened vigorously the under leg from the knee downwards comes forward to meet it with a vicious kick; the swirl of the feet and closing of the legs drives the body forward. This is what has come to be known in Great Britain as the "Northern Kick" by reason of its first being introduced by Lancashire swimmers.

The Trudgen Stroke.—This stroke, more commonly known as the trudgeon stroke, and on the continent of Europe as Spanish swimming, was first made prominent in England in 1873, by a swimmer named J. Trudgen, who stated that he had acquired the knowledge of it while in South America. It was, however, known to Clias, a writer on swimming, who described it in 1825 as "The Thrust." Trudgen's speed was so great for his time that swimmers quickly copied his style, and it is from this stroke that the crawl stroke has been developed. When swimming Trudgen kept on the chest and lifted the upper part of his body at each stroke out of the water and at each swing of the arms pulled himself forward, a considerable swirl of the water occurring as each movement was finished. The arms were brought forward sideways, each completing a circle on each side of the body, and the head kept completely above water. Those who copied Trudgen soon found it was less laborious and equally as fast to use a double over-arm stroke with the head and chest well down, and thus have the body supported by the water, using the ordinary over-arm leg kick.

The Crawl Stroke.—Like the trudgen, this is an adaptation from native swimmers. It was not generally known in Great Britain until 1902, when Richard Cavill came from Australia to compete in the English championships, but it is said to be common with the natives of the South Sea islands, and from there introduced into Australia about the year 1900. From thence it came to Europe and there C. M. Daniels, the American amateur champion of that period, made so excellent a study of it that in 1907 he not only so greatly increased his own pace as to be able to win the English championship, and beat the world's record for a hundred yards, but also introduced various improvements upon it. This stroke is distinct from any other form of swimming; the legs are kept straight, but not rigid. They whip the water backwards and forwards alternately, thus imitating the movements when walking on tiptoe. The power is obtained from the hips, knees and ankles. The width of the kick is about twelve inches between the heels. The speed of the kick is usually adjusted to the requirements of the individual. A supple swimmer is able to use a faster movement compared with one whose limbs are slow in action. It has been stated that some use as many as ten kicks to each complete stroke of the two arms, but it seems that the great majority find four kicks sufficiently trying. This striking or kicking is done from an upward to a downward direction, one leg at a time. The arms are used somewhat as in the trudgen stroke, they are bent at the elbows, dipped in alternately beyond the head and drawn smartly backwards until they come out of the water at the hips. The result of this movement is that when one arm is pulling or propelling the body through the water at the same moment, the other is being recovered through the air for the next stroke, thus avoiding resistance in the line of progress.

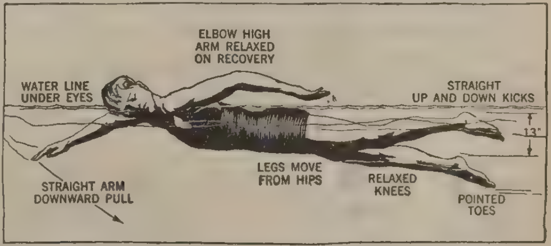


FIG. 4.—THE CRAWL STROKE, INTRODUCED INTERNATIONALLY IN 1908

Floating.—One of the most useful accomplishments for a swimmer is that of *floating,* but curiously enough there are some who cannot acquire a knowledge of it. It is purely a matter of buoyancy, and requires constant practice before one can become perfect in it. In learning to float the beginner experiences great difficulty in overcoming the tendency of the legs to sink, and if after frequent trials they are still found to sink, he should get someone to hold them up or else place them on the steps or behind the rail of the bath, and thus assisted learn to balance the body on the surface. Before doing so he should completely fill his lungs, spread his legs wide, and then lie backwards with the arms extended in a line with the body and beyond the head, with the palms upwards, care being taken to throw as much weight beyond the head as possible. Furthermore he must lie perfectly still and take care not to hollow the back or raise the abdomen above water. One may sink for an instant, but if the breath be held the lips will come above the surface when easy breathing may be indulged in. Only the face, chest and toes should appear above the surface of the water. A knowledge of floating is of good service to those attempting to save life.

Diving.—The usual method of entering the water is by what is known as *diving;* some think it should be termed "springing." The best method of learning to dive is to stand on the side of the bath and then stoop down until the body is nearly double, stretch out the arms in front of the head, sink the head between them and gradually fall over into the water. The ability to enter the water head first will then soon be acquired. The English header, or plain dive, and the swallow dive rank equally in competition, but at the last Olympic Games only the swallow dive was permitted. In most respects the primary points to be observed are the same in each form of diving. To the ordinary reader the word "diving," means a great deal and covers a multitude of movements. One who jumps from a bridge is said to be a diver; whether he touches the water head or feet first the action is referred to as a "dive." Diving is almost indispensable to the swimmer.

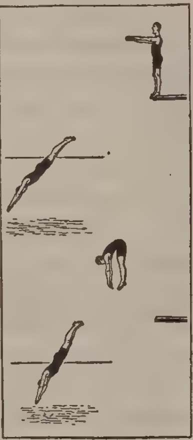


FIG. 5.— (ABOVE) ENGLISH PLAIN "HEADER" SHOWING STANCE AND ANGLE OF DIVE; (BELOW) PIKE DIVE, OR AMERICAN "JACK KNIFE"

The Swallow Dive.—This dive was first introduced into Great Britain from Sweden and has now become most popular. The take-off is taken with a strong outward and slightly upward spring, simultaneously swinging the arms upwards and outwards, extending them sideways nearly level with the shoulders, the back hollowed and the head held back; legs perfectly straight, toes pointed and legs pressed close together. The arms are brought together beyond the head as for a plain dive just before the body enters the water. The standard heights adopted by the International Amateur Swimming Federation are as follows:—

For spring boards—
1 metre (3ft. 3in.) and 3 metres (9ft. 9in.).
For firm boards—
3 to 5 metres (9ft. 9in. to 16ft. 3in.).
5 to 8 metres (16ft. 3in. to 26ft. 0in.).
8 to 12 metres (26ft. 0in. to 39ft. 0in.).

In actual practice a greater height than 10 metres (32ft. 6in.) is seldom used. To determine the relation of height of board to depth of water the following broad principle is adopted:—The height of a board should not exceed twice the depth of water, with a minimum depth of 6ft. A greater depth than 15ft. is unnecessary for any height of board.

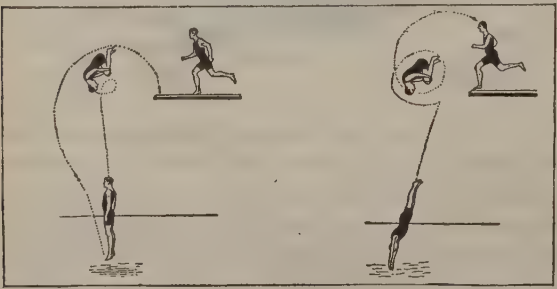


FIG. 6.—(LEFT) SINGLE SOMERSAULT DIVE; (RIGHT) ONE-AND-A-HALF SOMERSAULT DIVE

As standard heights have been fixed it is hoped that the Amateur Diving Association, which is the chief promoting body of diving in England, will insist upon standard spring and firm boards being used particularly in connection with the Olympic Games and other international competitions and also object to competitors using their own boards, as this gives them an unfair advantage over those who have not had the chance to practise from them. All fancy diving is based on varieties and combinations of somersaults, either single, one-and-a-half or double, pike dives, screw or twist dives. The Amateur Diving Association in its year book provides a list of 112 dives from spring and firm boards, which are valued according to difficulty of execution for the purpose of judging, which forms a good guide to the novice who desires by practice to become perfect as a diver. (*See* figs. 5, 6, 7, 8.)

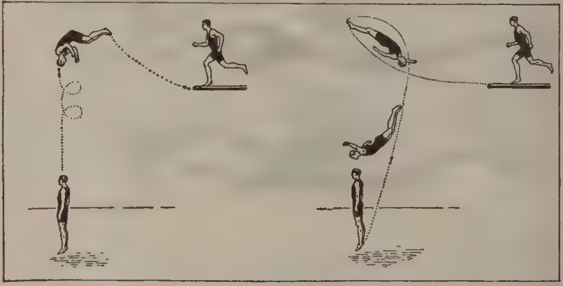


FIG. 7.—(LEFT) DOUBLE SOMERSAULT DIVE; (RIGHT) MOLBERG DIVE

A useful accomplishment is that known as surface diving, because it enables the swimmer to find and bring an object to the surface. The correct method of performing it is first to swim a few yards on the surface with the breast stroke, take a breath, then suddenly depress the head, look downwards, elevate the body at the hips, and at the same time make a powerful stroke with the legs and an upward stroke with the hands. The impetus thus obtained will suffice to take the swimmer to the bottom in 6ft. of water. Once under the surface it is only necessary to keep the head depressed and swim by means of the breast stroke in order to find the object of search. When about to rise to the surface, the head should be turned backwards with the eyes upwards, and a stroke made with arms and legs.

Plunging.—The sport is not very generally practised, though there is a championship for it. A plunge is a standing dive made head first from a firm take-off, free from spring. The body must be kept motionless, face downwards, no progressive movement must be imparted other than the action of the dive. The plunge terminates when the plunger raises his face above the surface of the water. With the idea of preventing long tests without breathing, it was deemed, in 1893, advisable by the Swimming Association to impose a time limit of one minute in all competitions. Yet even with this time limit the record plunge stands at 85ft. 6ins. for men and 71ft. for women.

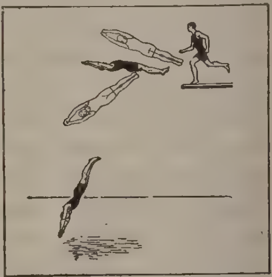


FIG. 8.—SCREW DIVE, SHOWING TURNING POSITIONS OF BODY IN MID-AIR

Open-air and Indoor Swimming.—Most of the principal races are decided in baths, but there has been a tendency to revert to open water in the summer and also to encourage long-distance swimming. The first public baths in Great Britain were opened by the corporation of Liverpool in 1828 and the Baths and Washhouses Act was passed in 1846, the first of the London parishes to adopt the act being St. Martin's in the Fields, which opened baths in Green Street, Leicester Square, in 1846. Since then public baths have been erected all over Great Britain and Ireland, and bath swimming has become, by reason of the lack of reasonable open water accommodation the principal means of teaching the young. But open water swimming, and more particularly swimming in the sea, is the best training and practice for those who really love the art, because they are able to swim under normal climatic conditions, instead of in tepid water.

When bathing in the open, care has to be taken to avoid weeds or undercurrents. In the event of accidentally getting into a bed of weeds, the swimmer should cease kicking and work with the arms, and the current will then take him through. If he tries to swim, the weeds will entangle his legs and put him in an awkward plight. If he is carried away by a current in a river, he should select a spot on either bank and swim diagonally towards it, never minding where he has left his clothes. When in the sea, the conditions are not always the same, though the general rule of swimming diagonally for shore also applies. For sea bathing, however, it is far better, no matter how good a swimmer one may be, to have a boat in attendance. Before bathing in a strange place, the swimmer should make himself acquainted with the currents and the direction of the tide. When the tide is going out the course should be made close in along the coast. In a rough sea the swimmer should not attempt to breast the waves, but as each wave rises he should swim through, thereby saving himself from buffeting, which, if long continued, would cause insensibility or else great waste of physical power. When using a boat for bathing the best way is to dive from the stern, to which some steps or a rope ladder should be fixed, in order to aid the swimmer when getting in again. Failing these being at hand, the best way is to lay hold of the stern with both hands and then, making a hard rising kick, raise the body till it rests on the edge at the hips. Then smartly slip the hands a little forward, turn to a sitting position and enter the boat.

Speed swimming records are so frequently altered that students had best obtain the Amateur Swimming Association's annual handbook, in which are detailed the accepted records up to date. The improvement in speed has been most remarkable. In 1877 the mile amateur record was 29min. 25½sec., and that stood until 1892. The record in 1909 was 24min. 1⅗sec. made by T. S. Battesby. In Jan. 1929 Arne Borg set up a world's record of 21min. 6⅘sec. The hundred yards record has been similarly reduced. In 1878 it was 1min. 16¾sec.; in 1888 it had been lowered by J. Nuttall to 1min. 6¼sec.; and in 1925 J. Weismuller of America, created a world's record of 52sec., which he lowered to 51sec. in 1927. The records over intermediate distances have also been considerably lowered, and many long-distance swimming records have from time to time been created.

In 1910 F. E. Beaurepaire of Australia scored a series of remarkable victories in English championships, winning every event from 100yds. to one mile inclusive. In 1912 an Hawaiian, Duke Kahanamoku, H. Hebner of Chicago and George Hodgson of Canada, set up world's records at the Stockholm Olympiad. Apart from the prowess of the foregoing, the Stockholm fixture was noteworthy for the advent of women into Olympic swimming contests. Miss Fannie Durack of Australia won the sprint in record time, while a quartette of British ladies secured the team event. A year later, J. G. Hatfield of England came to the front, and proved supreme in all distance events.

Olympic Games.—The governing swimming associations in Great Britain ceased operations during the war, but in certain areas commendable efforts were made to keep the flag flying by intensive work. Britain's only Olympic success at the Paris Games was scored by Miss Lucy Morton, who first came into prominence in 1915. The coaching propaganda was responsible for the rise to fame of the Misses E. Mayne, C. M. Jeans, H. M. James, I. Gilbert, G. Carson, M. Hamblin, M. A. Barker, E. King, M. J. Cooper, M. Specer, D. B. Hart, M. Laverty, also Messrs. A. Rawlinson, R. Flint and W. Stoney, all of whom have either won national titles or established records.

The Olympic Games at Antwerp in 1920 supplied convincing proof of American supremacy, for the Stars and Stripes were carried to success in the free, back stroke and team events in record time, but the breast swimming fell to Scandinavian contestants. New records were established with clockwork regularity. The Hawaiian-Americans, Kahanamoku in the 100 metres (1min. 1⅗sec.) Kealoah, in the back stroke 100 metres (1min. 15⅕sec.) being the outstanding performers among the men, whilst Miss Bleibtrey set up new world's figures for 100 metres (1min. 13⅗sec.) and 300 metres (4min. 34sec.), all of which have since been beaten. The Antwerp Olympiad was noteworthy for the advent of mere children into the Olympic Games. Nils Skoglund, a 14-year-old Swedish boy, took honours in the men's high diving event, and Miss Aileen Riggin, a 13-year-old American, earned world fame by annexing the fancy diving contest against all comers, with her youthful country-woman Miss Helen Wainwright taking second place. Swedish nominees took the high diving for men and women, but the fancy diving was secured by America's representatives. In 1923 Arne Borg made a world tour when he met the Australian champion Andrew Charlton, the latter proving successful in three contests, when new records were tabulated. John Weismuller, a well set-up youth of Austrian descent, created world's figures for every distance from 50yd. up to and including 220yd.; he also proved equally skilful when swimming on the back. Weismuller won the 100 and 400 metres events at the Olympic Games at Paris in 1924, his respective times being 59sec., and 5min. 4⅕sec. In the 400 metres Weismuller was forced to his utmost to defeat Arne Borg and Charlton, as only 2⅗sec. separated the first three. Charlton, however, won the 1,500 metres in 20min. 6⅖sec. breaking the Olympic and world's record of 22min. created by the Canadian, George Hodgson, at Stockholm in 1912. Although the Americans almost swept the board at Paris, it was noticeable that other countries including Sweden, Australia, England and Japan were rapidly closing up to them. Takaishi, a tiny Japanese, returned 1min. 1⅗sec. in the 100 metres and in the 1,500 metres semi-final he returned 21min. 58⅗sec.

In the 1928 Olympiad Weismuller again won the 100 metres, in 1sec. faster time than in 1924, but the American successes were not so sweeping as at Paris, Argentina, Germany, Holland, Japan and Sweden winning events.

Channel Swimming.—Much interest has centred in the many attempts to swim across the English channel; the first recorded attempt was made on Aug. 24, 1872, by J. B. Johnson, who started from Dover, but remained in the water only 65 minutes. It was on Aug. 12, 1875, that Capt. Matthew Webb made his first attempt. He started from Dover and remained in the water 6hr. 49min., when the weather became too rough for him to continue. It is estimated that he was about 13½ miles across when he had to give up. On Aug. 24 and 25, 1875, he swam across the English channel, diving from the Admiralty pier, Dover, and touching Calais sands, after swimming for 21hr. 45m., and at the time this accomplishment created a great sensation in England. Since then fifteen other successful attempts have been made and they are as follows:—Sept. 6, 1911, T. W. Burgess, 21hr. 35min.; Aug. 6, 1923, H. Sullivan, 20hr. 50min.; Aug. 12, 1923, S. Tirabosche, 16hr. 35min.; Sept. 9, 1923, C. Toth, 16hr. 54min.; Aug. 6, 1926, Miss G. Ederle, 14hr. 31min.; Aug. 28, 1926, Mrs. Corson, 15hr. 28min.; Aug. 30, 1926, H. Vierkotter, 12hr. 40min.; Sept. 10, 1926, G. Michel, 11hr. 5min.; Sept. 17, 1926, N. L. Derham, 13hr. 56min.; Aug. 5, 1927, E. H. Temme, 14hr. 29min.; Oct. 7, 1927, Miss M. Gleitze, 15hr. 15min.; Oct. 13, 1927, Mrs. Ivy Gill, 15hr. 9min.; Aug. 19, 1928, Miss Ivy Hawke, 19hr. 16min.; Aug. 24, 1928, Miss Hilda Sharp, 14hr. 58min.; Sept. 1, 1928, Helmy, 23hr. 40min. Messrs. Webb, Burgess and Sullivan swam from England to France and all the others from France to England; these results have created an interest in long-distance swimming in all parts of the world that has resulted in the accomplishment of trials and tests once thought impossible.

BIBLIOGRAPHY.—The literature on the subject of swimming is considerable; the most useful work of general reference is Ralph Thomas's *Swimming* (1904), which contains a bibliography from the earliest time. Other chief works on the technique of swimming that may be mentioned are: Thevenot, *The Art of Swimming* (1789); Steedman, *Manual of Swimming* (Melbourne, 1867); W. Wilson, *The Swimming Instructor* (1883); A. Sinclair and W. Henry, *Swimming* (Badminton Library, 1893); C. M. Daniels, *How to Swim and Save Life* (Spalding's Library, 1907); H. R. Austin, *How to Swim* (1914); L. de B. Handley, *Swimming and Watermanship* (New York, 1918); *Handbook of the Amateur Swimming Association*, containing list of

records, published annually; *Handbook of the Amateur Diving Association,* published annually. (X.)

THE UNITED STATES

Standardized water sports for men were launched in 1878, upon the formation of the Amateur Athletic Union of the United States, but not until 1917 did the organization undertake to supervise and regulate water sports for women. Universities began to promote competitive swimming shortly after 1880 and schools soon followed. By 1928 there were collegiate and scholastic associations fostering aquatics in all sections of the country and no less than 20,000 schoolboys took part in water carnivals conducted by a single organization, the Public School Athletic League of New York. Charles M. Daniels was the first American amateur swimmer to attain international rating. He shattered the world's open water record for 220 yd. free style in 1904 and subsequently reaped signal honours at home and abroad, bettering other records and winning the Olympic 100 metre championship at Athens in 1906 and again at London in 1908.

The great leap forward in speed swimming, however, followed the introduction of the crawl stroke, first used in standardized racing by Richard Cavill of Australia. The earliest knowledge of the crawl obtained by Americans was gleaned from hazy newspaper descriptions of Cavill's stroke. In attempting to imitate the action they unwittingly developed a faster leg drive, executing four scissoring kicks per stroke, instead of the two performed by Cavill. The new leg drive was combined by Americans with the double over-arm action of the trudgeon, and the resulting stroke christened four-beat crawl, to distinguish it from the two-beat Australian variety.

Meanwhile, experiments had led to the belief that the four-beat leg thrash was most effective when composed of one comparatively wide and three very narrow scissoring motions. This style, termed four-beat trudgeon-crawl, or four-beat single-rhythm crawl, became the accepted racing medium. The combination of movements was responsible for so notable an improvement in average performances that technical experts conceived the possibility of obtaining still greater speed from a six-beat drive set to a double rhythm—two major and four minor kicks—which would minimize resistance and afford more even distribution of propelling power. But coaches were unanimous in declaring that the swift thrash would prove entirely too laborious for distances longer than about 100 yd., and the subject was dropped temporarily.

Late in 1917, however, two young champions of the Women's Swimming Association of New York, Miss Charlotte Boyle and Miss Claire Galligan, determined to give the six-beat crawl a trial and by the summer of 1918 they broke records with it over the longer regulation courses, 880 yd. and one mile. So convincing was this demonstration that it caused a sudden change of mind among coaches and competitors. The six-beat crawl immediately won favour in the United States, presently in other countries and within a few years it had become the recognized stroke the world over, not only for racing, but for all around purposes. The coaching staff of the New York association later evolved a crawl system of elementary instruction which greatly simplified the task of teaching swimming to beginners. Then another of its champions, Miss Ethel McGary, successfully exploited in turn the eight and ten-beat varieties of crawl, achieving title and record honours.

The most impressive illustration of the progress made in the United States through the advent and development of the crawl is afforded by the old and new national records for the classic competitive fixtures, 100 yd. in 75 ft. pools and 1 m. over courses of 55 yd. and upward. Before the introduction of the crawl the men's respective records were listed at $58\frac{3}{5}$ sec. and 28 min. $14\frac{3}{5}$ sec., the women's unofficially quoted at 1 min. 22 sec. and 35 min. $38\frac{2}{5}$ seconds. By 1928 the men's standards had been slashed to 51 sec. and 21 min. $35\frac{3}{5}$ sec., the women's to 1 min. $\frac{9}{10}$ sec. and 24 min. $49\frac{3}{5}$ seconds. It must be ascribed chiefly to the crawl, too, that American swimmers of both sexes, from trailing far behind rivals from other countries, rose to undisputed international leadership. At the Olympiad of 1912 in Stockholm, before the stroke had been perfected and generally adopted, the United States was fifth in the natatorial competition, outpointed by Germany, Sweden, England and Australia in this order. At Antwerp in 1920, on the other hand, American men and women, the latter taking part in their first Olympiad, decisively outscored all opposing teams. This they repeated at Paris in 1924, and Amsterdam in 1928.

Daniels, America's first international swimmer, garnered his early laurels with the trudgeon, but he did not attain nearly his best speed until he became a devotee of the crawl. Miss Gertrude Ederle, who swam the English channel in 1926, the first woman to accomplish the feat, used the crawl and covered the course in 14 hr. 34 min., faster time than ever returned by any man up to then. Among the outstanding figures in the history of American swimming besides the men and women named, are Henry Sullivan, Charles Toth and Mrs. Mille Gade Corson, also channel conquerors; Harry Hebner, Olympic champion and first to use the crawl back stroke; Duke Kahanamoku of Honolulu, Perry McGillivray, Norman Ross, John Weissmuller, Walter Spence, Walter Laufer, George Kojac and the Misses Ethelda Bleibtrey, Sybil Bauer, Aileen Riggin, Helen Wainwright, Ethel Lackie, Agnes Geraghty, Albina Osipowich, Josephine McKim, and Martha Norelius, all swimmers of international rank and prolific record-breakers in their day. (L. DE B. H.)

SWINBURNE, ALGERNON CHARLES (1837–1909), English poet and critic, was born in London on April 5, 1837. He was the son of Admiral Charles Henry Swinburne (of an old Northumbrian family) and of Lady Jane Henrietta, a daughter of George, 3rd earl of Ashburnham. His childhood was spent on the Northumberland estate of his grandfather, Sir John Edward Swinburne, Bart., and at his father's place, East Dene, in the Isle of Wight. Of the two, the influences of the island are, perhaps naturally, the stronger in his poetry; and many of his most beautiful pieces were actually written at the Orchard, an exquisite spot by Niton Bay, where he was a constant visitor.

After five years at Eton, Swinburne went to Balliol college, Oxford, in 1857. Jowett was his firm friend after he left Oxford, and Swinburne visited him repeatedly at the seaside and in the country. He left Oxford in 1860, and in the same year published the two dramas, *The Queen Mother* and *Rosamond,* a wonderful performance for so young a poet, fuller of dramatic energy than most of his later plays, and rich in harmonies of blank verse.

After spending some time with the Bell Scotts at Newcastle, Swinburne came to London, and began the intimate friendship with D. G. Rossetti which was to last for the next ten years. In 1861 he was introduced to Monckton Milnes (Lord Houghton, *q.v.*), who took an interest in his work and invited him to Fryston. There Swinburne created an unforgettable impression in the brilliant circle which gathered there, by his wide and varied acquaintance with ancient and modern literature and his astonishing memory. In 1862 he met Meredith, and a review of one of Victor Hugo's books resulted in correspondence. In the autumn of that year he lived with Meredith and the Rossettis at 16 Cheyne Walk. Swinburne showed symptoms of something approaching epilepsy, and it was thought better that he should be with friends. In 1864 he made a tour in France and Italy. At Florence he met Mrs. Gaskell and Landor. For Landor he had a great admiration, but their meetings were few and short. On his return to London he took lodgings in Dorset Street, where he made his home for many years.

In 1865 appeared the lyrical tragedy of *Atalanta in Calydon,* followed by *Chastelard,* and the famous *Poems and Ballads* in 1866. The *Poems and Ballads* were vehemently attacked, but *Dolores* and *Faustine* were on everyone's lips: as a poet of the time has said, "We all went about chanting to one another these new, astonishing melodies." By the close of his 30th year, in spite of hostility and detraction, Swinburne had placed himself in the highest rank of contemporary poets, and had even established himself as leader of a choir of singers to whom he was at once master and prophet.

Meanwhile, his life was disturbed by domestic sorrow. A favourite sister died at East Dene, and was buried in the churchyard of Bonchurch. Her loss overwhelmed Admiral Swinburne with grief, and he could no longer tolerate the house that was so full of tender memories. So the family moved to Holmwood, in the Thames Valley, near Reading. Swinburne entered on a course of gaiety in London which seriously affected his health and alarmed his friends. At the same time he saw much of the Pre-Raphaelite movement, and for the next few years he was involved in a rush of fresh emotions and rapidly changing loyalties.

Works.—It is indeed necessary to any appreciation of Swinburne's genius that one should understand that his inspiration was almost invariably derivative. His first book is deliberately Shakespearian in design and expression; the *Atalanta*, of course, is equally deliberate in its pursuit of the Hellenic spirit. Then, with a wider swing of the pendulum, he recedes, in *Poems and Ballads*, to the example of Baudelaire and of the Pre-Raphaelites themselves; with the *Song of Italy* (1867) he is drawing towards the revolt of Mazzini (whom he had met at the house of George Howard, afterwards earl of Carlisle); by the time *Songs before Sunrise* are completed (in 1871) he is altogether under the influence of Victor Hugo, while Rome has become to him "first name of the world's names." But, if Swinburne's inspiration was derivative, his manner was in no sense imitative; he brought to poetry a spirit entirely his own, and a method even more individual than his spirit. It is well to distinguish clearly between the influences which touched him and the original, personal fashion in which he assumed those influences, and made them his own. The spirit of Swinburne's muse was always a spirit of revolution. In *Poems and Ballads* the revolt is against moral conventions and restraints; in *Songs before Sunrise* the arena of the contest is no longer only the sensual sphere, but the political and the ecclesiastical. The detestation of kings and priests, which marked so much of the work of his maturity, is now in full swing, and Swinburne's language is sometimes tinged with extravagance and an almost virulent animosity.

With *Bothwell* (1874) he returned to drama and the story of Mary Stuart. The play has fine scenes and is burning with poetry, but its length transcends all possibilities of harmonious unity. *Erechtheus* (1876) was a return to the Greek inspiration of *Atalanta;* and then in the second series of *Poems and Ballads* (1878) the French influence is seen to be at work, and Victor Hugo begins to hold alone the place possessed, at different times, by Baudelaire and Mazzini. At this time Swinburne's energy was at fever height; in 1879 he published his eloquent *Study of Shakespeare* and *Poems and Ballads* (second series) and in 1880 no fewer than three volumes, *The Modern Heptalogia*, a brilliant anonymous essay in parody, *Songs of the Springtides*, and *Studies in Song*. It was shortly after this date that Swinburne's friendship for Theodore Watts-Dunton (then Theodore Watts) grew into one of brotherly intimacy. After 1880 Swinburne's life remained without disturbing event, devoted entirely to the pursuit of literature in peace and leisure.

The conclusion of the Elizabethan trilogy, *Mary Stuart*, was published in 1881, and in the following year *Tristram of Lyonesse*, a wonderfully individual contribution to the modern treatment of the Arthurian legend, in which the heroic couplet is made to assume opulent, romantic cadences of which it had hitherto seemed incapable. Among the publications of the next few years must be mentioned *A Century of Roundells*, 1883; *A Midsummer Holiday*, 1884; and *Miscellanies*, 1886. The current of his poetry, indeed, continued unchecked; and though it would be vain to pretend that he added greatly either to the range of his subjects or to the fecundity of his versification, it is at least true that his melody was unbroken, and his resplendent torrent of words inexhaustible. His *Marino Faliero* (1885) and *Locrine* (1887) have passages of power and intensity unsurpassed in any of his earlier work, and the rich metrical effects of *Astrophel* (1894) and *The Tale of Balin* (1896) are inferior in music and range to none but his own masterpieces. In 1899 appeared his *Rosamund, Queen of the Lombards;* in 1908 his *Duke of Gandia;* and in 1904 was begun the publication of a collected edition of his poems and dramas in 11 volumes.

Later Years.—Meanwhile, in the autumn of 1879 the state of his health seriously alarmed his friends, and, with the consent of Lady Jane Swinburne, Watts-Dunton took him to live at his house, The Pines, Putney, where the last 30 years of his life were spent in complete retirement. He very rarely made the short journey into London, although his health was gradually restored. The friends visited Paris in 1882. In 1888 a flash of his old excitability involved him in a quarrel with Whistler.

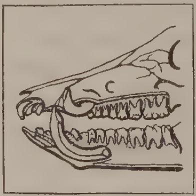
Besides this wealth of poetry, Swinburne was active as a critic, and several volumes of fine impassioned prose testify to the variety and fluctuation of his literary allegiances. His *Note on Charlotte Brontë* (1877) must be read by every student of its subject; the *Study of Shakespeare* (1880)—followed in 1909 by *The Age of Shakespeare*—is full of vigorous and arresting thought, and many of his scattered essays are rich in suggestion and appreciation. His studies of Elizabethan literature are, indeed, full of "the noble tribute of praise," and no contemporary critic did so much to revive an interest in that wonderful period of dramatic recrudescence, the side-issues of which have been generally somewhat obscured by the pervading and dominating genius of Shakespeare. His prose work also includes an early novel in the form of letters, *Love's Cross-currents*, which had appeared serially in the Tatler and was revised for publication in 1905.

Place in Literature.—The service which Swinburne rendered to the English language as a vehicle for lyrical effect is simply incalculable. He revolutionized the entire scheme of English prosody. Nor was his singular vogue due only to this extraordinary metrical ingenuity. The effect of his artistic personality was in itself intoxicating, even delirious. He was the poet of youth insurgent against all the restraints of conventionality and custom. The young lover of poetry, when first he encounters Swinburne's influence, is almost bound to be swept away by it; the wild, extravagant license, the apparent sincerity, the vigour and the verve, cry directly to the aspirations of youth like a clarion in the wilderness. But, while this is inevitable, it is also true that the critical lover of poetry outgrows an unquestioning allegiance to the Swinburnian mood more quickly than any other of the diverse emotions aroused by the study of the great poets. It is impossible to acquit his poetry entirely of the charge of an animalism which wars against the higher issues of the spirit—an animalism sometimes of love, sometimes of hatred, but, in both extremes, out of centre and harmony.

Yet, when everything has been said that can be said against the unaesthetic violences of the poet's excesses, his service to contemporary poetry outweighed all disadvantages. No one did more to free English literature from the shackles of formalism; no one, among his contemporaries, pursued the poetic calling with so sincere and resplendent an allegiance to the claims of absolute and unadulterated poetry. Some English poets have turned preachers; others have been seduced by the attractions of philosophy; but Swinburne always remained an artist absorbed in a lyrical ecstasy, a singer and not a seer. When the history of Victorian poetry comes to be written, it will be found that his personality was, in its due perspective, among the most potent of his time; and as an artistic influence it will be pronounced both inspiring and beneficent. On April 10, 1909 the poet died at his home, "The Pines," where he had lived many years. Swinburne's poems were published in 6 vols. in 1904, and his tragedies in 5 vols. in 1905–06. *See* also the article by Edmund Gosse, in the Dic. Nat. Biog. (2nd supplement 1901–11); H. Nicholson, *Swinburne* (English Men of Letters Series 1926); G. Lafourcade, *La Jeunesse de Swinburne* (2 vols., bibl. 1928); and S. C. Chew, *Swinburne* (1929). (E. G.; X.)

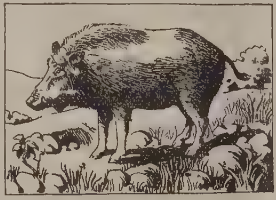
SWINDON, a market town and municipal borough in the Swindon parliamentary division of Wiltshire, England, 77½ m. W. of London by the G.W. railway, of which it is an important junction. Pop. (1921) 54,920. It has two parts, the new and the old. The present town received its charter in 1901. The new town grew up around the vast locomotive and wagon works of the G.W. railway. It rose rapidly on a strip of waste land, and churches and chapels were built for the workmen, whose numbers soon exceeded 10,000. Each man contributes to a medical fund which maintains the fever, accident and general hospitals, providing also laundries and baths. There are a mechanics' institute, containing a large library, theatre, reading-rooms and lecture-hall. The company owns a park with football and cricket grounds. The old town stands on a hill overlooking the Gloucestershire borders. The railway engine and wagon works now employ over 12,000 hands. Many are engaged in the neighbouring quarries, and there are also clothing factories and corn mills.

SWINE, a name applied to the domestic pig, but also used to include its wild relatives. The animals constitute the family *Suidae* of the *Suina*. (*See* ARTIODACTYLA.) The *Suidae* are divisible into the true swine (*Suinae*) of the Old World, and the American peccaries (*q.v.*) (*Dicotylinae*). The *Suinae* are characterized by an elongated, mobile snout, with an expanded, truncated, terminal surface in which the nostrils are placed; narrow feet with four toes on each, the outer pair not reaching the ground when walking; the canines in both jaws developed into upwardly directed tusks, best developed in the male.


THE DENTITION OF THE BOAR, 12 INCISORS, 4 CANINES, 16 PREMOLARS AND 12 MOLARS: TOTAL 44

The typical genus *Sus* is exemplified by the domesticated pigs (*see* PIG) and the wild boar. (*See* BOAR.) Allied to these are the pigmy hog of Nepal (*Porcula salvania*), about the size of a hare; and the African river-hogs (*q.v.*) (*Potamochoerus*).

Linking these genera with the wart-hogs is the African *Hylochoerus*, a forest-dwelling form with a thick coat of coarse black hair. The remaining forms are the wart-hogs (*Phacochoerus*, *q.v.*) and the babirusa (*q.v.*). Extinct swine, some of gigantic size, are known from strata as far back as the Pliocene of Europe and Asia; many of these belonged to the genus *Sus*.


THE WILD BOAR (SUS SCROFA)

SWINE FEVER, the name applied in Great Britain to a disease which occurs only in swine; in America, the synonym, hog cholera, is used; in Germany, *Schweinepest*.

The disease has a wide distribution throughout Europe, America and Africa, and is not uncommon in the British Isles. Although in the past the cause of the disease has been ascribed to various bacilli, it has been recognized for a number of years that the condition is due to a filter-passing virus (*q.v.*).

The filtrates from the blood of pigs affected with swine fever are free of visible organisms and yet convey the disease when administered to healthy swine. Methods of cultivating the causal virus outside the body are not known. Differences of opinion have existed as to the part played by the visible bacteria in the causation of the disease, but the view is generally held that the virus of swine fever so lowers the resistance of its host that bacteria, normally non-pathogenic to healthy pigs, are capable of becoming pathogenic and so to assume the rôle of secondary invaders. The bacillus suipestifer is one of the most important of these and has been shown to be present in the intestines of healthy pigs. Morphologically it occurs as a short, motile rod, and biologically it is related to the paratyphoid group; it stains readily with the basic aniline dyes and is easily culturable.

Natural infection results from immediate or mediate contagion. The disease may be introduced into healthy herds by the introduction of infected pigs; exposure of swine in markets in infected areas is a fertile source of infection; so are vehicles and trucks in which pigs are conveyed from place to place; dealers, castrators who journey from farm to farm, and attendants may serve as agencies whereby contagion is conveyed.

Outbreaks are liable to recur in premises where the disease has existed previously, as the virus appears to retain its vitality for fairly long periods outside the animal body. Within a space of time which rarely extends to three weeks after exposure to infection, and may not be more than four days, the disease is ushered in by fever, the subsequent symptoms varying somewhat with the form the disease assumes. The animal has no appetite, is depressed, ill and separates itself from its companions; the conjunctivae are reddened and congested and may secrete a mucopurulent discharge; vomition is common, and constipation and diarrhoea are both met with; sometimes the faeces become dysenteric and the odour is peculiar and disagreeable.

In a number of cases a skin rash develops, the parts principally involved being the region of the ears, the axilla, groin and the skin covering the abdominal area. The mucous membrane lining the mouth, fauces and pharynx may become inflamed, later ulcers form and become covered with a diphtheritic exudation. As a result the animal is unable to feed and respiration is rendered difficult. The lungs may be the seat of pneumonic changes and the animal has then a short, dry and paroxysmal cough, a nasal discharge, difficulty in respiration, and the other symptoms characteristic of acute lung infection. Gastritis and enteritis are common. The animal lies about and if compelled to move does so reluctantly and sometimes with a staggering gait and an arched back; later it is unable to rise and becomes comatose.

As in other acute septicaemic diseases, a hyperacute form may develop and death supervenes within a few days, or a less acute form may set in where one or more groups of organs become involved; a chronic type is also encountered, life drags on over a considerable period and the animal becomes more debilitated and emaciated and remains a possible source of infection to other pigs. Recovery occurs in some cases, the virulence of, and the mortality from, the disease varying widely in different outbreaks.

Methods of prevention consist in keeping of swine in properly constructed piggeries and observing the laws of modern hygiene. Present-day open-air methods of pig raising are of value. Fresh pigs introduced into premises must be submitted to isolation for a sufficient space of time, in order to allow the disease to develop, if present: a period of rather more than three weeks is desirable. In infected areas every effort must be made to prevent the introduction of the contagion from outside sources. When stud boars are kept special precautions are necessary and the law must be carefully observed.

Since pigs which have recovered completely from an attack of swine fever possess a high degree of immunity, attempts have been made to perfect a hyperimmune serum against the virus of the disease. This serum has been extensively used in various countries with good results and it possesses the power of protecting swine against the disease, provided it is administered before exposure to infection or in the early days after infection; obviously it can be of little service after the onset of the disease as it is not potent against the organismal secondary invaders. In herds where the disease exists it is desirable to use the serum upon those animals which are not showing symptoms of the disease and to slaughter the animals affected.

Since the protective power of the hyperimmune serum is expended after a few weeks, attempts have been made to confer an active immunity by mixing the immunized pigs with those affected with swine fever, in order that a natural attack of the disease may be developed in a very modified form. This method has been proved to be less dangerous than an alternative method which consists in the simultaneous injection of hyperimmune serum and virulent blood taken from an animal suffering from swine fever. The former method, as stated, is preferable and it has given good results in practice, but it is not free from danger as some animals develop and die from the disease. (A. R. S.)

SWINEMÜNDE, port and seaside resort in the Prussian province of Pomerania, at the east extremity of the island of Usedom, and on the river Swine which connects the Stettiner Haff with the Baltic. Pop. (1925) 18,213. The Swine, the central and shortest passage between the Stettiner Haff and the Baltic Sea, was formerly flanked by the fishing villages of West and East Swine. Towards the beginning of last century it was made navigable for large ships, and Swinemünde, which was founded on the site of West Swine in 1748, was fortified and raised to the dignity of a town by Frederick the Great in 1765. The entrance to the harbour, the best on the Prussian Baltic coast, is protected by two long breakwaters, and is strongly fortified. The fairway is 360–490 ft. wide, with a depth of 30 ft. at the quays.

SWINGING, a radio term denoting variation in intensity of a received radio signal resulting from changes in the frequency of the transmitted waves.

SWINTON, SIR ERNEST DUNLOP (1868–), British soldier, was born on Oct. 21, 1868, and commissioned in the Royal Engineers in 1888. In the South African War he was first adjutant and then commander of the 1st Railway Pioneer Regiment. In 1904 Swinton produced *The Defence of Duffer's Drift,* a tactical study which became an unofficial textbook in the British and Indian army, and an official one in the U.S. army. In 1909, when an instructor at Woolwich, he wrote, under the pseudonym of Ole-Luk-Oie, a book of short stories entitled *The Green Curve,* which, by its combination of literary power and military imagination, gained a wide reputation. Appointed secretary of the historical section, Committee of Imperial Defence, in 1910, he compiled the official history of the Russo-Japanese War. Soon after the outbreak of war in 1914 he was sent out to France as the official Military Correspondent ("Eyewitness"). His proposals to Sir Maurice Hankey, Secretary of the Committee of Imperial Defence, in Oct. 1914 became the first link in the causation of the machine gun and wire destroyer, afterwards christened the tank (*q.v.*). In 1915 he returned to England to become secretary to the War Committee of the Cabinet. In this capacity he had much to do with the preparation of the first tanks. In 1925 he was appointed professor of military history at Oxford.

SWINTON, an urban district in the West Riding of Yorkshire, England, 10½ m. N.E. of Sheffield on the L.M.S. and L.N.E. railways, at the junction of the Don navigation with the Dearne and Dove navigation. Pop. (1921), 13,912. The town was formerly renowned for its Rockingham ware.

SWINTON AND PENDLEBURY, an urban district in the Eccles municipal and parliamentary borough, Lancashire, England, 5 m. N.W. of Manchester, contiguous with Salford, with stations on the L.M.S railway. Pop. (1921), 30,916. The Swinton industrial schools were opened in Feb. 1846. The manufacture of cotton, and coal-mining are the chief industries. Anciently a large part of Swinton was possessed by the Knights Hospitallers of St. John of Jerusalem.

SWISS LITERATURE. Peculiarities of the geographical situation of Switzerland make it impossible to speak of a "Swiss" literature in the sense in which we speak of a French or English literature. Switzerland has occupied the position of a "marchland" to its three great neighbours, Germany, France and Italy; and the attraction of the languages of these three nations has exercised an overwhelming influence on Swiss letters. There has, however, almost always been a characteristically Swiss note in the books produced in the territory now known as Switzerland.

GERMAN

Switzerland remained substantially a literary dependent of Germany even after her political liberty had been achieved. Hadlaub and his contemporaries were rather local German, than Swiss, poets. At the time of the Reformation, there was a momentary danger that German Switzerland would develop an Alemannic literary language differing from that of Germany. Fortunately this differentiation has been confined to the popular spoken language of "Schweizer Deutsch" (which, however, plays also a respectable rôle in letters), and Swiss writers in German were able to retain the wide public of German-speaking nations.

The abbey of St. Gall was a cradle, not only of Swiss literature, but of German letters in general, at a time corresponding to our Anglo-Saxon period. For details, *see* articles St. Gallen, Notker, Hymns, Waltharius, German Literature, etc. For our purposes we may begin this sketch with the League or Pact of 1291 (*see* p. 681 *infra*). That document, indeed, was written in Latin; but all later alliances (such as, *e.g.*, the Priests' Ordinance of 1370) were drawn up in German. This was the period of the German minnesingers (*q.v.*), at least 30 of whom are known to have originated at Zürich and other parts of what is now German Switzerland. The Codex Manesse (now in Paris), compiled by the (Swiss) father and son of that name, dates from the beginning of the 14th century and includes specimens of 141 poets. Master John Hadlaub (13–14th centuries), perhaps the most important Swiss minnesinger, forms the subject of a charming tale by Gottfried Keller (*q.v.*) and contributed not a little to the growth of Swiss nationalism and patriotism. Other prominent names are Rudolf von Fenis, count of Neuchâtel (12th or 13th century), who was much influenced by the Provençal troubadours, and Berthold Steinmar of Argovia, of original and vigorous talent.

Fables and Popular Songs.—In Switzerland, as in Germany, the romantic lyric and epic of the minnesinger period were followed by an age of more prosaic and didactic work. It may be said to be ushered in by the *Edelstein,* a versified collection of fables by Ulrich Boner, a Dominican friar of Berne (first half of the 14th century), with which may be mentioned *Der Ring* of Heinrich Wittenberger (Thurgau), a sort of comic epic, and the *Schachzabelbuch,* an allegorical poem by Konrad von Ammenhausen (1347). The *White Book* of Sarnen (*c.* 1470) and the chronicle of Melchior Russ of Lucerne (1482) contain the earliest mentions of William Tell (*see* Tell). Diebold Schilling of Berne (1484) gives us a stirring narrative of the Burgundian wars. More interesting, perhaps, to lovers of literature are the popular songs, especially the war songs celebrating the marvellous victories of the early Swiss. One of the earliest and most famous of these commemorates the battle of Sempach (1386) and the heroism of Arnold von Winkelried (*q.v.*), familiar in the later version associated with the name of Hans Halbsuter of Lucerne (1541). Similar songs celebrate the victories of Naefels (1388), Grandson (1476), Morat (1476), Nancy (1477), and Giornico (1478).

The beginnings of the drama in German Switzerland resembled those in Germany. Indeed, the earliest known ms. of a Passion play emanates from the abbey of Muri in Argovia (early 13th century). Switzerland also had its share of the secular *Fastenspiele* of Shrovetide, the best known of which is *Der Kluge Knecht,* by an anonymous author of the 15th century.

Switzerland shared also in the production of the mystical and humanist writings that heralded the Reformation. Perhaps the most notable Swiss mystic is Elsbeth Stagel (d. *c.* 1355), a nun of Töss, near Zürich. She was an ardent disciple of the German mystic Heinrich Suso (b. at Constance).

The first stirrings of Humanism in Switzerland may be attributed to the visit of the Italian scholar Poggio to St. Gall (1416) and to the Councils of Constance (1416–18) and Basle (1431–49). Aeneas Sylvius, present at the latter, founded the University of Basle a little later (1459). A zealous disciple of these two scholars was Niklaus von Wyl, an Argovian (b. *c.* 1410), who is an outstanding figure in the chronicles of Humanism.

Effects of the Reformation.—The literature of German Switzerland in the 16th century was, like that of French Switzerland, mainly a product of the Protestant Reformation. Though Zwingli was a less powerful literary force than Luther or Calvin, his enthusiasm for progress included many secular as well as religious interests. The Zürich Bible, largely consisting of Luther's version, was issued in 1531. The drama, too, still in a somewhat primitive form, was mainly in the hands of the Protestants. Zwingli's colleague and successor Heinrich Bullinger (*q.v.*) wrote at least one play. The most prominent literary name of the period is that of Nicholas Manuel (1484–1550), the painter, who wrote also many plays and satires. Jakob Ruf (d. 1558) resuscitated (1545) the old *Urnerspiel,* dealing with the William Tell legend.

The chroniclers of the 16th century are of more significance for us than the drama, inasmuch as they deal with still-living facts. Among the most important are the brilliant and fanciful Giles Tschudi (*q.v.*), though he wrote mainly in Latin; Johannes Stumpf (*q.v.*), an annalist of more accuracy if of less charm; and Josias Simler (1530–76), writing in Latin. Joachim von Watt of St. Gall, known as Vadianus (1484–1551), compiled an interesting chronicle of the abbots. Valerius Anshelm (d. 1540) told the story of Berne down to 1536. Bullinger (*q.v.*) and Hans Salat (d. *c.* 1552) wrote narratives of the Swiss Reformation from opposite points of view. The journal of Andreas Ryff (1550–1603) gives us a picture of the daily life of a pious merchant of the day. The autobiographies of the father and son, Thomas and Felix Platter (d. 1582 and 1614), are among the most charming prose works of the period. Konrad von Gessner (*q.v.*) wrote in Latin and ranks as a naturalist and scholar rather than as an author. The realm of imaginative prose is scantily represented by Wilhelm Ziely (d. *c.* 1542), who translated French romances, and Johann Wetzel, who published oriental tales, after an Italian model.

The 18th Century Revival.—Signs of revival begin with the 18th century. Zürich, Berne and Basle were the chief literary centres. The prevailing spirit was one of liberal Protestantism; one indication of this being the growing influence of English authors at the expense of French. Friedrich Drollinger (1688–1742) of Basle (though born in Baden), translator of Pope, forms a link with the revival of Swiss literature represented by Haller of Berne and Rousseau of Geneva.

Albrecht von Haller (*q.v.*), though specially distinguished as a scientific writer, is a notable figure in pure literature, both for his contemporary influence (in Germany as well as in Switzerland) and as one of the first of the early authors who is still read with appreciation. His long poem on the Alps (*Die Alpen,* 1732) did much to stimulate Swiss patriotism and interest in Swiss scenery; and his friend Goethe called him "the father of national poetry." His son, Gottlieb Emanuel von Haller (1755–86), produced, in his *Bibliothek der Schweizergeschichte,* a work that is still indispensable to the historical student. Among Haller's followers are the poets J. K. Peyer of Sachshausen (1707–68), Samuel Grimm of Burgdorf (1733–94) and Vinzenz von Tscharner of Berne (1728–78).

A prominent literary figure of Basle in this period was Isaac Iselin (1728–83), the chief begetter of the Helvetic Society (*see* below), whose treatises on the philosophy of history (*Geschichte der Menschheit,* 1764) and ideal philosophy (*Philosophische und Patriotische Träume eines Menschenfreundes,* 1775) were eloquent expositions of the idealistic and patriotic movement of his day. Otherwise Basle was more prominent as a scientific centre, notably with the eminent mathematicians, Leonard Euler (*q.v.*) and the Bernoullis (*q.v.*).

Zürich as Intellectual Capital.—But the real intellectual capital of Switzerland in the 18th century was Zürich, the "Athens on the Limmat." The most prominent names are those of Johann Jakob Bodmer (*q.v.*) and John Jakob Breitinger (1701–76), who, though not themselves stars of the first magnitude, had an important effect in extricating German literature from its old shackles and guiding it into a more promising course. They were much influenced by Milton, Shakespeare and other English writers, and were violently, but unsuccessfully, opposed by Gottsched, the leader of the Saxon or "French" school. In 1721–23 Bodmer and Breitinger carried on the *Diskursen der Maler,* a periodical to spread their views, while more elaborate and systematic expositions of their critical doctrine as to poetry were set forth in Bodmer's *Kritische Abhandlung von dem Wunderbaren in der Poesie* (1740) and Breitinger's *Kritische Dichtkunst* (1740).

Among the most important Zürich contemporaries of Bodmer were Salomon Gessner (*q.v.*), the pastoral poet; J. H. Pestalozzi (*q.v.*), the educationalist; and J. K. Lavater (*q.v.*), now best remembered as a physiognomist and phrenologist, though his lifetime influence was great in many other fields. Johann Caspar Hirzel (1725–1803) is notable for his *Wirthschaft eines philosophischen Bauers* (1761), the record of "Kleinjogg," a village Socrates, which attained great contemporary popularity. Johann Georg Sulzer (1720–79) claims attention for his *Allgemeine Theorie der schönen Künste.* Hirzel was one of the founders of the Helvetic Society (1761).

Of other Swiss writers of this period, not specially associated with the three towns named above, one of the best known is J. G. Zimmermann (1728–95), the lover of solitude. Johannes von Müller (*q.v.*) wrote the first detailed history of Switzerland, a book of influence and value. J. H. Zschokke (1771–1848), Swiss by adoption, also wrote a popular Swiss history, but is best known for his numerous short stories. J. J. Hottinger (1763–1860) and the brothers G. and F. von Wyss (d. 1893 and 1907) are also noteworthy historians (of a somewhat later date).

The Napoleonic Period.—This was naturally, for Swiss literature, more or less sterile; but the democratic revival after 1830 was as marked in letters as elsewhere.

Three names stand out at this time above all others—Albrecht Bitzius (*q.v.*), better known as "Jeremias Gotthelf," the novelist of peasant life; Gottfried Keller (*q.v.*) a very representative Swiss novelist and poet; and Conrad Ferdinand Meyer (*q.v.*), another poet and novelist, of more cosmopolitan leanings and tastes. Other notable writers are: Johann Martin Usteri (1763–1829), one of the earliest dialect poets; Gaudenz von Salis-Seewitz (1762–1834), a Grisons poet, known to English readers by Longfellow's version of his *Song of the Silent Land;* U. Hegner (1759–1840) and D. Hess (1770–1843), two novelists of local colour; Gottlieb Jakob Kühn (1775–1845), a well-known dialect poet; J. R. Wyss (1781–1830), author of the Swiss national anthem (*Rufst du, mein Vaterland?*) and son of J. D. Wyss, writer of *The Swiss Family Robinson;* K. R. Tanner (d. 1849), a lyric poet; Jakob Frey (1824–75), a follower of Bitzius; A. E. Fröhlich (*q.v.*), the fabulist; Jacob Burckhardt (*q.v.*), author of the *Cicerone;* the Zürich poets, L. Widmer (1806–68), H. Leuthold (1827–79), and A. Corrodi (1826–85); J. J. Bachofen (1815–87), a writer on Rome and Roman law, whose works have recently made a new and strong appeal; and F. Schmid (1823–88), a metaphysical poet.

Writers of the 20th Century.—Among writers whose activity belongs in whole or part to the 20th century, the outstanding name is that of Carl Spitteler (*q.v.*), a really great epic and lyric poet. With him may be named his friend J. V. Widmann (*q.v.*), a poet and dramatist of taste and distinction. R. Faesi, H. Federer, A. Frey, J. C. Heer, A. Huggenberger, Paul Ilg, Max Pulver, J. Schaffner, A. Steffen and Ernest Zahn are all writers of mark. Other noteworthy poets are Gottfried Bohnenblust, H. Hiltbrunner (*Werk der Welt,* 1927), Siegfried Lang, Karl Stamm (1890–1919), Dominik Müller, F. Hofer and Isabella Kaiser (*Mein Herz*), who writes both in French and German. The chief dialect poets include Meinrad Lienert (b. 1865), the "Swiss Hebbel"; Otto von Greyerz; and Joseph Reinhart. Novelists and story-tellers of note, besides those already mentioned are: J. Bosshart (1862–1924), whose later works showed great power (e.g., *Ein Rufer in der Wüste*); J. Bührer (*Aus Konrad Sulzers Tagebuch*); A. Fankhauser (b. 1890); John Knittel, who writes in English (e.g., *Aaron West,* with preface by R. Hichens, and *Into the Abyss,* 1927); Felix Moeschlin (*Die Königschmieds*); W. Siegfried (*Tino Muralt*); A. Vögtlin; Robert Walser; Maria Waser (*Wir Narren von Gestern*); Lisa Wenger (*Was das Leben mir lehrte,* 1927); and Otto Wirz (*Gewalten eines Toren,* 1922). The leading story-writers in dialect are R. von Tavel (*Veteranezyt,* 1927), J. Reinhart (*see* above), and Simon Gfeller (*Meieschössli; Heimisbach; Aemmegrund,* 1927).

Among the best critics, essayists and biographers of the day are C. A. Bernoulli, notable for his books on Nietzsche (1910), Bachofen, and others, and also the author of plays and novels, G. Bohnenblust (*see* above); Emil Ermatinger, an authority on German literature and author of a vigorous romance (*Der Weg ins Leben*); O von Greyerz (*see* above); R. Faesi (*q.v.*); and Eduard Korrodi. Among historians we may note Wilhelm Oeschsli, whose admirable *History of Switzerland from 1419 to 1919,* has been turned into English by E. and C. Paul (1922); Eduard Fueter, author of *Die Schweiz seit 1848* (1927); and Ernst Gagliardi, author of *Dokumente zur Geschichte des Bürgermeisters Hans Waldmann, and of Geschichte der Schweiz,* of which the concluding volume, covering the history of Switzerland from 1848 to 1926, appeared in 1927.

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im deutschen Geistesleben, a series of monographs edit. by H. Maync, containing useful contributions by R. Faesi, O. von Greyerz, E. Korrodi, etc.); and *Die Junge Schweiz* (edit. by E. Korrodi).

(J. F. M.)

FRENCH

French established itself in the 13th century as the written language and the vehicle of law in the districts which form French Switzerland. Between that time and the Reformation, however, little original literature was produced. Some chronicles, a few fragments of mysteries, and one or two romances printed at Geneva towards the end of the 15th century, are almost all that remain. The literary age begins with the intellectual impetus supplied by the Reformation. The *Histoire littéraire de Genève,* published by Senebier in 1786, gives an idea of the abundant literary production of a single Swiss city.

The Age of Rousseau.—Even in the 18th century it cannot be said that a national literature existed in French Switzerland. Yet at this period the Protestant cities of refuge became intensely interested in literature, and taste began to be cultivated by the patrician and bourgeois classes. The atmosphere of the Reformation mingled with that of the 18th century. French Switzerland has at no time been more cosmopolitan in the best sense of the word; it has never been a more brilliant intellectual centre or a more active laboratory of new ideas.

The works of Rousseau and Madame de Staël, and Benjamin Constant's *Adolphe,* are the main contributions of Switzerland to French literature during the 18th and early 19th centuries.

The Swiss literary movement, which became more national in the last century, stood somewhat apart from that of France. The Swiss writers are given to thought and self-examination; they are seekers after truth, less ready to complain of destiny than to acknowledge their own shortcomings, plain citizens who are at the same time dreamers. The greatest modern novelist of French Switzerland, C. F. Ramuz, is principally famous for the pictures he gives of his native country; the same is true of the poet Juste Olivier, and, still earlier, of the racy stories of Rodolphe Töpffer.

Vinet and Amiel.—Although, however, the writers who describe the picturesque features of local life occupy an important place in French Swiss literature—they are, indeed, primarily depicters of their land and their nation, and only secondarily novelists or short story writers—the first place is due not so much to them as to the critics and moralists. It was Vinet (1797–1847) and Amiel (1821–81) who first extended the intellectual prestige of French Switzerland beyond the frontiers.

Among the poets of French Switzerland, very few reveal a stormy temperament or make their passions and their griefs the subject of their art. Swiss lyrical poetry is the product of a happy people. Sometimes it is religious in character, and sometimes an Alpine note is struck (Juste Olivier, 1807–76, Eugène Rambert, H. Warnery).

Writers of Fiction.—It is curious that the interest in moral observation and self-analysis which prevailed in the 19th century should not have led to the development of the analytical novel. Töpffer (1799–1847) wrote short stories of middle-class life and imaginative sketches, descriptions of things seen in wanderings through the town or among the mountains. Eugène Rambert was a writer of Alpine idylls. Philippe Monnier (1864–1911), also a humanist, wrote detailed descriptions of Geneva and of his own village. It is not surprising that a Genevese, V. Cherbuliez (1829–90) should have created the cosmopolitan novel in France. Edouard Rod (1857–1910), who also gained fame in Paris, betrays his French Swiss origin by the interest he shows in the internal moral conflicts of his characters.

Early in the present century a change began to take place both in the spirit and in the technique of the literature of French Switzerland. The didactic, moral and eclectic elements—the Protestant spirit, in short—have become less conspicuous. The past is almost repudiated. There is still a lack of dramatic literature (though mention should be made of the rustic theatre of Mézières, Vaud and of R. Morax). The modern poets write in an easier style than their predecessors (Henry Spiess, R. L. Piachaud, P. Girard). Even now, however, there are more descriptive writers and recorders of rural life than novelists proper. The chief names to be mentioned are those of the great Vaudois writer C. F. Ramuz, B. Vallotton, Noëlle Roger, and the creators of the new analytical school, Robert de Traz and Jacques Chenevière.

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ITALIAN

Italian Switzerland is best known by its artists, while its literature is naturally subject to strong Italian influences, and not to any of a strictly Swiss nature. Stefano Franscini (1796–1857) did much for his native land, especially in educational matters, while his chief published work (1835) was one that gave a general account of the canton of Ticino. But this is not so thorough and good as a later book by Luigi Lavizzari (1814–1875), entitled *Escursioni nel cantone Ticino* (1863) which is very complete from all points of view. Angelo Baroffio (d. 1893) and Emilio Motta represent the historical sciences, the latter contributing much to the *Bolletino della Svizzera Italiana* (from 1870 onwards), which, though mainly historical, devotes much space to literary and historical matters relating to the canton. The art of novel writing does not flourish in Ticino. But it has produced a great number of poets such as Pietro Peri (1794–1869), who translated the Swiss national anthem into Italian, J. B. Buzzi (1825–1898), Giovanni Airoldi (died before 1900) and Carlo Cioccari (1829–1891)—the two former were lyric poets, and the third a dramatist. The younger poets are F. Chiesa and M. A. Nessi. Possibly the most conspicuous literary figure of the moment is Luigi Zoppif, who wrote *L'Esteta.*

SWISSVALE, a borough of Allegheny county, Pennsylvania, U.S.A., 6 m. S.E. of Pittsburgh, on the Pennsylvania railroad. Pop. (1920) 10,958 (82% native white); 1928 local estimate over 18,000. It is an important manufacturing centre, with an annual output valued at $16,000,000.

SWISS WARS, 1315–1529. When the central organization of the Holy Roman Empire broke down in the thirteenth century, there were certain communities which had not yet slipped into subordination to the feudal states which were to replace the emperor as the practical governing authority in Germany. The origin of Switzerland in its modern sense lies in the fact that the men of Uri and Schwyz obtained in 1231 and 1240 respectively *Freiheitsbriefe,* or charters of liberty from Frederic II., declaring them to be free from comital authority and direct vassals of the crown. How Unterwalden, the third original member of the Old-Swiss union, got its claim to a similar immunity is not clear. But in 1291 these "Three Original Cantons" formed the so-called "Eternal Alliance" which bound them to mutual support, and pledged them to submit to no external authority.

The danger to the primitive Swiss lay in the House of Habsburg; not because two of its members achieved the Imperial crown in the late 13th century, but because its heads (whether crowned or uncrowned) were the holders of the largest feudal accumulation of land in what is now Switzerland. From first to last the Habsburgs were great at land-grabbing: hence it was not strange that the "Three Cantons" supported all claimants to the imperial crown outside the Habsburg family—such as Henry VII. of Luxemburg and Louis of Bavaria.

As nominal partisans of Louis of Bavaria against his rival for the crown, Frederic of Habsburg, the Schwyzers had sacked the abbey of Einsiedeln in 1314, on the pretext that the abbot held to the other allegiance. It was this casual raid which was destined to bring the name of Schwyz into general knowledge for the first time. The counter-emperor Frederic directed his brother Duke Leopold to chastise this nucleus of Bavarian partisans in a region close to the main Habsburg holding in south Swabia. Hence came the battle of Morgarten (1315). Leopold of Austria with the knighthood of the Hapsburg lands in Swabia, and some town-levies of infantry from Zürich and Zug, started out in November to chastise the Swiss. The mountaineers took post in the narrow defile of Morgarten, between the lake of Egeri and the steep hills above. They had blocked the road with a wall of rough stone, and hidden themselves in folds of the adjacent upper slopes. Duke Leopold who had taken no precautions of reconnaissance, came unexpectedly upon the stone barrier, with his army strung out in file for half a mile behind. He hastily ordered his vanguard to pull down the obstacle and drive off the men behind it. But while it was thus engaged the Swiss charged down on the whole flank of the Austrian line of march, heralding their approach with a shower of boulders and tree trunks which had been laid above the road. The unfortunate knights, unable to advance or retreat, or to wheel their horses to charge up an impracticable slope, were mostly hurled into the lake by the first onset. The duke cut his way out; the infantry in the rear fled.

A second exploit, 25 years later, forms a much more serious episode in the history of the art of war. The result of Morgarten had been that other towns and rural communities in the Alps had adhered to the original cantons and sought their alliance against the local princes. In 1339 the town of Berne, the most important urban centre in the land, being at odds with the count of Kyburg concluded a treaty with the cantons. This roused against them the whole feudal aristocracy as far as the Jura, and the counts of Kyburg, Neuchâtel, Gruyère and Nidau, the Lord of Vaud, and many other magnates marched against Berne, and laid siege to the town of Laupen. The confederates sent succours to the Bernese, and a general action was fought on June 21, 1329 on the hillside above Laupen. This was no fight in a narrow defile unfavourable to horsemen, but a pitched battle, in which for the first time the Swiss used the deep infantry column, which was to be their favourite formation in after years. The lords of the lowlands charged a dozen times against the phalanx formed by the men of the Forest Cantons without breaking it, and when attacked in flank by the other half of the Swiss army, the levy of Berne gave way and retreated, leaving 80 barons and hundreds of men-at-arms dead upon the field.

Naturally, after such a display, the confederacy was joined by many new members, both urban and rural, including the considerable towns of Zürich and Zug. They could then challenge the Habsburg supremacy in northern Switzerland, and in 1386 provoked Duke Leopold the Valiant, nephew of the elder Leopold of Morgarten, by invading his dominions. On July 9 of that year the duke, having collected the knightly levy of his Swabian and Tirolese dominions, and hired many mercenaries, marched against Lucerne, the most central strategical point of the confederacy. The greater part of the Swiss forces were at the moment campaigning near Zürich, far away; and it was only the levies of the four Forest Cantons which met Leopold on the hillside of Sempach, above the lake and town of the same name, as he found his way up one of the roads to Lucerne.

By this time the deductions which feudal Europe had drawn from the battles of Crécy and Poitiers, were prevailing in Germany no less than in France. Leopold, like John of Valois at Poitiers, dismounted all his knights save a reserve of mounted men, and strove to oppose to the phalanx of the Swiss infantry a better and more heavily armoured mass of men-at-arms on foot, fighting with the long lance. The crash was tremendous, the front rank on both sides went down; but the impetus of the Swiss prevailed—we are told that after a time the knights were tired out by the very weight of their panoplies. The reserve of horse misbehaved, and rode off when the duke and his banner fell.

In their earlier battles the Swiss used the halberd, the equivalent of the English bill, more than the pike. But in their developed tactics of the 15th century we find the pike predominant, no doubt because it was a more effective weapon for beating off cavalry charges. In their later wars we find them usually advancing in an échelon of three deep columns of pikes, with a vanguard thrown forward, a main-battle to its side and rear, and a rear-guard column again to the side of the main-battle but not level with it. They had a certain number of light troops, crossbowmen and in the later decades hand-gun men, who were thrown out on the flanks to screen the advance. But it was always the weight of the column and its impenetrability which won the day. In cases where the Swiss force was much outnumbered, and failed to break up the enemy, it would fight a defensive battle with desperate obstinacy. At Arbedo in 1422 the invaders of the duchy of Milan were beaten by the great Condottiere Carmagnola, but won themselves a retreat without overwhelming loss. At St. Jacob in 1444 an isolated corps of less than a thousand men, surrounded by ten times their strength, were not exterminated till they had laid low twice their own number of the Armagnac mercenaries of the dauphin Louis. They were very hard to break when they had "formed the hedgehog" as their captains called the solid square with pikes projecting on all sides.

Both Granson (March 2, 1476) and Morat (June 22, 1476) were examples of the Swiss tactics of rapid advance in échelon against an enemy taken somewhat by surprise, and attacked before he had assumed his intended fighting position. At Granson Charles of Burgundy, who had just captured (and hanged) the Swiss garrison of that town on the lake of Neuchâtel, got short warning that the confederates were descending on his camp from the hills of Mount Aubert. The duke was getting his line formed, when the first Swiss column, well ahead of the other two, came rushing down on his left wing. Charles charged it ineffectively with his cavalry, which failed to break in, but at least stopped its advance. He was then preparing to turn his artillery against its front, and to wheel the infantry of his centre round its flank, when the second and third Swiss columns came rushing down the slopes, and caught the Burgundian guns and infantry while both were on the move and exposing themselves to a lateral attack. Instead of fronting to face the new assailants, the duke's infantry fled in panic, and he was forced to abandon his cannon, and quit the field with his cavalry, much of which was still in fair order. His loss had been only 1,000 men, but his guns, his camp, and his treasury fell into the hands of the victors, who had about 200 casualties—all in the leading column. Charles was convinced that he had been defeated only because he had been surprised, and because his infantry had misbehaved in a sudden crisis. He resumed his attack on the Swiss in June, by laying siege to the little town of Morat on the lake of the same name. He fortified himself with lines of entrenchments facing outward, on the hills lying above both sides of the town, and having garnished the palisades with his numerous artillery (he had completely replaced the losses of Granson) waited to be attacked in position. His cavalry were to be held in reserve, till the Swiss column should have shattered themselves against the entrenchments.

The fault of the position was that a dense wood lay opposite it, giving illimitable cover: and the duke was heedless enough to neglect reconnaissance to see what was beyond the broad belt of timber. He had been waiting ten days to be attacked, before the Swiss appeared in front of him on June 21 in great force. On the following morning the Burgundian army waited behind its palisades for many hours, till the day broke up with blinding and continuous rain-storm. No attempt seems to have been made to "feel" the enemy, who was known to be behind the woods. After noon was past the duke, making up his mind that the weather was too bad for fighting, sent his main body back to their camp to feed and get shelter, leaving only the guns, and a line of posts behind the palisades.

This was the moment for which the Swiss had been waiting—their leading column emerged from the corner of the woods, and ran, half hidden by the pouring rain, straight at the southern end of the Duke's entrenchments. The artillery salvo tore some deep holes in the phalanx, but before the guns could make a second discharge, the Swiss were over the ditch and across the palisades, where they found but few enemies on guard. The second and third columns followed the first, carrying, almost without resistance, all the southern half of the duke's lines. Charles however did not consider the day lost, and led his army up from its camp, in great disorder, as quickly as each corps could form, to drive the Swiss out of the entrenchments. Disaster naturally followed—there was no line of battle whatever—and though many of the Burgundians fought well, the down-rush of the enemy's columns swept the whole of the duke's army into and over the camp on the lake-shore. There was a frightful massacre to follow, for the troops in Charles's centre were driven into the lake and exterminated, their line of retreat having been cut. Those on his northern wing, who had never been attacked, escaped by taking a détour toward the further end of the lake. But at least 7,000 out of the duke's 20,000 men had perished by the sword, or by drowning.

It is strange to find that after two such experiences as Granson and Morat, Charles lost his last battle and his life at Nancy, in 1477, by allowing himself to be once more surprised.

For the next 30 years the Swiss infantry were the model and terror of all central Europe. This was the age in which Machiavelli describes them as "marching with 10,000 or 15,000 pikemen against any number of horse, and winning a general opinion of their excellence from the many remarkable services that they performed." They smote the Emperor Maximilian's Swabian and Tirolese levies as their ancestors had smitten those of his kinsmen, the two Leopolds, at Morgarten and Sempach—moving in square through his countryside, beating off his knights from their "hedgehog" front, and trampling down his infantry bands, the landsknechts, whom he had trained to fight after the Swiss fashion in column and with serried depth of pikes. In Italy the confederates made and unmade princes, selling their service where it was profitable, rather than seeking for the general advantage of their confederacy.

Meanwhile the Renaissance, many-sided in things military as in every line of thought, was producing scientific soldiers who were pondering on the problem of how to deal with the hitherto invincible column of pikes. Some found the solution which ancient Rome had used against the Macedonian phalanx, the Spanish sword and buckler, fatal against the pikeman if once a hole had been bored in his array. Machiavelli saw and praised this tactic—the bearer of a long weapon is helpless when his opponent has got in close and can stab. There was an interesting example of this sort of slaughter at the battle of Ravenna. But the Spanish sword and buckler were only found in one national army, and no one else took up their device. More effective was the idea (imperfectly tried by Charles of Burgundy at Morat) of field-fortification supplemented by firearms—if only the Swiss could be induced to attack frontally. Sometimes they did, and were shot down helplessly as at Bicocca (1522). More scientific, and perhaps the most decisive of all the tactics which broke the reputation of the Swiss infantry, was another idea which Charles had failed to exploit successfully. Cavalry charges from the side can force the phalanx to halt, since it must form front to flank to beat them off. Even if repulsed, they stop its advance.

It was the battle of Marignano (Sept. 13, 1515) which displayed this fatal drawback to the Swiss tactics. When the great column of pikemen broke into the French line, Francis I. led no less than 30 successive charges against its flanks, with small bodies of a few hundred men-at-arms. Each was repulsed for several hours, but meanwhile the whole of the French artillery concentrated on to the front of the phalanx, which at last was so torn to pieces that it had to retire with the loss of half of its numbers or more. Gunpowder thus turned out to be the poison which destroyed the power of the Swiss pikemen. (C. W. C. O.)

SWITCH PLANTS, a botanical term for plants, such as broom, with leaves very small or absent, and slender green shoots.

SWITHUN (or SWITHIN), **ST.** (d. 862), bishop of Winchester and patron saint of Winchester Cathedral from the 10th to the 16th century. He is scarcely mentioned in any document of his own time. His death is entered in the *Anglo-Saxon Chronicle* under the year 861; and his signature is appended to several charters in Kemble's *Codex diplomaticus*. Of these charters three belong to 833, 838, 860–862. In the first the saint signs as "Swithunus presbyter regis Egberti," in the second as "Swithunus diaconus," and in the third as "Swithunus episcopus." Hence if the second charter be genuine the first must be spurious, and is so marked in Kemble. More than a hundred years later, when Dunstan and Ethelwold of Winchester were inaugurating their church reform, St. Swithun was adopted as patron of the restored church at Winchester, formerly dedicated to St. Peter and St. Paul. His body was transferred from its almost forgotten grave to Ethelwold's new basilica on July 15, 971, and according to contemporary writers, miracles accompanied the translation.

The revival of St. Swithun's fame gave rise to a mass of legendary literature. The so-called *Vitae Swithuni* of Lantfred and Wulstan, written about A.D. 1000, hardly contain any germ of biographical fact; and the earliest detailed authority is a biography ascribed to Gotzelin (*fl.* 1058–78). From this writer, who has perhaps preserved some fragments of genuine tradition, we learn that St. Swithun was appointed bishop of Winchester under Aethelwulf. At his request Aethelwulf gave the tenth of his royal lands to the Church. He died on July 2, 862, saying that he was not to be buried within the church but outside in "a vile and unworthy place."

William of Malmesbury adds that, as Bishop Alhstan of Sherborne was Aethelwulf's minister for temporal, so St. Swithun was for spiritual matters. The same chronicler uses a remarkable phrase in recording the bishop's prayer that his burial might be "ubi et pedibus praetereuntium et stillicidiis ex alto rorantibus esset obnoxius." This expression has been taken as indicating that the well-known weather myth contained in the doggrel lines—

St. Swithin's day if thou dost rain
For forty days it will remain;
St. Swithin's day if thou be fair
For forty days 'twill rain na mair—

had already, in the 12th century, crystallized round the name of St. Swithun; but it is doubtful if the passage lends itself by any straining to this interpretation.

The so-called lives of St. Swithun written by Wulstan, Lantfred, and perhaps others towards the end of the 10th century may be found in the Bollandist *Acta sanctorum* (July), i. 321–327; Mabillon's *Acta SS. O. B.* vi. 70, etc., vii. 628, etc.; and J. Earle's *Life and Times of St. Swithun*, 59, etc. *See* also William of Malmesbury, *Gest. reg.* i. 150, and *De gest. pont.* 160, 167, 179; Florence of Worcester, i. 168; T. Rudborne ap. Wharton's *Anglia sacra*, i. 287; T. D. Hardy's *Cat. of mss.* i. 513–517; J. Brand's *Popular Antiquities*; R. Chambers's *Book of Days:* Ethelwulf's *Tithe Charters*, nearly all of which refer to St. Swithun in the body of the text, may be studied in Haddon and Stubbs's *Councils*, iii. 636–645.

SWITZERLAND (Ger. Schweiz; Fr. Suisse; It. Svizzera). The Swiss Confederation consists of 22 cantons with a republican and federal Constitution. It is situated in central Europe and bounded north by Baden and Württemberg (Germany), east by Vorarlberg and Tirol (Austria) with the small principality of Liechtenstein lying between Vorarlberg and Switzerland, south-east and south by Trentino, Lombardy and Piedmont (Italy), and south-west, west and north-west by the departments of Haute Savoie, Jura, Ain, Doubs, Haute-Rhin (France).

Relief and Structure.—Switzerland extends between 45° 49′ and 47° 48′ 30″ N. lat., and from 5° 58′ to 10° 30′ E. long. It forms an oval-shaped mass of which the greatest length (west-south-west to east-north-east) is 226 m., and the greatest breadth (north to south) is 137 m. It has little or no physical unity, consisting as it does of numerous small districts, differing widely in language, religion, ethnology and customs, bound together in a political alliance, made originally for common defence. Its political boundaries are natural only for short distances.

In summary, Switzerland of to-day consists of three great river valleys (Rhône, Rhine and Aar), lying to the north of the main chain of the Alps and including within their Swiss basins all the region between the Alps and the Jura. In addition, the wedge-shaped canton of Ticino runs south from the St. Gotthard massif and drains to the Po, whilst in the extreme east a tongue of the Grisons canton drains north-east via the Engadine, into the Danube. The Rhône and Rhine valleys are shut off from that of the Aar by the great northern ridge of the Bernese Oberland and Tödi Alps. The Aar valley is wide and undulating, but the upper Rhine and Rhône have cut deep trenches in the structural depression which separates the great parallel chains. The main chain of the Alps provides the loftiest wholly-Swiss summit (15,217 ft.) in the crowning Dufourspitze of Monte Rosa, though the Dom (14,942 ft.) in the Mischabel range, immediately north of Monte Rosa, is the highest entirely Swiss mountain mass. The highest summit in the northern parallel ridge is the Finsteraarhorn (14,026 ft.) in the Bernese Oberland, while the lowest level within the confederation is on the Lago Maggiore (646 ft.).

The geological build of the Alps (*q.v.*) has been proved to be exceedingly complex; the contorted, folded, and even overfolded recent rocks have been fractured, exposing old crystalline cores to denudation; the Jura (*q.v.*) are much less complicated in their folding and in their exposures. Much of the central hummocky plain is covered with undisturbed very recent rocks of Oligocene and Miocene age, many of which are marine deposits formed at a period when an arm of the Mediterranean spread up the present Rhône course along the outer border of the Alps as far east as Austria. These deposits are concealed in many parts of the plain by the most recent glacial and alluvial accumulations.

Hydrography.—The present confederation drains into the North sea, Mediterranean sea (direct), Adriatic sea and Black sea which, respectively, receive the Rhine, Rhône, Ticino-Po and Inn-Danube. The Swiss portions of their basins are approximately: 11,160, 2,760, 1,360 and 660 sq. miles.

Many of her *rivers,* with their Alpine origin, tend to seasonal overflows which have necessitated artificial embankment. The most important control scheme was that of Conrad Escher of Zürich (later Conrad von der Linth) who, in 1807–27, turned the turbulent Linth into Walensee, from which it emerges as a canalized stream. An earlier (1714) successful work was the diversion of the troublesome Kander into the Lake of Thun, where it is now placidly building an extensive fertile delta.

The *lakes* of Switzerland are very numerous: the largest, Geneva (S.W.) and Constance (N.E.) are on the frontiers and are not wholly Swiss. Neuchâtel (92½ sq.m.) is the largest wholly-Swiss lake. About 30 sq.m. at the north end of Lago Maggiore (143 sq.m.) belongs to Switzerland; next in order of size are Lucerne, Zürich, about half of the Swiss-Italian Lake of Lugano (20 sq.m.), Thun, Brienz, Morat, the Wallen, and Sempach (5½ sq.m.); no others exceed 4 sq. miles. Eleven of these lakes are in the Aar basin, two (Maggiore and Lugano) are in the Po basin, and Geneva is the great Rhône filter. The lakes of the Swiss portion of the Inn basin are small; the largest are Sils (1½ sq.m.), and the still smaller, slightly lower and adjacent Silvaplana. Many small mountain lakes are of interest, such as the dreary Daubensee (7,264 ft. alt.) near to the Gemmi pass; the extremely beautiful Oeschinensee (5,223 ft. alt.) mirroring the snowy Blümlis Alp, and the remarkable, though sometimes empty Märjelensee (7,766 ft. alt.) on which float miniature icebergs from the Great Aletsch glacier.

Of the countless *waterfalls* in Switzerland those of the Rhine (near Schaffhausen), 100 ft. high, inclusive of rapids, and 340 ft. wide, are the grandest, but the most beautiful are of less volume and greater height, such as those of the Lauterbrunnen valley and particularly the Staubbach, a mere veil of water hanging in front of a precipice 1,000 ft. high.

Switzerland contains many more *glaciers* than the combined total for adjacent lands; the number is estimated at over 1,000, but no exact computations are possible on account of numerous detached ice-masses which may or may not rank as glaciers. Practically all of them are now in retreat, though they will long continue to feed all the important rivers and streams of Switzerland. They probably occupy 700 sq.m., very unequally distributed; eleven of the cantons possess no glaciers. The greatest area is found in the Valais (more than half of the total area), followed by the Grisons and Berne (about ⅙th each); then by Uri, Glarus and Ticino (the last about 13 sq.m.); the remaining cantons—Unterwalden, Vaud, St. Gall, Schwyz and Appenzell have, in aggregate, a glacier area little superior to that of Ticino alone. The longest glacier in the main Alpine chain is the Gorner (9¼ m.), but it is exceeded by the Great Aletsch (16½ m.) and by the Fiescher and the Unteraar (10 m. each) which run down from the high eastern mountains of the Bernese Oberland.

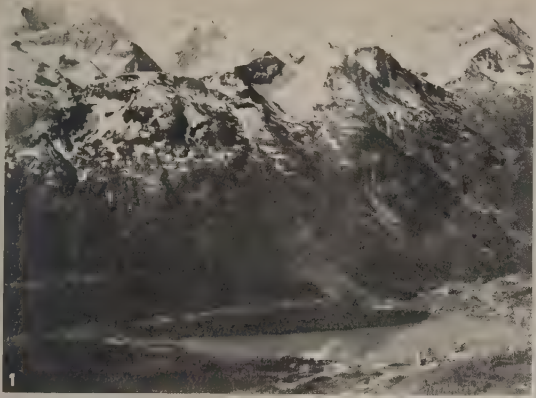
Climate.—In an area such as Switzerland which extends through less than two degrees of latitude, climate will be influenced more particularly by differences of altitude, aspect and gradient; these show wide and surprisingly sudden variations, *e.g.,* Monte Rosa (15,217 ft. high) is distant only 30 m. in a "straight" line from Lago Maggiore, with waters in the same latitude, but only 646 ft. in altitude. Great heights are characterized by (i.) low barometer readings: Monte Rosa summit records about half sea-level pressure; hence the possibility of "mountain sickness"; (ii.) usually more brilliant sunshine and dry air, particularly in winter, producing "sun-burning" and "ice-dazzle," which in some subjects amounts to "snow-blindness"; (iii.) much lower temperatures; among the Alps the average fall in temperature is about 1·2° F on the south side and about 0·9° F on the north side for each 330 ft. of ascent. The height of the Alpine crest and its main direction also profoundly influence the winds. In addition to local winds of certain higher levels which show a daily change of direction—down-hill in the morning and up-hill in the evening —there are other characteristic winds which are much less localized in their effects, as the southerly *föhn,* warm, dry and oppressive, which affects considerable areas in east Switzerland, particularly during spring and autumn; and the northerly *bise,* a cold wind experienced in Geneva. Switzerland's many climates are important, not only in Europe's playground generally, but also in the "nests of sanatoria." Hence, climate and weather statistics have been carefully compiled for many stations. The majority of Swiss tours and health resorts guide-books include a selection, but for a logical treatment of the climate details, reference should be made to such works as W. G. Kendrew, *Climates of the Continents* (London, 2nd ed. 1927).

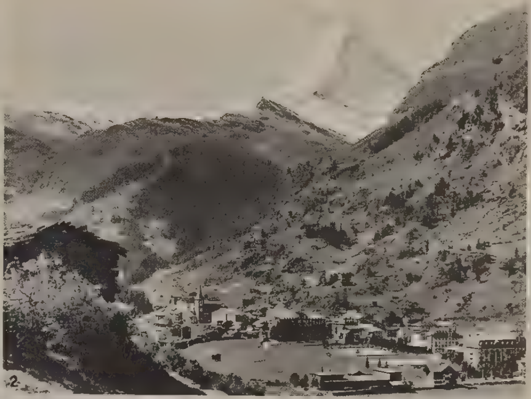
January is the coldest month, the following averages being recorded: Basle (909 ft. alt.) 31·8° F; Altdorf (1,480 ft. alt.) 32·4° F; Davos (5,121 ft. alt.) 18·7° F; St. Gotthard (6,877 ft. alt.) 18·1° F; Säntis (8,202 ft. alt.) 16·2° F, whilst an unusually low average is from Bevers (5,610 ft. alt.) with 14·2° F. Precipitation (either rain or melted snow) shows wide variations, *e.g.,* Basle has 32·5 in. total annual precipitation; Altdorf, 49·0 in.; Davos, 35·7 in. and Säntis, 95·7 in. At several stations much of this falls as snow. On Säntis the precipitation is as snow from November to April inclusive, and only July and August have more rain than snow. Snow accumulates to a depth of 20 to 25 ft. at Bevers and upwards of 45 ft. on Säntis. July is the hottest month, the average July records in degrees F being: Basle 66·4, Altdorf 64·4, Davos 53·8, St. Gotthard 46·2, Säntis 41·0, Bevers 53·2, the range at the last station, 39·0°, tending to be extreme. Säntis, though cold, is much more equable, 24·8°. The snow line, showing considerable local variations, is about 9,000 ft. high on the western Alps, and about 10,500 ft. in the drier eastern mountains.

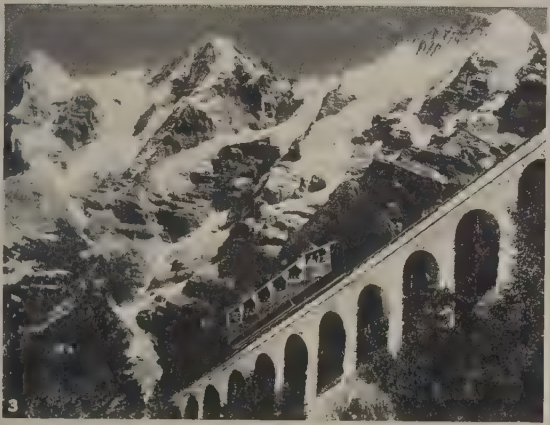
Forests.—The entire forest area of Switzerland on Jan. 1, 1924, was 3,803 sq.m. (nearly 24% of the whole country), chiefly coniferous (pine, fir and larch), but with considerable patches of oak, beech and maple on the lower lands. This total represents a considerable increase in recent years largely dependent on: (*a*) confederation-controlled re-afforestation schemes (in 1925 over 15 million trees [chiefly coniferous] were planted); (*b*) scientific preservation of the woodlands with which the forestry department of the Federal polytechnic school at Zürich is closely associated. The Federal Constitution of 1874 handed over to the confederation the responsibility for the forests "in the high mountains," and in 1876 it was enacted that the public forests should be surveyed, rights of way and of fuel should be legally determined and then surrendered with suitable compensation, the forest areas should never be reduced but increased by new planting schemes, with, if necessary, Federal financial support. Since 1902 the Confederation has oversight of all forests, however owned, within its area. The most extensive forests occur in the five cantons of Berne, Grisons, Vaud, Valais and Ticino.

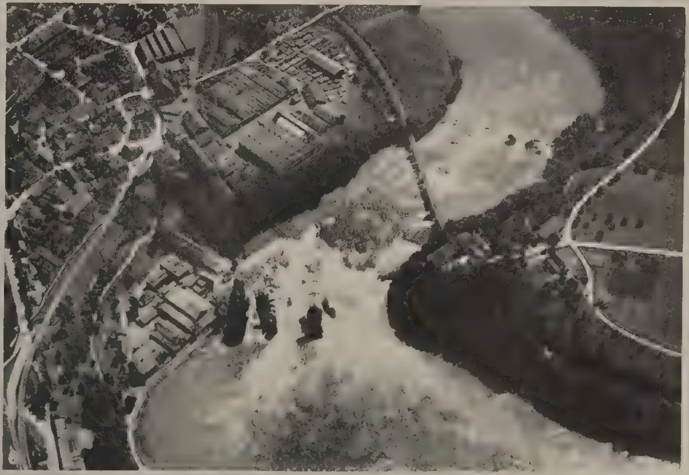
Area.—The 1923–24 determination gave Switzerland a total area of 15,940 sq.m. Of this, 77·45% are reckoned as "productive," and support the large total of over 212,000 peasant proprietors, chiefly on the grasslands which occupy 53·2% of the *productive* area; about two-thirds of the grassland is pasture. Forests occupy 28·9% of the "productive" area. Of the "unproductive" area, amounting to nearly 3,600 sq.m., the greater part is composed of bare mountain and plateau slope, yet much consists of lakes and rivers, while glaciers cover about 700 sq.m.

Population.—Well-organized census returns were made at ten-





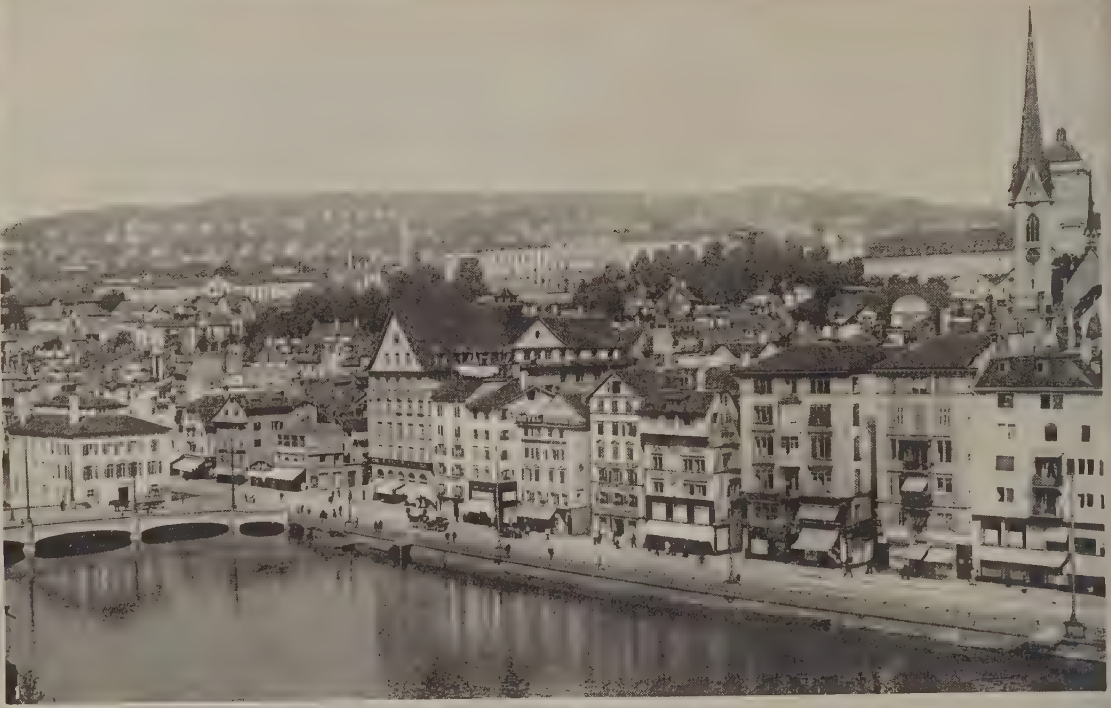


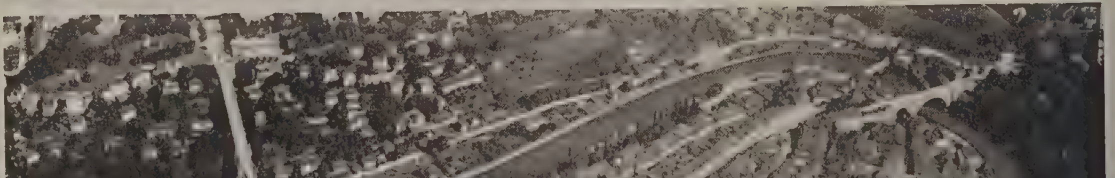


BY COURTESY OF (1, 6) THE SWISS FEDERAL AERODROME, (2, 3, 4, 5) THE SWISS FEDERAL RAILROADS

VIEWS OF SWITZERLAND

1. Aeroplane photograph (altitude 11,145 feet) of the Bernina Mountains and St. Moritz, tourist capital in the Engadine, Switzerland
2. Zermatt, with the snow-capped pyramid of "The Matterhorn"
3. A thrilling Alpine railway up the Bernese Oberland, Switzerland. The summits of Eiger, Monch and Jungfrau stand out against the skyline
4. Goat-herding and associated industries, e.g. cheese making, are important in the Bernese Oberland
5. Haymakers on Baregg above Grindelwald, Bernese Oberland. The microscopic character of these rich mountain pastures or "alps" has resulted in the retention of primitive methods of harvestry
6. Aeroplane photograph (altitude 3,280 feet) of the Rhine Falls, near Schaffhausen, Switzerland





BY COURTESY OF (2) THE SWISS FEDERAL AERODROME; PHOTOGRAPH, (1) COPR. E. M. NEWMAN FROM THE PUBLISHERS PHOTO SERVICE

VIEWS OF SWISS CITIES

1. Limat Quai and part of Zurich. This city is the educational capital of Switzerland; the magnificent university buildings are seen in the background

2. Aeroplane photograph of Berne (altitude 6,560 feet), the capital of Switzerland. The heart of the city is encircled by the River Aar which adds considerably to its beauty but raises difficult transport problems

year intervals from 1850 on (except that a census was taken in 1888 and not in 1890). To the nearest ⅛-million, the several totals were as follows, beginning at 1850 and ending at 1920: 2⅜, 2½, 2⅝, 2⅞, 3, 3⅜, 3¾, 3⅞. There has also been a steady increase in density of population from 150 per sq.m. in 1850 through 207 per sq.m. in 1900, to 243 per sq.m. in 1920. The estimated total population on Dec. 1, 1926, was 3,959,000 (248 per sq.m.). The total increase in the second half of the 19th century was 38%, and in the first quarter of the 20th was 23%.

The least densely populated cantons are the Alpine ones, *e.g.*, Grisons (43 per sq.m.), Uri (58); the Jura cantons are much better populated: Vaud (255), Neuchâtel (421), whilst the densest of all the complete cantons are Geneva (1,583) and Zürich (823). The half-canton of Basle-Stadt (10,050, area 14 sq.m.) is an exception. See *Statisches Jahrbuch der Schweiz*.

The *Non-Swiss element* of the population increased from 3% in 1850 to 11·6% in 1900, but fell to 10·4% in 1920; its total increased from 71,570 to 402,385. The Germans are the most numerous; next in order come Italians, French and Austrians.

The *emigration* of Swiss beyond seas was but 1,691 in 1877, though it rose in 1883 to 13,502 (the maximum as yet attained). In 1899 it had fallen to 2,493, but in the five years ending 1926 (inclusive), it has averaged about 5,400, viz., 5,787, 8,006, 4,140, 4,334, 4,947.

Language.—In the languages habitually spoken, Switzerland presents much variety. By the Federal Constitution of 1874, German, French and Italian are recognized as "national languages" for the purposes of debates in the Federal parliament, and for the public notification of Federal laws and decrees. Romansch and Ladin enjoy no such public recognition. These quaint survivals of a "lingua rustica" of the Roman empire are dialectal differences rather than distinctly different languages. They are chiefly spoken in the canton of Grisons (*q.v.*), Ladin in the Engadine, etc., and Romansch in the Bünder Oberland, etc. The literature of this tongue is scanty and the dialects are partly maintained artificially by societies founded for that purpose. Even in the Grisons where one-third of the people speak the language and approximately one-fifth Italian, German predominates, as it does also in 15 other cantons; in the remaining ones, French prevails in Vaud, Neuchâtel, Geneva, Fribourg, and the Valais, and Italian in Ticino. Detailed census returns as to language have revealed a certain amount of shifting. German was spoken by 71·3% of the population in 1880, by 69·8% in 1900 and by 70·9% in 1920; the figures for French are respectively: 21·4, 22 and 21·2%, and for Italian, 5·7, 6·7, 6·1%, while Romansch (and Ladin—not tabulated apart) fell from 1·4 and 1·2 to 1·1%.

Chief Political Divisions.—The political divisions are the communes (of which there are now about 3,000), district (198), and cantons (22). (See GOVERNMENT.) Of the cantons, 19 are undivided. In 1831 the rural districts of Basle revolted against the undemocratic rule of the urban trade guild; the latter were twice defeated in the field before they agreed (in 1833) to the subdivision of the canton into Basle-Stadt and Basle Land. Unterwalden, from before 1291, was divided into Obwalden and Nidwalden, representing two distinct physical divisions in different river valleys. In 1291, Nidwalden accepted alliance with Uri and Schwyz; Obwalden did not join until later. The Reformation led to a division (1597) of Appenzell into the Inner Rhoden, mainly Roman Catholic and pastoral, and Ausser Rhoden, largely Protestant and industrial.

In 1925, 17 towns had an estimated population exceeding 15,000. The populations of the five largest towns, each exceeding 70,000, are as follows, the figure for 1900 being enclosed within brackets: Zürich 210,720 (150,703), Basle 139,560 (109,161), Geneva 126,000 (104,796), Berne 107,960 (64,227), Lausanne 74,250 (46,732). These towns occupied the same order in 1900, but in 1850 Geneva was the largest town.

The loftiest inhabited village is Juf (*c.* 6,900 ft.) at the head of the Avers valley, near the Septimer pass into the upper Engadine; the lowest settlement is Ascona (666 ft.) on the delta of Val Maggia (Lago Maggiore).

Government.—The administration of the Swiss confederation is quite distinct from that of the 22 constituent cantons, which have individual government as sovereign states, though in several directions they have voluntarily surrendered their rights to the Federal Government. The cantons are built up of two main types of communes, or *gemeinden*. These are the real units.

The *burgher communes* (*communes bourgeoises* or *bürgergemeinden*) are now principally of historical interest, having for the most part been gradually absorbed by the second class of communes. Initially they were groupings of the people to manage the "lands subject to common user" (mainly summer pastures and forests). Later, by purchase or otherwise, the burghers became possessors of manorial rights. But when the Federal diet imposed the care of the poor on the several communes (1551) these naturally aided only their own burgher members. Thus, all non-burgher "settlers," were excluded from any share in the enjoyment of the "common lands," or in their management, though they paid local rates. Increased communication facilities, together with a shifting industrial population, made such restrictions invidious and unfair, particularly after the introduction, under the Helvetic republic (1798–1802) of a Federal citizenship, superior to cantonal citizenship. Later, the increase of communal public duties meant financial obligations exceeding the sums produced by the "common lands." To avoid some of these inconveniences, *political communes* (*municipalités* or *einwohnergemeinden*) were set up. The duties of these communes were largely increased after the liberal movement of 1830; the care of the highways, the police, the schools, the administration of the poor law being successively handed over to them. Swiss citizens belonging to cantons other than those in which they resided were, by the Federal Constitution of 1848, given rights of voting there in cantonal and Federal matters, but not in those relating exclusively to the commune itself, but the Federal Constitution of 1874 gave to permanent Swiss settlers communal voting rights, subject to three months' residence.

In most cantons a number of communes are grouped together to form a district (*amtsbezirke*) under a prefect who represents the cantonal government. Minor communes are controlled by a small council. In the larger communes an executive council is chosen by a general assembly of all male Swiss citizens over 20 years of age, of good conduct and with three months' communal residence. A *maire* (*gemeindepräsident*) is elected by the larger body to preside over the council which has the management of all local affairs, including the carrying out of cantonal and Federal laws or decrees, save and except matters relating to the pastures and forests held in common.

Cantons. (*See* Population.)—Each of the 22 cantons has its own legislature, executive and judiciary. (*See* Justice.) The older cantons have in some instances (Unterwalden, Appenzell and Glarus) preserved their ancient democratic assemblies (*landesgemeinden*), in which all male citizens of full age meet, usually annually during April or May, in the open air for the purpose of legislation and the selection of an annual administrative council. In the remaining cantons the legislature (*grosser Rat* or *grand conseil*) is composed of representatives chosen by universal male suffrage and usually by proportional representation. These councils exercise all the functions of the *landesgemeinden*. The executive also in most of the newer cantons is elected by a popular vote and not as hitherto by the cantonal legislature. All the cantons have the *referendum* and the *popular initiative*, the application of which varies in the different cantons.

Confederation.—On the cessation of the Federal Pact in 1848 a new constitution was accepted by general consent. This is fundamentally the constitution in operation to-day, but sundry revisions were made in 1874, and the 1874 amended constitution is the one now in force. Any subsequent revision can be made by normal Federal legislation with a compulsory *referendum*, on the demand of 50,000 franchised citizens, or by *popular initiative*. Changes require a favourable majority in total votes and total number of cantons. Federal sovereignty is exercised by the legislative Federal assembly (*Bundesversammlung*) and by the executive Federal council (*Bundesrat*), both meeting at Berne. The assembly consists of two chambers—the National Council (*Nationalrat*) and the Council of the States (*Ständerat*). The National Council are chosen in direct election by the enfranchised males; the franchise has not yet been extended to females. The basis of representation is one deputy for each 20,000 total population of the canton, with an additional deputy for any remainder exceeding 10,000. On the 1920 census returns there are thus 198 representatives varying from 34 for Berne and 27 for Zürich to 1 for Uri; 13 of the 22 cantons have less than eight representatives each. The deputies receive attendance pay and travelling expenses from Federal funds; neither allowance is lavish. The States Council consists of two members from each canton and one from each half-canton, or 44 in all. The mode of their election, term of membership and rate of pay are entirely cantonal matters and vary accordingly. The average financial allowance is less than for a deputy to the National Council. A general election of representatives takes place every three years, suffrage is universal, voters becoming enfranchised at 20 years of age, and any voter, other than a clergyman, may be elected a deputy. Laws passed by the Federal Assembly, though this represents both people and canton, can be vetoed as a result of a majority-supported referendum based on a *popular initiative* demand of 30,000 enfranchised citizens.

The seven members of the Federal Council are elected for three years by the Federal Assembly. The following departments are represented: Foreign Affairs, Justice, Interior, Military, Finance, Public Economics, Railways and Post Office. The president of the Confederation holds the foreign portfolio. Both the president of the Confederation and the vice-president of the Federal Council are elected for one year only (Jan. 1–Dec. 31) by the Federal Assembly, and cannot be immediately re-elected. Federal councillors cannot hold a plurality of office, either federal or cantonal, and must not engage in any calling or office. The salary for each councillor is £1,000 per annum, except in the case of the president, who receives an extra allowance of £80 per annum. The Federal Government (Assembly and Council) is supreme in matters of peace, war and treaties. It regulates the army, railways, posts, mint, national banknote issues, weights and measures of the republic, and is being increasingly entrusted with matters formerly considered to be purely cantonal.

Religion.—The Federal Constitution of 1874, while recognizing no established Swiss Church, guarantees full religious liberty and freedom of worship, as well as exemption from any *compulsory* church rates. It repeats the Constitution of 1848 in forbidding the settlement of Jesuits and all affiliated religious orders in Switzerland, and extends this prohibition to any other orders that may endanger the safety of the State, or interfere with the peace of other creeds.

The Protestants formed 59·3% of the total population in 1850, 57·8% in 1900 and 57·5% in 1920; the Roman Catholics, 40·6%, 41·6% and 40·9% in these respective years, while the Jews increased from 0·1% to 0·4% and to 0·5% in 1920—the remainder (other religions or none) showed a considerable increase in the 20th century. Twelve cantons in 1920 had a majority of Protestants and ten of Catholics.

Of the more populous cantons, Zürich, Bern, Vaud, Neuchâtel and Basle are mainly Protestant, while Lucerne, Fribourg, Ticino, Valais and the Forest cantons are principally Catholic. Although a Federal Swiss Church is not recognized, any canton may establish one or more Churches (*Landeskirchen*). Practices differ considerably in the several cantons; some have one creed solely established, others have two jointly; Neuchâtel has three established churches (Protestants, Roman Catholics and Christian Catholics), and Geneva, in 1907, disestablished both of her existing Churches. The Roman Catholic priests are much more numerous than the Protestant clergy, and comprise more than 6,000 regular and secular priests under five diocesan bishops—Sion (founded in the 4th century), Geneva and Lausanne (4th and 6th century), Basle (4th century, but reorganized in 1828), Coire (5th century), and St. Gall (a separate see since 1847). There are besides the sees of Lugano (created in 1888 for Italian Switzerland—but now united to the see of Basle), and Bethlehem (a see *in partibus*, annexed in 1840 to the abbacy of St. Maurice in the Valais). The Christian Catholics are a sect split off from the Romanists in 1874 on the question of papal infallibility, and since 1876 have had a bishop of their own who resides in Bern. They are strongest in Bern, Soleure and Geneva. A few monasteries in Switzerland escaped suppression. The principal are the Benedictine houses of Disentis (founded in the 7th century), rebuilt in 1846 and now used as schools; Einsiedeln (10th century), now a great pilgrimage centre: 180,000 yearly; and Engelberg (12th century) now famed also for its cheeses. There are also Augustinian houses at St. Maurice (founded in the 4th century—held by Augustinians since 1128) and on the Great St. Bernard (11th century). The government of the Protestant Church is Calvinistic.

Justice.—Each canton elects, controls and pays (often merely a nominal sum, even if the posts are not entirely honorary) its own magistracy for ordinary civil and criminal trials. There are cantonal variations in the penal code, *e.g.*, capital punishment exists only in nine cantons and one half-canton.

The *Federal Supreme Court* (*Bundesgericht*) sits at Lausanne. There are 24 full members (plus nine supplementary judges), elected by the Federal Assembly to hold office for six years with eligibility for re-election. The Federal Assembly also elects every two years the president and vice-president who, as such, cannot be re-elected. The original and final jurisdiction of the *Bundesgericht* extends to disputes between the confederation, the cantons, corporations, and private individuals, so far as these differences refer to Federal matters, and involve more than 3,000 fr. in dispute, in financial suits. It is a court of appeal against cantonal authorities in the application of Federal laws, and also against decisions of other Federal departments. It is a court of trial for persons accused of treason, or other offences against the confederation. The four courts of the *Bundesgericht* are: Court of Accusation, Criminal Court (with paid jurors elected by the people), Federal Penal Court, Court of Cassation.

Federal Finances, Post Office, Bank.—Before 1848 there was no strong Federal authority, and Federal finances were almost unknown. The subsequent increase in power of the confederation is shown by the annual balance sheet. In 1849 the receipts were nearly £240,000, as against an expenditure of £260,000. By 1873 the amount on each side exceeded 1¼ million pounds; in 1883, two million pounds; in 1900, four millions. In 1928 revenue was estimated at £12,889,200 and expenditure at £13,260,000. An "adverse" figure has been a feature of recent budgets. The floating debt (Jan. 1, 1926) was slightly in excess of £4,000,000.

By the Federal Constitution of 1848 the *post office* was made a Federal responsibility, and a Federal law of 1851 extended this to the electric telegraph. In the 1874 constitution, both branches remained within the jurisdiction of the confederation, while in 1878, this control extended to the telephone service.

In 1891 the principle of a *State bank* with a monopoly of note issue was accepted. A first scheme was rejected by a popular vote in 1897, but a second was successful in 1905. The "Swiss National Bank" was opened on June 20, 1907, with its headquarters divided between Zürich and Berne. On March 7, 1928, it had, as main items, nearly 796 million fr. in circulation as notes as against 432½ million fr. in bullion (gold and silver), and over 315 million fr. in bills; the lowest denomination for a national banknote is five francs. The current and deposit accounts amounted to nearly 92 million francs. Since April 1, 1927, gold currencies of other countries of the former Latin Monetary Union (dissolved in 1926) have ceased to be legal tender in Switzerland. (W. A. B. C.; W. E. Wh.)

DEFENCE

Historical.—The inhabitants of Switzerland were always a hardy and independent race, but their high military reputation dates from the middle of the 15th century, when the comparatively ill-armed and untrained mountaineers signally defeated Charles the Bold of Burgundy and the flower of the chivalry of Europe in the battles of Granson, Morat and Nancy (*q.v.; see* also Swiss

WARS). The wealthier countries vied with each other in hiring them as mercenaries, and the poor but warlike Swiss found the profession of arms a lucrative one. (*See* ARMY.)

Their fall was due in the end to their own indiscipline in the first place, and the rise of the Spanish standing army and its musketeers in the second.

Present-day Army.—Being composed of militia, the Swiss Army contains no forces maintained permanently with the colours with the exception of a corps of instructors, a system which has been followed in some of the self-governing nations of the British Empire and in several of the smaller European nations.

Recruitment and Service.—All male citizens are liable to military service from the year in which their 20th birthday falls until the year of their 48th birthday. Service may either be rendered personally, or by the payment of a military tax. Volunteering before the legal age is permitted. The military tax is payable up to the age of 40. Enlistment takes place in the year of the 19th birthday. Personal service includes attendance for training, active service at home or abroad in defence of the country, and maintenance of public order and security. Men passed fit for auxiliary service pay a tax in lieu of military training for the years in which it would otherwise be performed. After physical training for boys, provided by the cantons under the supervision of the Federal Government, the training is carried out under the military department. After a recruit course of 65 days for infantry and engineers, 90 days for cavalry, 75 days for artillery, air force and fortress troops, and 60 days for departmental troops, members of the active army undergo annual training for 11 to 14 days for 10 years for sergeants and above and for 7 to 8 years below that rank. Men in the landwehr do 11 days training every 4 years, but corporals and privates are only called up for one repetition training. There are also compulsory musketry courses, performed in rifle clubs. Officers are trained in cadet schools for 45 to 80 days according to arm of the service. There are special courses up to the rank of captain, lasting for 30 to 50 days, and, after attaining that rank three courses lasting 60, 42, and 21 days respectively for training general staff officers.

Strength and Organization.—The budget effectives (1927) provide a permanent training staff of 267. The training cadres number 7,578 employed on an average of 32 days in a year; 24,780 recruits undergo courses varying from 62 to 92 days, and 126,059 undergo 13 to 16 days refresher courses. There must also be taken into account the preliminary training:—24,000 men undergoing physical training, 8,000 training with arms, 13,000 undergoing junior musketry training, and 3,000 in the cadet corps. About 240,000 do compulsory and 160,000 optional training in the rifle clubs. Account must also be taken of the military police, which is under the commander-in-chief of the army and free from cantonal laws when acting with the troops.

The army, which consists of a first line (*élite*) for ages from 20 to 32 inclusive, landwehr for ages from 33 to 40 inclusive, and landsturm for ages from 41 to 48 inclusive, has since July 1925 been organized in 6 divisions and army troops. The 1st, 3rd, 5th and 6th divisions each contain one mountain brigade. The 2nd and 4th divisions contain no mountain troops. The composition of a division calls for no special comment except for the presence therein of cyclist companies, machine-gun companies and 4 motor transport columns. A mountain brigade contains 6 battalions of first-line mountain infantry, and 3 of landwehr mountain infantry, 2 mountain batteries, 1 company of mountain engineers and the usual auxiliary services, all equipped for mountain warfare. The mobile artillery in the army troops is tractor-drawn.

Higher Command.—The Federal Council is the supreme head. One of the federal councillors is head of the military department, the central authority in peace time for dealing with military questions. If a levy of troops is ordered on a large scale the federal assembly appoints a commander-in-chief of the army. There is a general staff under the military department and a national defence committee, with the head of the military department as chairman and the chief of the general staff, 3 army corps commanders and the officer commanding infantry as members. The committee ceases to function when a commander-in-chief is appointed. Switzerland is divided territorially into 8 military areas with headquarters at I. Lausanne, II. Bienne, III. Berne, IV. Aarau, V. Zürich, VI. Bellinzona, VII. Altdorf, VIII. Coire, for organizing the territorial services in time of war. The territory is also divided into 6 divisional military districts with headquarters at I. Morges, II. Fribourg, III. Berne, IV. Aarau, V. Zürich, and VI. St. Gallen. Under the above-mentioned 3 Army-Corps Commands the troops in the divisional areas are grouped as follows:—First Corps, the 1st and 2nd divisions, St. Maurice garrison and army troops; second corps, the 3rd and 4th divisions and army troops; third corps, the 5th and 6th divisions, St. Gothard garrison and army troops. There is a Central Military School, officer schools and courses for the different arms and for non-commissioned officers. There are permanent works at St. Maurice and St. Gothard. The annual budget shows an expenditure of about 2,000,000 francs on forts and fortifications.

Military Air Force.—There is a military air service under the general staff. Its commander is called chief of the military air service. The provisional organization of the air service is in 3 "flying groups" composed, in detail, of 10 "flights" forming 15 companies, pilots corps, corps of observers, 3 photographic sections and 1 air park company. The number of companies in a "flight" is not definitely prescribed. The companies of various types number 40 in all (30 first-line, 5 mixed and 5 *landwehr*). Pilot officers, after at least 24 months continuous training, become "monthly pilots" and do 100 hours flying per annum, usually spread over 10 months. Reserve pilots do 50 hours, spread over 5 months. Similar conditions apply to observers. Officers from the other areas can be seconded both to the pilot corps and to the observers corps. The budget effectives for 1927 show 11 on the air training staff, 169 in the training cadres in addition to 246 engaged monthly, 400 in the recruits training course (77 days) and 1,550 in the refresher training courses doing 15 day courses. Taken in all, about 70,000 parade-days were performed in the cadre, recruits and refresher training courses.

See also League of Nations *Armaments Year-Book* (Geneva, 1928).
(G. G. A.)

ECONOMICS AND TRADE

According to the last Swiss (1920) census, of the total population of 3,880,320 inhabitants, 26·6% were sustained by agriculture, 41·1% by manufactures and mechanical pursuits, 9·9% by trade, 6·7% by transportation, 6·2% by the professions, 3·3% by personal and domestic service and the rest, 6·4%, by incomes drawn from other sources. Although it is not possible from these or from any other available figures to ascertain exactly what proportion of the population of Switzerland drew its livelihood directly and indirectly from the tourist traffic, it is quite obvious that it was very far from being the majority. According to an estimate made in 1912 by the Association of Swiss Hotel Keepers, about 43,000 persons were then occupied in hotels patronized mostly by foreign tourists. As the tourist traffic has not yet completely recovered from the serious depression it underwent during the war and during the post-war crisis, that figure should still be approximately correct. Now, according to the census of 1920, besides nearly 500,000 persons actively engaged in agriculture, over 807,000 were engaged in manufacturing pursuits—224,000 in mechanical trades, 68,000 in watch making, 48,000 in other metal trades and 143,000 in textile factories.

Manufactures.—As a matter of fact, Switzerland is one of the most highly industrialized States of Europe. Only Great Britain and Belgium have a relatively greater industrial population.

The table on p. 680, indicating the number of persons occupied in 1910 and 1920, the annual export values for 1913 and 1927 and the triennial average export values for 1911–13 and 1925–7 may give some idea of the size and of the development of the most important Swiss manufactures.

The figures relating to persons employed are taken from the decennial census returns and those relating to exports from the annual trade statistics. Although they do not refer to the same period, nor even to exactly the same manufactures, they may

Principal Exporting Industries

Industry	Number of persons employed (000's omitted)		Value of annual exports (000,000's of Swiss francs omitted)							
	1910	1920	1911	1912	1913	Av. 1911 1913	1925	1926	1927	Av. 1925 1927
Watch making	53	63	164	174	183	174	302	258	273	278
Silk weaving	24	20	104	111	107	107	209	187	202	199
Machine making	52	80	83	91	98	91	183	164	180	176
Chemical	6	13	50	55	58	54	111	119	137	122
Cotton embroidering	72	43	207	212	203	207	130	114	110	118
Cotton weaving	19	19	36	38	37	37	123	96	107	109
Cotton spinning	13	13	17	17	17	17	71	46	58	58
Aluminium	1·1	2·4	7	14	13	11	52	55	54	54
Condensed milk	1·6	2·2	39	47	44	43	41	41	44	42
Boot and shoe	24	26	11	14	19	14	34	36	38	36
Artificial silk	0·7	1·8	4	5	5	5	30	34	36	33
Chocolate	6	8·7	47	55	58	53	35	30	33	33

suffice to illustrate several of the main characteristics of industrial Switzerland. Of these characteristics the following two may be especially noted.

In the first place, it is extremely striking that none of the principal Swiss manufactured exports except condensed milk, and, to some extent, boots and shoes are drawn from Swiss raw materials, nor, with the exception of aluminium, are any of them produced mainly with the aid of hydraulic power, the only natural source of energy to be found in the country. Switzerland possesses no mineral resources worth mentioning and her soil is singularly poor in industrial products. As her manufactures are, besides, deprived of the advantage of an important home market and of direct and cheap access to the sea, their remarkable development can be explained only by the individual enterprise and ability of her population, the stability of her external and internal political position and the abundance and consequent cheapness of her capital resources.

The second point illustrated by the above figures is the very unequal development of the various national industries in the course of the last 15 years. If we allow for the depreciation of the monetary standard which, although based on gold both before the war and to-day, has lost about ⅓ of its pre-war value, we will note that the watch making, condensed milk and chocolate industries have lost some ground since 1913 and that the embroidery trade, a victim of feminine caprice, has been seriously crippled. The same is true, and for the same reasons, of the formerly very prosperous silk ribbon industry. The other main exporting manufactures of Switzerland have prospered in spite of unfavourable economic conditions.

Agriculture.—The mountainous character of the larger part of Switzerland, the high average altitude, the over-abundance of rain and the prevailing system of small holdings all combine to prevent Switzerland from being a preponderantly agricultural country.

For the last 70 years at least, the rural population has been steadily decreasing in relative importance. The war and the agrarian protectionist tendencies which have asserted themselves since, have, it is true, prevented its absolute decline in the course of the last years. In spite of these retarding factors, however, its relative decline persists as the following figures show:

Agricultural population. Number of persons engaged in agricultural pursuits (000's omitted)			Percentage of total professional population		
1900	1910	1920	1900	1910	1920
			%	%	%
473	469	474	32·2	27·5	26·6

For over a century, Switzerland has been becoming increasingly dependent upon imports for her food supply, especially for her bread stuffs. This has led to increased agrarian protection, the results of which are shown in the following table:

Imports of Cereal Foodstuffs and of Cattle for Slaughter

	1911	1912	1913	Average 1911–13	1925	1926	1927	Average 1925–27
Wheat*	4393	4856	5292	4847	4084	4384	4526	4331
Other cereals*	3538	3573	3639	3583	3770	3475	4071	3772
Flour, etc.*	820	790	714	772	120	87	71	93
Cattle for slaughter†	84	97	83	88	42	27	16	28

*In thousands of metric quintals. †In thousands of heads.

As Switzerland does not export any appreciable quantity of cereal foodstuffs, these figures show that she remains to-day, as she was before the war, essentially dependent upon foreign grain for the sustenance of her population. But they also show that she has not become increasingly so. Under the State import monopoly, under which a super-price is paid to domestic producers out of the gross profits made by the sale of wheat, the price of bread has been affected. Under the system which is to be substituted for the import monopoly in 1929, this super-price will be paid out of the proceeds of a general, so-called statistical fee levied on all imports.

In the limitation of imports of cattle for slaughter, instead of a State monopoly, a policy has been adopted which, both by increased customs duties on cattle and meat and especially by the quantitative rationing of imports according to prices, domestic cattle raising and fattening have been artificially encouraged.

International Trade.—In spite of these tendencies, the international trade of Switzerland, although adversely affected by the war, has since almost regained its pre-war importance. The following table shows the general trend of its recent evolution:

	1911	1912	1913	Av. 1911 1913	1925	1926	1927	Av. 1925 1927
Total trade	3060	3337	3296	3231	4672	4251	4587	4503
Imports	1802	1979	1920	1900	2633	2415	2564	2537
Exports	1257	1358	1376	1330	2039	1836	2023	1966
Excess of imports	545	622	543	570	594	579	541	571
% of excess	30·24	31·4	28·3	28·98	22·6	24·0	21·9	22·8
Imports	%	%	%	%	%	%	%	%
Foodstuffs	32·46	31·77	31·22	31·82	27·72	28·14	27·13	27·66
Raw materials	34·91	35·24	35·71	35·29	38·37	34·78	34·86	36·00
Manufact. goods	32·63	32·99	33·07	32·9	33·91	37·08	38·01	36·33
From:								
Europe	1552	1704	1599	1612	1965	1800	1885	1883
%	86·2	86·1	83·3	85·2	74·6	74·5	73·6	74·2
America	156	175	215	182	452	417	449	439
%	8·6	8·8	11·2	9·5	17·2	17·4	17·5	17·4
Germany	581	647	631	620	471	465	542	493
France	340	376	348	355	499	496	475	490
Italy	181	193	207	194	266	251	226	248
United States	75	84	118	92	227	188	220	213
Great Britain	100	117	112	110	278	148	189	205
Exports	%	%	%	%	%	%	%	%
Foodstuffs	13·85	14·59	14·61	14·35	9·53	10·43	10·90	10·29
Raw materials	10·70	11·00	11·10	10·93	7·88	9·16	9·45	8·83
Manufact. goods	75·45	74·41	74·29	74·72	82·59	80·41	79·65	80·88
To:								
Europe	938	1017	1027	994	1450	1204	1408	1354
%	74·6	74·9	74·6	74·7	71·1	65·5	69·6	68·7
America	234	245	246	242	345	417	355	372
%	18·8	18·0	17·9	18·2	16·9	22·7	17·5	19·0
Germany	275	307	306	296	368	267	398	331
France	133	138	141	137	173	154	135	154
Italy	85	91	89	88	104	113	115	111
United States	142	136	136	138	227	188	210	208
Great Britain	213	230	236	226	420	299	309	343

All figures in this table, except percentages, refer to millions of Swiss francs.

Since the pre-war period, the total foreign trade of Switzerland has appreciably increased in total monetary value, but the ratio of this nominal increase is slightly less than that of the concomitant depreciation of the franc. In other words, the total trade has not yet in real value, that is in the volume of goods exchanged, completely recovered from the crisis of the war. This is illustrated also by the following figures roughly showing, in thousands of metric tons, the relative importance of Swiss imports and exports in 1913 and 1927.

Volume of Trade

	Imports		Exports	
	1913	1927	1913	1927
Raw materials	57	51	4,8	4,7
Manufactured products	5,6	5,7	2,3	2,2
Foodstuffs	15	13	1,4	1,4
Total	77,6	69,7	8,5	8,3

It will be noticed further that in real values as in volume, exports have diminished less than imports, thus rendering the Swiss balance of trade a little less unfavourable—to use this convenient but fallacious expression—than it was before the war. It should not be assumed, however, that this change in the balance of trade, indicated by the relative excess of import over export values in the two periods considered, has necessarily modified the balance of payments. Compared with the years before the war, the amount of interest derived from foreign investments has doubtless decreased, whereas the sums annually invested abroad have probably never been greater than in the course of the last few years. The abundance and cheapness of money in Switzerland has led to a great and continuous exportation of capital, mainly to neighbouring countries. This process, which has placed Basle, Geneva and especially Zürich in the first rank of continental money markets, is one of the most striking economic phenomena of recent times. Although of course still preponderant, Europe's position in the foreign trade of Switzerland has been weakened in favour of America. This is particularly so as regards the imports to Switzerland, more than 85% of which came from Europe before the war, whereas to-day the proportion is less than 75% and seems to be diminishing from year to year.

Great Britain was always one of Switzerland's best customers before the war. She usually occupied the second position, immediately after Germany. Since the war, and until 1926, she had moved up to the first place. In 1927, however, Germany had again bought more Swiss goods than Great Britain.

The birth and death rates are continuously falling and in 1928 reached one of the lowest levels in Europe. The urban and industrial population are increasing more rapidly than the rural and agricultural, so that Switzerland is becoming ever more highly industrialized. (W. E. R.)

HISTORY

The Swiss Confederation is made up of 22 small States, differing from each other in nearly every point—religious, political, social, industrial, physical and linguistic; yet it forms a nation the patriotism of whose members is universally acknowledged. History alone can supply us with the key to this puzzle; but Swiss history is very intricate and very local. A firm hold on a few guiding principles is therefore most desirable, and of these there are three which we must always bear in mind. (1) The first is *the connection of Swiss history with that of the Empire.* Swiss history is largely the history of the drawing together of bits of each of the imperial kingdoms (Germany, Italy and Burgundy) for common defence against a common foe—the Habsburgs; and, when this family have secured to themselves the permanent possession of the empire, the Swiss League little by little wins its independence of the empire, practically in 1499, formally in 1648. (2) The second is *the German origin and nature of the Confederation.* Round a German nucleus (the three Forest districts) there gradually gather other German districts; and it is not till 1803 and 1815 that its French- and Italian-speaking "subjects" are raised to political equality with their former masters. (3) Swiss history is *a study in federalism.* Based on the defensive alliances of 1291 and 1315 between the three Forest districts, the Confederation is enlarged by the admission of other districts and towns, all leagued with the original three members, but not necessarily with each other. Hence great difficulties are encountered in looking after common interests; the Diet was merely an assembly of ambassadors with powers very strictly limited by their instructions, and there was no central executive authority. The whole constitutional history of the Confederation is summed up in its transition to a federal State, which, while a single State in its foreign relations, in home matters maintains the more or less absolute independence of its members.

Early History of the Three Lands.—On Aug. 1, 1291, the men of the valley of Uri, the free community of the valley of Schwyz, and the association of the men of the lower valley or Nidwalden—Obwalden or the upper valley is not mentioned in the text, though it is named on the seal appended—formed an Everlasting League for the purpose of self-defence against all who should attack or trouble them, a league which is expressly stated to be a confirmation of a former one. This league was the foundation of the Swiss Confederation.

The legal and political conditions of each district were very different. (*a*) In 853 Louis the German granted all his lands in the *pagellus Uraniae* to the convent of Sts. Felix and Regula in Zürich (the present Fraumünster), and exempted them from all jurisdiction save that of the king (*Reichsfreiheit*), so that though locally within the Zürichgau they were not subject to its count, the king's deputy. The abbey thus became possessed of the greater part of the valley of the Reuss between the present Devil's Bridge and the Lake of Lucerne, for the upper valley (Urseren) belonged at that time to the abbey of Disentis in the Rhine valley, and did not become permanently allied with Uri till 1410. The privileged position of the abbey tenants gradually led the other men of the valley to "commend" themselves to the abbey. The important post of "protector" (*advocatus* or *vogt*) of the abbey was given to one family after another by the emperor; but when, in 1218, the office was granted to the Habsburgs, the protests of the abbey tenants led to its withdrawal in 1231, the valley thenceforward depending immediately on the king. (*b*) In Schwyz (first mentioned in 972) we must distinguish between the districts west and east of Steinen. In the former the land was in the hands of many nobles, amongst whom were the Habsburgs; in the latter there was, at the foot of the Mythen, a self-governing community of free men; both, however, were politically subject to the king's delegates, the counts of the Zürichgau, who after 1173 were the ever-advancing Habsburgs. But in 1240 the free community of Schwyz obtained from the emperor Frederick II. a charter which removed them from the jurisdiction of the counts, placing them in immediate dependence on the king, like the abbey men of Uri. In a few years, however, the Habsburgs contrived to dispense with this charter in practice. (*c*) In Unterwalden things were very different. The upper valley (Obwalden or Sarnen), like the lower (Nidwalden or Stans), formed part of the Zürichgau, while in both the soil was owned by many ecclesiastical and lay lords, among them being the Habsburgs and the Alsatian abbey of Murbach. Hence in this district there were privileged tenants, but no free community, and no centre of unity, and this explains why Obwalden and Nidwalden won their way upwards so much more slowly than their neighbours in Uri and Schwyz.

The League of 1291.—The Habsburgs had been steadily rising for many years from the position of an unimportant family in the Aargau to that of a powerful clan of large landed proprietors in Swabia and Alsace, and had attained a certain political importance as counts of the Zürichgau and Aargau. In one or both qualities the cadet or Laufenburg line, to which the family estates in the Forest districts round the Lake of Lucerne had fallen on the division of the inheritance in 1232, seem to have exercised their legal rights in a harsh manner. In 1240 the free men of Schwyz obtained protection from the emperor. It was natural that when, after the excommunication and deposition of Frederick II. by Innocent IV. in 1245, the head of the cadet line of Habsburg sided with the pope, some of the men of the Forest districts should rally round the emperor. Schwyz joined Sarnen and Lucerne (though Uri and Obwalden supported the pope); and in 1247 the men of Schwyz, Sarnen and Lucerne were threatened by the pope with excommunication if they persisted in upholding the emperor and defying their hereditary lords the counts of Habsburg. The rapid decline of Frederick's cause soon enabled the Habsburgs to regain their authority in these districts. These incidents are the only foundation in fact of the legendary stories of Habsburg oppression told of and by a later age. After this temporary check the power of the Habsburgs continued to increase rapidly. In 1273 the head of the cadet line sold all his lands and rights in the Forest districts to the head of the elder or Alsatian line, Rudolph, who a few months later was elected emperor. He recognized the privileges of Uri but not those of Schwyz; and, as he now united in his own person the characters of emperor, count of the Zürichgau, and landowner in the Forest districts, such a union of offices might be expected to result in a confusion of rights. On April 16, 1291, Rudolph bought from the abbey of Murbach in Alsace (of which he was "advocate") all its rights over the town of Lucerne and the abbey estates in Unterwalden. It thus seemed probable that the other Forest districts would be shut off from their natural means of communication with the outer world by way of the lake. Rudolph's death, on July 15 of the same year, cleared the way, and a fortnight later (Aug. 1) the Everlasting League was made between the men of Uri, Schwyz and Nidwalden for the purpose of self-defence against a common foe.

Morgarten and the League of 1315.—In the struggle for the empire, which extended over the years following the conclusion of the League of 1291, we find that the Confederates supported without exception the anti-Habsburg candidate. On Oct. 16, 1291 Uri and Schwyz allied themselves with Zürich, and joined the general rising in Swabia against Albert, the new head of the house of Habsburg. It soon failed, but hopes revived when in 1292 Adolf of Nassau was chosen emperor. In 1297 he confirmed to the free men of Schwyz their charter of 1240, and, strangely enough, confirmed the same charter to Uri, instead of their own of 1231. It is in his reign that we have the first recorded meeting of the *Landsgemeinde* (or legislative assembly) of Schwyz (1294). But in 1298 Albert of Habsburg himself was elected to the empire. His rule was strict and severe, though not oppressive. He did not indeed confirm the charters of Uri or of Schwyz, but he did not attack the ancient rights of the former, and in the latter he exercised his rights as a landowner and did not abuse his political rights as emperor or as count. In Unterwalden we find that in 1304 the two valleys were joined together under a common administrator (the local deputy of the count)—a great step forward to permanent union. The stories of Albert's tyranny in the Forest districts are not heard of till two centuries later. His successor, Henry of Luxemburg, confirmed, on June 3, 1309, to Uri and Schwyz their charters of 1297, and, for some unknown reason, confirmed to Unterwalden all the liberties granted by his predecessor, though as a matter of fact none had been granted. This charter, and the nomination of one royal bailiff to administer the three districts, had the effect of placing them all in an identical political position, and that the most privileged yet given to any of them—the freedom of the free community of Schwyz. A few days later the Confederates made a fresh treaty of alliance with Zürich; and in 1310 the emperor placed certain other inhabitants of Schwyz on the same privileged footing as the free community. Although Henry granted the request of the Habsburgs for an inquiry into their precise rights in Alsace and in the Forest districts, no steps were taken to carry out this investigation.

On Henry's death in 1313 the men of Schwyz seized the opportunity for making a wanton attack on the great abbey of Einsiedeln, with which they had a long-standing quarrel as to rights of pasture. The abbot caused them to be excommunicated and Frederick of Habsburg (the choice of the minority of the electors), who was the hereditary "advocate" of the abbey, placed them under the ban of the empire. His rival, Louis of Bavaria, to whom they appealed, removed the ban; on which Frederick issued a decree by which he restored to his family all their rights and possessions in *the three valleys* and Urseren, and charged his brother Leopold with the execution of this order. The Confederates hastily concluded alliances with Glarus, Urseren, Arth and Interlaken to protect themselves from attack on every side. Leopold collected a brilliant army at the Austrian town of Zug in order to attack Schwyz, while a body of troops was to take Unterwalden in the rear by way of the Brünig Pass. On Nov. 15, 1315, Leopold moved forward along the shore of the Lake of Aegeri, intending to assail the town of Schwyz by climbing the slopes of Morgarten above the south-eastern end of the lake. There they were awaited by the valiant band of the Confederates who utterly defeated them. Leopold fled in hot haste to Winterthur, and the attack by the Brünig was driven back by the men of Unterwalden. On Dec. 9, 1315 representatives of the victorious highlanders met at Brunnen, on the Lake of Lucerne and renewed the Everlasting League of 1291. In their main lines the two documents are very similar, the later being chiefly an expansion of the earlier. That of 1315 is in German (in contrast to the 1291 League, which is in Latin), and has one or two striking clauses largely indebted to a decree issued by Zürich on July 24, 1291. None of the three districts or their dependents is to recognize a new lord without the consent and counsel of the rest. Strict obedience in all lawful matters is to be rendered to the rightful lord in each case, unless he attacks or wrongs any of the Confederates, in which case they are to be free from all obligations. No negotiations, so long as the "Länder" have no lord, are to be entered on with outside powers, save by common agreement of all. Louis solemnly recognized and confirmed the new league in 1316, and in 1318 a truce was concluded between the Confederates and the Habsburgs, who treat with them on equal terms. The lands and rights annexed belonging to the Habsburgs in the Forest districts are fully recognized as they existed in the days of Henry of Luxemburg, and freedom of commerce is granted. But there is not one word about the *political* rights of the Habsburgs as counts of the Zürichgau and Aargau.

The League of Eight Members.—As early as 1320 we find the name "Switzerland" (*Sweicz*) (derived from Schwyz, which had always been the leader in the struggle) applied to the three Forest cantons, and in 1352 extended to the Confederation as a whole. But it was not till after Sempach (1386) that it came into popular use, and it did not form the official name of the Confederation till 1803. This is in itself a proof of the great renown which the League won by its victory at Morgarten. Another is that as years go by we find other members admitted to the privileges of the original alliance of the three Forest districts. First to join the League (1332) was the neighbouring town of Lucerne, which had grown up round the monastery of St. Leodegar or Leger (whence the place took its name), a cell of the great house of Murbach in Alsace, and had been sold to the Habsburgs in 1291. Its accession brought a new element into the pastoral association of the Forest districts, which now surrounded the entire Lake of Lucerne. Next, in 1351, came the ancient town of Zürich, through a civic revolution, in which the leader of the democratic party allied the town with the League. In this way the League now advanced from the hilly country to the plains, though the terms of the treaty with Zürich did not bind it so closely to the Confederates as in the other cases, and hence rendered it possible for Zürich now and again to incline towards Austria in a fashion which did great hurt to its allies. In 1352 the League was enlarged by the admission of Glarus and Zug. Glarus belonged to the monastery of Säckingen on the Rhine, of which the Habsburgs were "advocates," claiming therefore many rights over the valley, which refused to admit them, and joyfully received the Confederates who came to its aid; but it was placed on a lower footing than the other members of the League, being bound to obey their orders. Three weeks later the town and district of Zug, attacked by the League and abandoned by their Habsburg masters, joined the Confederation, forming a transition link between its civic and rural members. The immediate occasion of the union of these two districts was the war begun by the Austrian duke against Zürich, which was ended by the peace of 1352, by which Glarus and Zug were to be restored to the Habsburgs, who also regained their rights over Lucerne. Zug was won for good by a bold stroke of the men of Schwyz in 1364, but it was not till the day of Näfels (1388) that Glarus recovered its lost freedom. These temporary losses were, however, far outweighed by the entrance into the League in 1353 of the famous town of Berne, founded in 1191 by Berthold V. of Zäringen, which had become a free imperial city in 1218 on the extinction of the Zäringen dynasty, and made a treaty with the Forest districts as early as 1323. In 1352 she had been forced to take part in the war against Zürich, but soon after the conclusion of peace entered the League as the ally of the three Forest districts, being thus only indirectly joined to Lucerne and Zürich. The special importance of the accession of Bern was that the League now began to spread to the west, and was thus brought into connection for the first time with the French-speaking land of Savoy. The League thus numbered eight members, the fruits of Morgarten, and no further members were admitted till 1481, after the Burgundian War. But, in order thoroughly to understand the nature of the League, it must be remembered that, while each of the five new members was allied with the original nucleus—the three Forest districts—these five were not directly allied to one another.

Sempach.—After a short interval of peace the quarrels with Austria broke out afresh. Lucerne fretted much under the Austrian rule, received many Austrian subjects among her citizens, and refused to pay custom duties to the Austrian bailiff at Rothenburg, on the ground that she had the right of free traffic. An attack on the custom-house at Rothenburg, and the gift of the privileges of burghership to the discontented inhabitants of the little town of Sempach a short way off, so irritated Leopold III. (who then held all the possessions of his house outside Austria) that he collected an army, with the intention of crushing his rebellious town. Lucerne meanwhile had summoned the other members of the League to her aid, and, approximately 1,600 men of Uri, Schwyz, Unterwalden and Lucerne opposed the 6,000 which made up the Austrian army. The decisive fight took place on July 9, 1386, near Sempach. Leopold, with a large number of his followers, was slain, and the Habsburg power within the borders of the Confederation finally broken. Glarus at once rose in arms, but it was not till the expiration of the truce made after Sempach that Leopold's brother, Albert of Austria, brought an army against Glarus, and was defeated at Näfels (not far from Glarus) on April 9, 1388, by a handful of Glarus and Schwyz men.

In 1389 a peace for seven years was made, the Confederates being secured in all their conquests; and on July 16, 1394, the peace was prolonged for 20 years (and again in 1412 for 50 years), various stipulations being made by which the long struggle of the League against the Habsburgs was finally crowned with success. By the peace of 1394 Glarus was freed on payment of £200 annually; Zug too was released from Habsburg rule. Schwyz was given the *advocatia* of the great abbey of Einsiedeln; Lucerne got the Entlebuch (finally in 1405), Sempach and Rothenburg; Bern and Soleure were confirmed in their conquests. Above all, the Confederation as a whole was relieved from the overlordship of the Habsburgs, to whom, however, all their rights and dues as landed proprietors were expressly reserved, Bern, Zürich and Soleure guaranteeing the maintenance of these rights and dues with power in case of need to call on the other Confederates to support them by arms. Though the house of Habsburg entertained hopes of recovering its former rights, so that technically the treaties of 1389, 1394 and 1412 were but truces, it finally and forever renounced all its feudal rights and privileges within the Confederation by the "Everlasting Compact" of 1474.

The victory at Sempach enabled the League to extend both its influence and its territory. Both the League and its individual members were now able to take the offensive. In the 15th century each member increased and rounded off its territory, though it usually withheld political rights from the men of the newly acquired lands. It was in the same century that Appenzell, St. Gall and the Upper Valais first became associated with the League, though they did not become full members for a long time—Appenzell in 1513, St. Gall in 1803, the Valais in 1815. Above all, the 15th century saw the first attempt of the Confederation to secure a footing south of the Alps.

In 1412 the treaty of 1394 between the League and the Habsburgs had been renewed for 50 years; but when in 1415 the emperor Sigismund placed Duke Frederick of Austria under the ban of the empire (*see* CONSTANCE), the League hesitated, because of their treaty of 1412, till the emperor declared that this treaty did not release them from their obligations to the empire. In the name, therefore, of the emperor, and by his special command, the different members of the League overran the extensive Habsburg possessions in the Aargau. The chief share fell to Bern, but certain districts (known as the *Freie Aemter*) were joined together and governed as bailiwicks held in common by all the members of the League (save Uri, busied in the south, and Bern, who had already secured the lion's share of the spoil for herself). This is the first case in which the League as a whole took up the position of rulers over districts which, though guaranteed in the enjoyment of their old rights, were nevertheless politically unfree.

First Italian Conquests.—As the natural policy of Bern was to seek to enlarge its borders at the expense of Austria, and later of Savoy, so we find that Uri, shut off by physical causes from extension in other directions, as steadily turned its eyes towards the south. In 1410 the valley of Urseren was finally joined to Uri, an acquisition which gave to Uri complete command over the St. Gotthard pass, long commercially important, and now to serve for purposes of war and conquest. Already in 1403 Uri and Obwalden had occupied the long narrow upper Ticino valley on the south of the pass called the Val Leventina; in 1411 the men of the same two lands, exasperated by the insults of the local lords, called on the other members of the League, and all jointly (except Bern) occupied the Val d'Ossola, on the south side of the Simplon pass. But in 1414 they lost this to Savoy, and, with the object of getting it back, obtained in 1416–17 the alliance of the men of the Upper Valais, then fighting for freedom, and thus regained the valley (1416). In 1419 Uri and Obwalden bought from its lord the town and district of Bellinzona. This rapid advance, however, did not approve itself to the duke of Milan; the Confederates were not at one with regard to these southern conquests; the duke of Milan intrigued with them, and finally in 1426, by a payment of a large sum of money and the grant of certain commercial privileges, the Val Leventina, the Val d'Ossola and Bellinzona were formally restored to him.

The First Civil War.—The original contrasts between the social condition of the different members of the League became more marked when the period of conquest began, and led to quarrels and ill-feeling in the matter of the Aargau and the Italian conquests which a few years later ripened into a civil war, brought about by the dispute as to the succession to the lands of Frederick, count of Toggenburg, the last male representative of his house. Count Frederick's predecessors had greatly extended their domains, so that they took in not only the Toggenburg or upper valley of the Thur, but Uznach, Sargans, the Rhine valley between Feldkirch and Sargans, the Prättigau and the Davos valley. He himself, the last great feudal lord on the left bank of the Rhine, had managed to secure his vast possessions by making treaties with several members of the League. His death (April 30, 1436) was the signal for the breaking out of strife. The Prättigau and Davos valley formed the League of the Ten Jurisdictions in Raetia, while Frederick's widow took sides with Zürich against Schwyz for different portions of the great inheritance which had been promised them. After being twice defeated, Zürich was forced in 1440 to buy peace by certain cessions to Schwyz, the general feeling of the Confederates being opposed to Zürich, so that several of them went so far as to send men and arms to Schwyz. Zürich, however, was bitterly disappointed at these defeats, and had recourse to the policy which she had adopted in 1356 and 1393—an alliance with Austria (concluded in 1442), which now held the imperial throne in the person of Frederick III. Though technically within her rights according to the terms on which she had joined the League in 1351, this act of Zürich caused the greatest irritation in the Confederation, and civil war at once broke out. In 1443 the Zürich troops were completely defeated at St. Jakob on the Sihl, close under the walls of the city. Next year the city itself was long besieged. Frederick, unable to get help elsewhere, procured from Charles VII. of France the despatch of a body of Armagnac free lances (the Ecorcheurs), who came, 30,000 strong, under the dauphin Louis, plundering and harrying the land, till at the very gates of the free imperial city of Basle, the desperate resistance of a small body of Confederates (1,200 to 1,500), till cut to pieces, checked the advance of the free booters, who returned whence they had come. Several small engagements ensued, Zürich long declining to make peace because the Confederates required, as the result of a solemn arbitration, the abandonment of the Austrian alliance. At length it was concluded in 1450, the Confederates restoring almost all the lands they had won from Zürich.

Constitution of the League, c. 1450.—These fresh proofs of the valour of the Confederates, and of the growing importance of the League, produced important results. In 1452 they made their first treaty of alliance with France, a connection which was destined to exercise so much influence on their history. Round the League there began to gather a new class of allies, more closely joined to it, or to certain members of it, than by a mere treaty of friendship, yet not admitted to the rank of a full member of the League. Of these associates three, the abbot (1451) and town of St. Gall (1454), and the town of Bienne (Biel), through its alliance (1352) with Berne, were given seats and votes in the Diet, being called *socii;* while others, known as *confoederati,* were not so closely bound to the League, such as the Valais (1416–17), Schaffhausen (1454), Rottweil (1463), Mulhouse (1466), (to the class of *confoederati* belonged in later times Neuchâtel, 1406–1501), the Three Leagues of Raetia (1497–98), Geneva (1519–36), and the bishop of Basle (1579). Appenzell, too, in 1452, rose from the rank of a "protected district" into the class of associates, outside which were certain places "protected" by several members of the League, such as Gersau (1359), the abbey of Engelberg (*c.* 1421), and the town of Rapperswil (1464).

In 1439 Sigismund succeeded his father Frederick in the Habsburg lands in Alsace, the Thurgau, and Tirol and, being much irritated by the constant encroachments of the Confederates, in particular by the loss of Rapperswil (1458), declared war against them, but fared very badly. In 1460 the Confederates overran the Thurgau and occupied Sargans. Winterthur was only saved by an heroic defence. Hence in 1461 Sigismund had to give up his claims on those lands and renew the peace for 15 years, while in 1467 he sold Winterthur to Zürich. Thus the whole line of the Rhine was lost to the Habsburgs, who retained (till 1801) in the territories of the Confederates the Frickthal only. The Thurgovian bailiwicks were governed in common as "subject" lands by all the Confederates except Berne. The touchiness of the now rapidly advancing League was shown by the eagerness with which in 1468 its members took up arms against certain small feudal nobles who were carrying on a harassing guerrilla warfare with their allies Schaffhausen and Mulhouse. They laid siege to Waldshut, and to buy them off Sigismund in Aug. 1468 engaged to pay 10,000 gulden as damages by June 24, 1469; in default of payment the Confederates were to keep for ever the Black Forest, and Waldshut on the Rhine. A short time before (1467) the League had made treaties of friendship with Philip the Good, duke of Burgundy, and with the duke of Milan.

The Burgundian War.—Sigismund did not know where to obtain the sum he had promised to pay. In this strait he turned to Charles the Bold, duke of Burgundy. On May 9, 1469, Charles promised to give Sigismund 50,000 florins, receiving as security for repayment Upper Alsace, the Breisgau, the Sundgau, the Black Forest, and the four Black Forest towns on the Rhine (Rheinfelden, Säckingen, Laufenburg and Waldshut), and agreed to give Sigismund aid against the Swiss, if he was attacked by them. It was not unnatural for Sigismund to think of attacking the League, but Charles's engagement to him is quite inconsistent with the friendly agreement made between Burgundy and the League as late as 1467. The emperor then on his side annulled Sigismund's treaty of 1468 with the Swiss, and placed them under the ban of the empire.

The Swiss in these circumstances began to look towards Louis XI. of France, who had confirmed the treaty of friendship made with them by his father in 1452. Sigismund had applied to him early in 1469 to help him in his many troubles, and to give him aid against the Swiss, but Louis had point-blank refused. Anxious to secure their neutrality in case of war between him and Charles, he made a treaty with them on Aug. 13, 1470 to this effect.

Sigismund in the next few years tried hard to get from Charles the promised aid against the Swiss (the money was paid punctually enough by Charles on his behalf). Charles on his side, in 1471–72, tried to make an alliance with the Swiss. Probably Charles wished to use both Sigismund and the Swiss to further his own interests, but his shifty policy had the effect of alienating both from him. Sigismund, disgusted with Charles, now inclined towards Louis, whose ally he formally became in the summer of 1473. The Confederates on their side were greatly moved by the oppression of their friends and allies in Alsace by Hagenbach, and tried in vain (Jan. 1474) to obtain some redress from his master. Charles's too astute policy had thus lost him both Sigismund and the Swiss. They now looked upon Louis, who, thoroughly aware of Charles's ambition, aimed at the reconciliation of Sigismund and the Swiss. On March 30, 1474 the Everlasting Compact was signed at Constance, by which Sigismund finally renounced all Austrian claims on the lands of the Confederates; they, on the other hand, agreed to support him if Charles did not give up the mortgaged lands when the money was paid down. The next day the Swiss and Sigismund joined the league of the Alsatian and Rhine cities. Charles was called on to receive the money contributed by the Alsatian cities, and to restore his lands to Sigismund. He, however, took no steps. Within a week the oppressive bailiff Hagenbach was captured, and a month later (May 9, 1474) he was put to death. On Oct. 9, the emperor, acting of course at the instance of Sigismund, ordered the Swiss to declare war against Charles, which took place on Oct. 25. Next day Louis formally ratified his alliance with the Confederates, promising money and pensions, the latter to be increased if he did not send men. Throughout these negotiations and later Berne directs Swiss policy, though all the Confederates are not quite agreed. She was specially exposed to attack from Charles and Charles's ally (since 1468) Savoy, and her best chance of extending her territory lay towards the west and south. The Forest districts, however, were very suspicious of this movement to the west, by which Berne alone could profit, though the League as a whole might lose; then, too, Uri had in 1440 finally won the Val Leventina, and she and her neighbours favoured a southerly policy—a policy which was crowned with success after the gallant victory won at Giornico in 1478 by a handful of men from Zürich, Lucerne, Uri and Schwyz over 12,000 Milanese troops.

The war in the west was begun by Berne and her allies by marauding expeditions across the Jura, in which Héricourt (Nov. 1474) and Blamont (Aug. 1475) were taken. Meanwhile Yolande, the duchess of Savoy, had, through fear of her brother Louis XI. and hatred of Berne finally joined Charles and Milan (Jan. 1475), the immediate result of which was the capture, by the Bernese and friends, of several places in Vaud, notably Grandson and Echallens, both held of Savoy by a member of the house of Chalon, princes of Orange (April 1475), as well as of Orbe and Jougne, held by the same, but under the count of Burgundy. In the summer Berne seized on the Savoyard district of Aigle. Soon after (Oct.–Nov. 1475) the same energetic policy won for her the Savoyard towns of Morat, Avenches, Estavayer and Yverdon; while (Sept.) the Upper Valais, which had conquered all Lower or Savoyard Valais, entered into alliance with Berne for the purpose of opposing Savoy by preventing the arrival of Milanese troops. Alarmed at their success, the emperor and Louis deserted (June–Sept.) the Confederates, who thus, by the influence of Louis and Bernese ambition, saw themselves led on and then abandoned to the wrath of Charles, and very likely to lose their new conquests. They had entered on the war as "helpers" of the emperor, and now became principals in the war against Charles, who hastened across the Jura (Feb. 1476) to the aid of his ally Yolande. On Feb. 21 Charles laid siege to the castle of Grandson, and after a week's siege the garrison of Bernese and Fribourgers was forced to surrender, while, by way of retaliation for the massacre of the garrison of Estavayer in 1475, of the 412 men two only were spared in order to act as executioners of their comrades. This hideous news met a large body of the Confederates gathered together in great haste to relieve the garrison, and going to their rendezvous at Neuchâtel, where both the count and town had become allies of Berne in 1406. An advance body of Bernese, Fribourgers and Schwyzers, in order to avoid the castle of Vauxmarcus (seized by Charles), on the shore of the Lake of Neuchâtel, and on the direct road from Neuchâtel to Grandson, climbed over a wooded spur to the north, and attacked (March 2) the Burgundian outposts. Charles drew back his force in order to bring down the Swiss to the more level ground where his cavalry could act, but his rear misinterpreted the order, and when the main Swiss force appeared over the spur the Burgundian army was seized with a panic and fled in disorder. The Swiss had gained a glorious victory, and regained their conquest of Grandson, besides capturing very rich spoil in Charles's camp, parts of which are preserved to the present day in various Swiss armouries. Such was the famous battle of Grandson. Charles at once retired to Lausanne, and set about reorganizing his army. He resolved to advance on Berne by way of Morat (or Murten), and laid siege to it on June 9. The Confederates had now put away all jealousy of Berne, and collected a large army. The decisive battle took place on the afternoon of June 22. After facing each other many hours in the driving rain, a body of Swiss, by outflanking Charles's van, stormed his palisaded camp, and the Burgundians were soon hopelessly beaten, the losses on both sides (a contrast to Grandson) being exceedingly heavy. Vaud was reoccupied by the Swiss (Savoy having overrun it on Charles's advance); but Louis now stepped in and procured the restoration of that region to Savoy, save Grandson, Morat, Orbe and Echallens, which were to be held by the Bernese jointly with the Fribourgers, Aigle by Berne alone —Savoy at the same time renouncing all its claims over Fribourg. Thus French-speaking districts first became permanently connected with the Confederation, hitherto purely German, and the war had been one for the maintenance of recent conquests, rather than purely in defence of Swiss freedom. Charles tried in vain to raise a third army; René recovered Lorraine, and on Jan. 5, 1477, under the walls of Nancy, Charles's wide-reaching plans were ended by his defeat and death, many Swiss being with René's troops. The wish of the Bernese to overrun Franche-Comté was opposed by the older members of the Confederation, and finally, in 1479, Louis, by very large payments, secured the abandonment of all claims on that province, which was annexed to France.

Internal Disputes in the League.—These glorious victories really laid the foundation of Swiss nationality; but soon after them the jealousy between the civic and rural elements which had always hindered common action nearly broke up the Confederation. The circumstances of its origin were long reflected in the constitution. Apart from certain military and police regulations, common action was limited to the meeting of two envoys from each member of the Confederation and one from each of the "socii" in the Diet, the powers of which included foreign relations, war and peace, and common arrangements as to police, pestilence, customs duties, coinage, etc. The decisions of the majority did not bind the minority save in the case of the affairs of the bailiwicks ruled in common. Thus everything depended on common agreement and good will. But disputes as to the divisions of the lands conquered in the Burgundian War, and the proposal to admit into the League the towns of Fribourg and Soleure, which had rendered such good help in the war, caused the two parties to form separate unions, for by the latter proposal the number of towns would have been made the same as that of the "Länder," which these did not at all approve. At the Diet of Stans (Dec. 1481), when it seemed probable that the failure of all attempts to come to an understanding would result in the disruption of the League, the mediation of Nicholas von der Flüe (or Bruder Klaus), a holy hermit of Sachseln in Obwalden, succeeded in bringing both sides to reason, and the "compact of Stans" was agreed on. By this the promise of mutual aid and assistance was renewed, especially when one member attacked another, and stress was laid on the duty of the several Governments to maintain the peace, and not to help the subjects of any other member in case of a rising. The treasure and movables captured in the war were to be equally divided amongst the combatants, but the territories and towns amongst the members of the League. As a practical proof of the reconciliation, on the same day the towns of Fribourg and Soleure were received as full members of the Confederation.

Practical Freedom from the Empire.—The early history of each member of the Confederation, and of the Confederation itself, shows that they always professed to belong to the empire, trying to become immediately dependent on the emperor in order to prevent oppression by middle lords, and to enjoy practical liberty. The empire itself had now become very much of a shadow; cities and princes were gradually asserting their own independence, sometimes breaking away from it altogether. Now, by the time of the Burgundian War, the Confederation stood in a position analogous to that of a powerful free imperial city. As long as the emperor's nominal rights were not enforced, all went well; but, when Maximilian, in his attempt to reorganize the empire, erected in 1495 at Worms an imperial chamber which had jurisdiction in all disputes between members of the empire, the Confederates were very unwilling to obey it—partly because they could maintain peace at home by their own authority, and partly because it interfered with their practical independence. Again, their refusal to join the "Swabian League," formed in 1488 by the lords and cities of South Germany to keep the public peace, gave further offence, as well as their fresh alliances with France. Hence a struggle was inevitable, and the occasion by reason of which it broke out was the seizure by the Tirolese authorities in 1499 of the Münsterthal, which belonged to the "Gotteshausbund," one of three leagues which had gradually arisen in Raetia. These were the "Gotteshausbund" in 1367 (taking in all the dependents of the cathedral church at Chur living in the Oberhalbstein and Engadine); the "Ober" or "Grauer Bund" in 1395 and 1424 (taking in the abbey of Disentis and many counts and lords in the Vorder Rhein valley); and the "League of the Ten Jurisdictions" (Zehngerichtenbund), which arose in the Prättigau and Davos valley (1436) on the death of Count Frederick of Toggenburg, but which, owing to certain Austrian claims in it, was not quite so free as its neighbours. In 1497 the Ober Bund, in 1498 the Gotteshausbund, made a treaty of alliance with the Swiss Confederation, the Ten Jurisdictions being unable to do more than show sympathy, owing to Austrian claims, which were not bought up till 1649 and 1652. Hence this attack on the Münsterthal was an attack on an "associate" member of the Swiss Confederation, Maximilian being supported by the Swabian League; but its real historical importance is the influence it had on the relations of the Swiss to the empire. The struggle lasted several months, but both sides being exhausted, peace was made at Basle on Sept. 22, 1499. By this the matters in dispute were referred to arbitration, and the emperor annulled all the decisions of the imperial chamber against the Confederation; but nothing was laid down as to its future relations with the empire.

The League Enlarged to Thirteen Members.—With the object of strengthening the northern border of the Confederation, two more full members were admitted in 1501—Basle and Schaffhausen—on the same terms as Fribourg and Soleure. The city of Basle had originally been ruled by its bishop, but early in the 14th century it became a free imperial city; before 1501 it had made no permanent alliance with the Confederation, though it had been in continual relations with it. Schaffhausen had grown up round the Benedictine monastery of All Saints, and became in the early 13th century a free imperial city, but was mortgaged to Austria from 1330 to 1415. It bought its freedom in 1418 and became an "associate" of the Confederation in 1454. A few years later, in 1513, Appenzell, which in 1411 had become a "protected" district, and in 1452 an "associate" member of the Confederation, was admitted as the thirteenth full member.

Conquests in Italy.—In the first years of the 16th century the influence of the Confederates south of the Alps was largely extended. The system of giving pensions, in order to secure the right of enlisting men within the Confederation, and of capitulations, by which the different members supplied troops, was originated by Louis XI. in 1474, and later followed by many other princes. Though a tribute to Swiss valour, this practice had very evil results, of which the first-fruits were seen in the Milanese troubles (1500–16), of which the following is a summary. Both Charles VIII. (1484) and Louis XII. (1499 for ten years) renewed Louis XI.'s treaty. The French attempts to gain Milan were largely carried on by the help of Swiss mercenaries, some of whom were on the opposite side; and, as brotherly feeling was still too strong to make it possible for them to fight against one another, Lodovico Sforza's Swiss troops shamefully betrayed him to the French at Novara (1500). In 1500, too, the three Forest districts occupied Bellinzona (with the Val Blenio) at the request of its inhabitants, and in 1503 Louis XII. was forced to cede it to them. He, however, often held back the pay of his Swiss troops, and treated them as mere hirelings, so that when the ten years' treaty came to an end Matthew Schinner, bishop of Sitten (or Sion), induced them to join (1510) the pope, Julius II., then engaged in forming the Holy League to expel the French from Italy. But when, after the battle of Ravenna, Louis XII. became all-powerful in Lombardy, 20,000 Swiss poured down into the Milanese and occupied it, Felix Schmid, the burgomaster of Zürich, naming Maximilian (Lodovico's son) duke of Milan, in return for which he ceded to the Confederates Locarno, Val Maggia, Mendrisio and Lugano (1512), while the Raetian Leagues seized Chiavenna, Bormio and the Valtellina. In 1513 the Swiss completely defeated the French at Novara. Francis I. on his accession (1515) began to prepare to win back the Milanese, and, successfully evading the Swiss awaiting his descent from the Alps, beat them in a pitched battle at Marignano near Milan (Sept. 13, 1515), which broke the Swiss power in north Italy, so that in 1516 a peace was made with France—the Valais, the Three Raetian Leagues and both the abbot and town of St. Gall being included on the side of the Confederates. Provision was made for the neutrality of either party in case the other became involved in war, and large pensions were promised. This treaty was extended by another in 1521 (to which Zürich, then under Zwingli's influence, would not agree, holding aloof from the French alliance till 1614), by which the French king might, with the consent of the Confederation, enlist any number of men between 6,000 and 16,000, paying them fit wages, and the pensions were raised to 3,000 francs annually to each member of the Confederation. These two treaties were the starting-point of later French interference with Swiss affairs. (W. A. B. C.; X.)

REFORMATION AND COUNTER-REFORMATION

Zwingli.—When Zwingli came to Zürich as a preacher to the Grossmünster (1519), Protestantism found its way into Swiss history. The Evangelical movement in Switzerland was very different from Luther's Reformation in Germany. Zwingli was no direct disciple of Luther; he belonged to the group of the humanists. He had served as a chaplain with the troops in the Milanese, in 1512 and 1515, and began his career as a political rather than as a purely religious reformer. His influence grew first over the people of Zürich (where he reformed the church and looked after the farmers in the country), and then over those towns of the League which accepted the new creed. As the movement passed over into German territory, Zwingli seriously began to build up a Protestant League which was to include the new Lutheran territories of the empire together with the political enemies of the House of Habsburg.

Zwingli's interference with the political affairs of Switzerland had a lasting result. The League was definitely split into two parts. The Romanist camp included the Forest cantons with Lucerne, Zug, Soleure, Fribourg; the Evangelical camp was composed of the great city-cantons: Zürich, Berne, Basle with Glarus, Schaffhausen, Appenzell. Naturally, this rupture meant a great loss of power to the League. Switzerland was reduced to a merely passive position in the politics of Europe. There is, however, no reason to believe that religion was the sole cause of the split between Evangelicals and Romanists. The deep-rooted antagonism between the purely rural districts represented by the Forest cantons in the pre-Alps and the city-cantons of the Swiss plain underlay Swiss politics from the very beginning and has an economic explanation. Just as the pre-Reformation period had witnessed the Old Zürich War, the Reformation witnessed the war of Kappel, where Zürich stood again in the field against the Forest districts and their allies. And again Zürich was beaten, and her great leader Zwingli slain (1531). The Reformation movement was stopped at once; it lost all its offensive spirit; much of the ground it had gained before passed into the hands of the Catholics. The second peace of Kappel (1531), though formally recognizing the existing conditions of the expansion of the new creed, made special provisions to facilitate in the "common bailiwicks" the return of the people to the old creed. Protected by the victorious party, Catholicism recaptured many a lost position.

The Conquest of Vaud.—Berne had an eminently political interest in upholding the Evangelical creed regarding her policy towards Savoy. Since the wars of Burgundy, Berne had got a footing in the French-speaking districts round the lakes of Neuchâtel and Morat and south of them, and she wished to develop her position further south round the lake of Geneva. The city of Geneva was the natural centre of the northern Savoyard district and the key to Vaud as well. The conflict of her burghers with the duke of Savoy, into whose hands the see of Geneva had passed, and the strong effort of the burghers to free themselves from any feudal power, made the alliance of Geneva with the neighbouring Swiss cities a political necessity (alliance with Fribourg 1519, with Berne 1526). 1536, the date which marks the definite victory of Protestantism in Geneva, is also the year of the expulsion of the Savoyard forces from Vaud, and the establishment by Berne of her rule over the district of the Leman, where the new creed was introduced and serfdom was abolished in the country districts. This success compensated for the losses sustained by the Evangelical cause in German Switzerland. It was in two ways a gain to the country; it enabled Calvin to develop his theocracy in Geneva and to make Geneva the centre of Swiss Protestantism, on the basis of a union between the Geneva and Zürich reformers. A further consolidation of the territorial position of Geneva to the west and south of the lake was made impossible by the interference of the Catholic members of the League, who contracted different alliances with the duke of Savoy. Finally Geneva turned to France.

The Counter Reformation.—The Catholic members of the League developed a policy of their own. The first impulse had in fact come from the other side, Zwingli taking the lead in contracting an alliance founded on religious principles (*Christliches Burgrecht* between Zürich, Constance and Berne, etc. 1527–28). Yet the Romanists departed even more from former principles by directing their own efforts against the very tradition of national policy. This was all the more important as—since the second Peace of Kappel—the Catholics had secured the stronger position in the country. The Counter-Reformation had inspired them just as the Reformation had inspired the Protestants. They felt the influence of a great leader, Carlo Borromeo, the archbishop of Milan, whose diocese included the Italian bailiwicks, and who founded the "Collegium Helveticum" at Milan for the training of the Swiss clergy. The arrival of the Jesuits at Lucerne and Fribourg as well as the delegation of a permanent nuncio to the cantons marks the beginning of the regeneration of Roman Catholicism. The Capuchins—a Minorite order—extended their activity more to the country districts. Results were soon apparent: not only were border districts such as the Valais and the Chablais, and on the opposite side Constance, lost for Protestantism, but among the League itself, in Appenzell and in Glarus, the Catholic movement became so strong, that in the case of Appenzell, it ended with a rupture, the canton being henceforward divided into two half cantons. Lucerne became the centre, almost the capital, of Catholic Switzerland. The papal nuncio had his residence at Lucerne. The diet of the Catholic members met there (the Evangelicals sat at Aarau), supported by the invaluable activities of Ludwig Pfyffer, the great religious reactionary, formerly chief of the Swiss soldiers in the service of France, and commonly known in his time as the "Swiss king." A visible symbol of the new spirit amongst the Catholics was the Golden or Borromean League, founded in 1586. This League brought the old League near to disintegration as it formally stated that its members must prefer the new League to all former contracts; and it showed in fact by its alliances with the House of Habsburg (with the emperor 1529, with Spain 1557, 1587, etc.), that its members were strongly confirmed in their resolution to forget the past.

FROM THE THIRTY YEARS' WAR TO THE WARS OF NAPOLEON

Thirty Years' War.—With the beginning of the 17th century the waves of religious passion in the League were calming down, though nothing in the attitude of the parties was changed. The religious conflicts, originally internal disputes, became mixed up with the great political international problems of Europe. But the division of the parties did not coincide with the religious divisions. In the Thirty Years' War France took the side of the Protestants against the Habsburgs, and Swiss mercenaries from the Catholic Cantons fought on the side of Catholic France in helping the Protestant Powers to destroy the Habsburgs. Switzerland was lucky to escape the terrible lot of the German lands. The Raetian Leagues, however, were drawn into the war in consequence of the great strategical value of the Valtellina for the Habsburgs, as one of the main connections between Milan and the Tirol. For over 30 years the Grisons were the scene of the most atrocious party warfare; a Protestant party worked for the French, a Catholic party for the Spaniards, until George Jenatsch, originally a Protestant parson, with Spanish aid threw out the French, his own former allies,—thus liberating his country at last from foreign occupation.

The Treaty of Westphalia gave Switzerland that formal recognition of its independence from the empire, which it had possessed in fact since 1499. The position of the League was thus apparently strengthened, but the separation from the empire brought her more within the compass of France's influence. This less favourable result was partly compensated by the Defensionale of Wil (1647, finally adopted 1668) which marks the beginnings of the organization of a home army for the common defence of the Swiss territory, and shows for the first time since the Reformation a kind of national spirit within the League.

The Peasant War and First Villmergen War.—The 30 Years' War was followed by a social and economical revolution. The Peasant War (1653) grouped together the towns against the peasants; for the first time since the Reformation Evangelicals and Catholics acted together to defend their economic and administrative supremacy over the country people. The farmers had prospered during the period from 1618 to 1648. In this period was laid the foundation of Swiss wealth, the territories of the League having been spared the destruction suffered by their neighbours. But the after-war reaction was felt the more heavily by the farmers; the price of land, very high during the war, fell suddenly and a financial crisis followed. The towns persistently developed a dominating position over the land by the acquisition of former feudal rights, by simplifying the administration and by making it more efficient by levying higher taxes. Thus the country people felt a double dependence: an economic and a political one, and the Peasant War can be considered as a democratic reaction against the growing tendency towards oligarchy. It could not but end with defeat for the farmers and had consequently just the opposite effect to its purpose: it strengthened the towns instead of weakening them. This conflict between burghers and farmers was followed by a contest among the victors themselves. Remembering the experience of 1653 which had united Evangelical and Catholic members of the League, Zürich launched a scheme for a reform of the constitution of the League, based on the idea of more centralization and the predominance of the larger cantons. This idea, however, met with refusal from the Catholics, who realized that their predominant position within the League rested on the principle of the sovereignty of single members. They openly manifested their dislike of the new idea by reconfirming their own Golden League on the advice of the papal nuncio. Zürich decided to trust again to the luck of war, but again she was beaten (at Villmergen, Aargau, 1656). For another half century the League was to be under the sway of the Catholics.

Louis XIV.—Switzerland was so nearly connected with the kingdom of France that Louis XIV.'s reign had necessarily a lasting influence on Swiss affairs. First, the traditional friendship between the League and France was very solemnly renewed, when the delegates of the League confirmed a new treaty of alliance at Notre Dame by solemn oath (1663). Yet the king's policy of eastward expansion advanced the frontiers of France towards Swiss territory through the acquisition of Franche Comté. This territory, belonging to Spain, had acted like a buffer between Switzerland and France. The fall of Strasbourg—this old ally of the League—and the construction of a fortress near Basel on the Rhine were further signs of Louis's wish to encroach on the territory of the empire. All this might not totally have estranged Swiss sympathies from the king, had he not by the revocation of the Edict of Nantes (*q.v.*) provoked the anger of the Evangelicals. Zürich answered by concluding in 1693 a capitulation with Holland, though this had the unhappy result of Swiss troops fighting against each other (Malplaquet). The succession of the Bourbons to the Spanish throne, upsetting the equilibrium of European politics, was naturally felt by the League. France, hitherto the political friend of the Evangelicals, turned to the side of the Catholics, the former allies of Spain, while the Evangelicals began to back the empire. The French ambassador, so far the main agent in promoting the pacification of the League, henceforward openly favoured the Catholics against the Evangelicals. On his instigation the second Villmergen war broke out on the same issue as the first, but it ended this time in favour of the great cities. The balance of power was restored in favour of the Protestant party and the provisions of the second peace of Kappel were definitely abrogated (Peace of Aarau, 1712).

18th Century.—In the 18th century no spectacular events occurred before the beginning of the French Revolution. The economical and intellectual development, however, was quite remarkable. The wealth of the country was great; the population increased enormously, in many places doubling its number in the course of a century. Since 1444 there had been no real invasion. The mercenary service brought a great amount of money, 60–70,000 men and officers being constantly engaged in foreign armies. Swiss agriculture was very prosperous. Under the influence of the Physiocratic school big model farms were formed (*Hofwil*) and a more rational type of farming was introduced. Cattle for breeding and for food, horses for military purposes, wine and cheese (already manufactured on an industrial base) were the chief export articles. In the cotton trade 200,000 people—mostly in the eastern part of the country—were engaged; St. Gall had 30–40,000 embroiderers in its pay, who lived in the neighbouring districts. The centre of the silk trade was Zürich. Basle manufactured ribbons and the Jura district had already a small metallurgical industry.

All would have been well, had there not been a tendency to social stagnation. The cantons were altogether under the spell of absolutism. There were as many absolute Governments as cantons existed in the League. The character of Switzerland was therefore typically particularist as well as anti-democratic. The League was one of the most complicated political bodies of the time. It represented a federation of 13 quasi-independent states, to which were attached almost the same number of allied states. Each of the cantons had its own subjects and in addition groups of cantons ruled alternately in the "common bailiwicks." The cantons themselves had different types of Government. We can distinguish a group of *democratic* cantons, represented by Uri, Schwyz, Unterwalden, Zug, Glarus, Appenzell. Officially governed by the *Landsgemeinde*, the government posts were actually in the hands of a few families, which lived on pensions from the foreign Powers. To another group belong the *gild* cantons, Zürich, Basle and Schaffhausen. Their Governments were formed by the gild-corporations of the towns. The admission to the gilds was very strictly limited; people newly established in the town had no chance of admission and were likewise excluded from the Government. Finally the *aristocratic* cantons, Berne, Lucerne, Fribourg and Soleure formed a group of their own.

Two other types of Government were represented by the allies of the League: the federal type by the Valais and the Raetian Leagues and the monarchic type by the principality of Neuchâtel (which had passed into the hands of the Prussian king to counteract French influence) and the territories of the prince-bishop of Basle, the abbots of St. Gall and of Engelberg. The public law of the League consisted of those few charters commonly accepted in the 14th and 15th centuries and completed by the Defensionale of 1647, the renewal of which had not always been generally accepted. The absolutist tendency of the time, which in Bern excluded all but 67 families from the Government, further divided the population into a ruling and a ruled class. Besides the often badly treated subjects of the "common bailiwicks" the country subjects of the gild cantons were not much better off, and in the towns there was opposition from the non-admitted citizens and from those burghers who—though they were long established—had been deprived of some of the privileges of Government. It is, however, just to remark that in the aristocratic cantons (chiefly in Bern) the peasants were less exploited and agriculture was better developed than in the gild cantons. In Vaud for instance the discontented class were not the farmers, but the descendants of the old Savoyard aristocracy. Different attempts at a reform were made; some had their origin within the ruling class itself (Henzi's action at Berne, 1749) others came from the subjects (the Stäfener articles, 1794–5), but they were suppressed. In the second half of the century there was a general movement among the educated classes of the whole country to promote a political programme on a national basis and a society was formed to this end (*Helvetische Gesellschaft*, 1760).

Revolutionary and Napoleonic Period.—The League could not but be affected by the French Revolution, but without the French armies Switzerland would never have been revolutionized as it was in the years from 1798 to 1802. The revolution was actually imported into the League's territories. The invasion of French troops was suggested to the Revolutionary Government by members of the Helvetian club in Paris, but mainly by Frédéric César La Harpe (formerly tutor to the later Tsar Alexander I.) and Peter Ochs, the burgomaster of Basle, who believed that the French influence would have a salutary effect on the reform movement in Switzerland. In reality it brought the country the burden of a foreign occupation, which was nowhere enjoyed; in certain places, as in the Forest districts, it provoked a heroic, but naturally vain resistance. Apart from the strategic value of Switzerland the French could reckon with a splendid booty of which the State treasuries—symbols of accumulated wealth—were only a part. For years the country had to feed the French troops which Bonaparte kept ready for future campaigns. Switzerland got its first constitution, drawn on the principles of the French constitution of the Directory in April 1798. If the "Helvetic Republic" had worked, it would have transformed the League into a centralized State after the example of France.

With the French occupation, Switzerland became a part of the European theatre of war, and shared the fate of other certain European countries. The Valtellina and the Valais were cut off from the League (1797, 1802) as Napoleon needed the Valais for his communications with the Cisalpine Republic and the Valtellina as direct passage from Lombardy to Tirol. He also took Ticino in 1810, but soon offered to return it.

Napoleon's attitude towards Switzerland changed after 1801. Until 1801 Switzerland remained an occupied territory and was several times involved in the great struggle for or against France. The two battles of Zürich (June and Sept. 1799), one a defeat, the other a victory, for the French, were important incidents in the fight for the possession of the Swiss territory between France and the allies, Austria and Russia. France was victorious in the end. When Germany was reconstructed according to the terms of the Treaty of Lunéville, the occupation of the Swiss territory was no more a necessity. It was on the contrary an advantage for Napoleon to help the Swiss to settle down, and so to be sure of this strategically important territory. Thus Napoleon became the author of the first Swiss constitution of practical value—the Act of Mediation (1802–3), which he worked out with the help of delegates from the different Swiss parties. This constitution recognized the sovereignty of the cantons (joining to the old cantons the "common bailiwicks" and some allied districts) and revived the old diet. The president (*Landammann*) of the diet was formally to represent the central Government, but he was invested with no executive power. Napoleon realized that by giving back to Switzerland its federal Governments he diverted the country from taking an active part in the war against France. In a treaty of alliance he secured for himself the monopoly for the recruitments of Swiss troops, thus breaking the practice of many centuries, on which was built the principle of neutrality (1807, Swiss recalled from England). Independence was therefore a mere word. The Mediation period showed conclusively that there could be no freedom for Switzerland as long as Europe was dominated by a single power. Actual freedom was only restored when the Napoleonic power was definitely broken. (M. Si.)

THE 19TH AND 20TH CENTURIES

On Oct. 18, 1813, the Allies defeated Napoleon at Leipzig. This event, in which the Swiss were in no way involved, profoundly affected their history. Some weeks later the Allied armies reached the frontiers of the Swiss Confederation. It was at first doubtful whether they would cross. Opinion among the Allies was divided; the Russians and the Prussians objected, but the views of Austria, supported by England, finally triumphed. On Dec. 21, 1813, the neutrality of Switzerland was violated.

Reconstitution of the Frontiers.—The foreign troops were received with different feelings by different parties in Switzerland. They were welcomed as liberators by the old aristocratic cantons, which hoped that the old régime would be unconditionally restored. On the other hand they were regarded with disfavour by the cantons which the Act of Mediation had brought into existence. An aristocratic revolution broke out at Berne on Dec. 24, 1813, and this example was immediately followed in the other cantons. Everywhere the old Governments were restored to power; the Act of Mediation was denounced. This created oppositions and rivalries of so profound a character that war was several times on the point of breaking out between the cantons. The representatives of the Powers, among them Stratford Canning, were obliged to intervene, sometimes in a friendly way and sometimes with threats, to induce the Swiss to agree upon a new Federal Pact (Sept. 1814), which restored the old federal institutions, including the practically absolute sovereignty of the cantons; the diet was a diplomatic body with hardly any real power. At this time a great movement of liberation took place in the districts which Napoleon had detached from Switzerland, and certain of the neighbouring territories: the bishoprics of Basle, Neuchâtel, Geneva, Savoy, the Valais and Valtellina expressed a wish to form part of the Confederation. Neuchâtel recalled its prince, the king of Prussia. The Treaty of Paris (May 30, 1814), which fixed the frontiers of France, left most of these districts outside that country. On Sept. 12, 1814, Neuchâtel, Geneva and the Valais were officially received into the Confederation as cantons.

The final settlement of internal and external questions relating to Switzerland was undertaken by the Congress of Vienna. This was done, after long discussions and a great deal of criticism, by two acts dated March 20 and 29, 1815. The first act laid down the perpetual neutrality of Switzerland, which was given its old frontiers, with the exception of Mulhouse, which remained with France, and Valtellina, which went to Austria. The internal difficulties of the country were settled by the confirmation of the existing frontiers between the cantons and by a series of compromises on financial indemnities claimed by the various cantons from one another. By the second act, Switzerland received a slight accession of territory in Savoy, and its neutrality was extended to Northern Savoy.

Swiss neutrality did not, however, survive Napoleon's return. The very Powers which had just proclaimed its neutrality at once required the Confederation to enter into alliance with them, since they needed its aid in the struggle with France (May 20, 1815). The Federal troops entered Franche-Comté on July 3. When, however, the second Treaty of Paris was concluded on Nov. 20, 1815, the Swiss were not rewarded for their help as they had hoped. All they obtained was a slight rectification of their frontier on the French side, and the creation of a free zone near Geneva. These provisions were supplemented a few months later (March 16, 1816) by the Treaty of Turin, concluded with Sardinia. The frontiers of Switzerland have remained unchanged since that time.

The Restoration.—The early part of the Restoration period was characterized in Switzerland by an enthusiastic return to the political forms of the past, and at the same time by a serious economic crisis, due to the war. Swiss industry, which had for a long time been protected by the Continental blockade, now found all the markets of the Continent closed to it at the very time when it was again faced with the competition of England, especially in the textile trade. A strong Government at home and abroad would have been needed to deal with the situation; but no such Government existed. The cantons possessed and exercised the right to impose internal customs duties; but they were never able to agree upon a common customs policy. The Confederation exercised no central authority worthy of the name, and there was no spirit of solidarity among the Governments of the cantons, which were to a large extent dependent on the foreign countries with which they entertained direct relations. In particular the system of capitulations, which made the aristocracy of the cantons directly dependent on foreign countries, had again come into being on a large scale.

Switzerland was consequently obliged, under the pressure of Russian diplomacy, to become a member of the Holy Alliance on Jan. 27, 1817. Similarly it was obliged to persecute the liberal refugees who flocked into the territory of the Confederation from all the neighbouring countries. Switzerland made every effort to avoid being forced into action so contrary to the traditions of the country, but it was nevertheless compelled in 1823 to yield to the pressure of the Holy Alliance and to restrict the press.

Period of Regeneration.—The political, economic and moral influences described above made themselves felt in the revision of the constitutions of several cantons—Schaffhausen, Appenzell, Lucerne, Vaud, etc.—which was undertaken in 1828 and 1829. The movement gained in strength under the influence of the Revolution in France, and between 1830 and 1833 about ten cantons, including the largest, Zürich, Lucerne and Berne, revised their constitutions in the sense of greater liberalism.

The liberal movement of 1830, which has been called the period of regeneration as opposed to the restoration, had to face obstacles both in the cantonal and in the Federal sphere. At Neuchâtel the revolution which broke out against the government of the prince (the king of Prussia), was a failure. In Schwyz, civil war and the division of the canton into two parts were only averted by Federal mediation. Disturbances accompanied by loss of life broke out in the canton of Basle, and on Aug. 17, 1833, the diet decided to separate the canton into two half-cantons, one urban and the other rural. The liberals were anxious to obtain the revision of the Federal Pact. Taking advantage of the majority which they possessed in the diet, they obtained a decision to this effect on July 17, 1832.

The Young Europe movement, which had its centre in Switzerland, the intrigues of Mazzini, the meeting of the German liberals at Berne in 1834, the assassination of the German spy Lessing in 1835, the arrest of the French *agent provocateur* Conseil in 1836, led to a series of diplomatic difficulties for Switzerland. The most serious incident, which very nearly involved the Confederation in a war with France, was that which arose in 1838 out of the presence in Thurgau and the activities of Prince Louis Napoleon Bonaparte, afterwards Napoleon III.

The Sonderbund War.—Within the Confederation itself the struggle for the revision of the Federal Pact soon assumed a character of such violence as to presage the civil war which in fact subsequently broke out. On March 17, 1832, the liberal cantons concluded a sort of alliance among themselves, known as the "Concordat of the Seven" (*Siebener Concordat*), by which they mutually guaranteed their constitutions. In November the conservative cantons concluded a similar alliance (League of Sarnen). These alliances were not confessional in character, and included both Protestant and Catholic cantons. The situation, however, was altered by the Articles of Baden, adopted by the liberal cantons on Jan. 20, 1834; they contained a programme of ecclesiastical reform, and transformed the struggle for the revision of the Constitution into a religious quarrel.

The Articles of Baden were condemned by the ecclesiastical authorities on May 17, 1835, but were enforced with vigour and even with brutality by certain cantons. On Jan. 20, 1841, the canton of Aargau suppressed the monasteries, thus violating the Pact, which guaranteed them. On May 1, 1841, the Catholics returned to power in Lucerne, and on Oct. 24, 1844, they called in the Jesuits to teach in the cantonal high-school. This irritated the liberals of the cantons of Berne and Aargau, which organized armed bands (*corps francs*) who on two occasions invaded the territory of Lucerne. Seven Catholic cantons—Lucerne, Uri, Schwyz, Unterwalden, Zug, Fribourg and Valais—replied by concluding, on Dec. 11, 1845, a separate and secret alliance known as the *Sonderbund*. On July 20, 1847, the diet declared by a majority that the *Sonderbund* was contrary to the Constitution, and ordered its dissolution. The seven cantons refused to obey, and the Genevese General G. H. Dufour marched against them at the head of the Federal army and defeated them after a short campaign in Nov. 1847. He thus averted an intervention by the Powers which was being planned by Metternich and Guizot, although the scheme was opposed by Lord Palmerston.

The Federal State.—The Federal Constitution of 1848, while respecting the sovereignty of the cantons, gave the Confederation wide powers, particularly in the economic sphere. Executive power was placed in the hands of a Federal Council of seven members elected by Parliament for three years and in practice almost always re-elected. The legislative authority lay in two chambers, one representing the nation as a whole and the other the cantons. It will be seen from this that the authors of the Swiss Constitution—Kern of Thurgau, Druey of Vaud and James Fazy of Geneva—drew their inspiration largely from the American model. The headquarters of the Federal authorities, which had up till then been moved every two years, were fixed at Berne. The most novel feature of the new Constitution was the ample provision made for its amendment. It was the immutable character of the Pact of 1815 which had led to civil war, and the authors of the 1848 Constitution took pains to avoid falling into the same error. The new Federal authorities, in which the most moderate elements of the liberal party had a majority, at once set to work. The postal and telegraphic systems, the customs, the currency and weights and measures were unified in succession. The act of 1852 dealing with railways was the most important legislative measure, and once more exacerbated the rivalry between the various cantons and districts, more particularly Berne and Zürich. This did not, however, prevent rapid progress in the building of railways.

The new Confederation was at once faced with serious decisions on foreign policy. In 1848 Sardinia offered Switzerland its alliance against Austria; but such an offer was contrary to the perpetual neutrality of Switzerland, and it was rejected. In the years which followed the great crisis of 1848 a large number of political refugees established themselves in Switzerland, involving that country in disputes with most of the neighbouring Powers—France, Sardinia, Austria and Germany. In 1848 Neuchâtel (*q.v.*) had proclaimed a republic. In 1856 a revolution attempted to restore the power of the prince. War with Prussia was narrowly averted by the mediation of Napoleon III., to whom the Swiss cause was represented by the embassy of General Dufour to Paris. The king of Prussia was finally persuaded to renounce his rights, save the title—which his successor also subsequently dropped.

The foreign policy of the Confederation then began to take other directions. In 1864 the International Red Cross Committee was founded at Geneva on the initiative of Henry Dunant, Gustave Moynier and a certain number of Genevese citizens. The result of this was to give a humanitarian bias to Swiss neutrality in all subsequent wars, and to prepare the way for the international functions which the Confederation was later to perform. The first international office, dealing with telegraphs, was founded at Berne in 1865; and in 1872 Switzerland was the scene of the first attempt at international arbitration in the *Alabama* affair between Great Britain and the United States. (*See* ALABAMA ARBITRATION.)

In the meantime there had been a recrudescence of internal political dissension. In 1866 a series of amendments to the Federal Constitution were rejected by popular vote, with the exception of one which conferred equal rights of citizenship on Jews. In the following years a number of cantons, including Zürich, introduced into their constitution the principle of direct democracy, or in other words the right of the nation to have laws adopted by the legislative bodies submitted to it for approval.

The two great international events of 1870, the Vatican Council and the Franco-Prussian War, led to a widespread movement in Switzerland in favour of the revision of the Constitution. The former was held to show the necessity for the State to protect itself against the excessive power of the Church, and the second the need for the reorganization of the army. A first revision scheme was rejected in 1872 by a Federalist coalition consisting of the Catholic cantons and the French-speaking cantons. Two years later, however, a second scheme, which met the objections of the French-speaking cantons and included stronger anti-Catholic provisions, was adopted by the nation.

Direct Democracy.—The 1874 Constitution, which remains in force at the present day (1929), gives considerably wider powers to the Federal State, especially in military matters, and introduces direct democracy in Federal affairs in the form of the optional referendum on legislation.

Except for a revolution in the canton of Ticino in 1890, in which the Catholic Government was forcibly overthrown by its radical opponents, the Swiss internal political situation has since that time been dominated by economic preoccupations and by a tendency towards centralization. Throughout that period the radical party has had a majority in the Federal Assembly, and this fact has tended more and more to promote the transfer of the powers of the cantons on economic questions to the Confederation, especially since 1891, when the right of popular initiative on constitutional questions was introduced. To mention only the principal instances, the monopoly of spirits was handed over to the Confederation in 1887, the power to enact legislation on social insurance in 1890, and the monopoly of issuing bank notes in 1891. In 1898 the nation declared in favour of the purchase of the railways by the Confederation and the unification of civil and penal law. The National Bank was set up in 1906; in 1907 legislation was adopted increasing the powers of the Confederation in military affairs, and the Federal chambers adopted the new civil code; in 1908 the nation decided to prohibit the manufacture and consumption of absinthe; in 1912 it voted for the Insurance Act, provision for which was made by the Constitution, but the first draft for which had been rejected in 1900 because it was considered to confer too much power on the State.

In the economic sphere, the period was characterized by a great increase in industrial and commercial activity due partly to the construction of railways and partly to the introduction of a protectionist system. The St. Gotthard tunnel was constructed in 1880 and the line opened in 1882; the Simplon tunnel was opened in 1906 and the Loetschberg tunnel in 1913. An immense number of mountain railways were also built. A new customs tariff was adopted in 1884, and was modified not long after in the direction of increased protection. Another new customs tariff was adopted in 1891, with results of a twofold character; in Switzerland itself it aroused the covetous instincts of some of the cantons, and a demand was put forward by popular initiative for the distribution of part of the customs receipts among the cantons. This initiative, which was known as the *Beutezug* or plundering expedition, was rejected by the nation in 1894. In the sphere of foreign politics, the raising of the tariff led to a customs war with France (1893–95), in which the advantage remained to a certain extent with Switzerland.

Switzerland has been involved in three other international disputes, none of which have, however, been of great importance. The first was the Wohlgemuth affair in 1889, which arose out of the arrest on Swiss territory of an agent of the German political police. The second was the Silvestrelli affair in 1902. The dispute originated from the publication of anarchist articles in an Italian newspaper appearing in Switzerland; it led to the temporary breach of diplomatic relations with Italy. The third dispute arose with Germany in connection with the St. Gotthard (Railway) Convention in 1909. The Swiss considered that the German Government had on that occasion abused its superior diplomatic position, and a large section of public opinion was violently opposed to the ratification of the Convention. The Chambers, however, voted in favour of ratification, and a popular initiative was therefore instituted which led after the war, in 1921, to the introduction of an article into the Constitution according to which the ratification of long-term international treaties might optionally be submitted to a popular referendum.

The World War.—A national exhibition, which bore witness to the prosperity and to the industrial development of Switzerland, was being held at Berne in 1914 when the war broke out. The Federal Council at once took steps to safeguard the practical neutrality of Switzerland both from the political and the economic point of view. The army was mobilized to guard the frontiers, and the Federal Assembly appointed Colonel Ulrich Wille of Zürich as commander-in-chief. The Federal Council obtained from Parliament powers which, though perhaps not strictly compatible with the constitution, were required by the circumstances. It proceeded to take steps to obtain sufficient supplies of wheat and coal for the Confederation.

The war was a period of trial for the Swiss from the economic, political and moral point of view. It was found impossible, notwithstanding treaty obligations, to maintain complete economic neutrality. Switzerland was over-populated and over-industrialized in proportion to its resources, and was largely dependent on foreign countries for its supplies of foodstuffs and raw materials. The Allies refused to supply foodstuffs unless Switzerland ceased to trade with Germany, while Germany threatened, if Switzerland did so, to withhold the necessary coal supplies. The situation became exceedingly critical after Italy came into the war in May 1915, and still more when the United States also entered the field in April 1917. Although in one way the industries of Switzerland made the position of the country more difficult, they nevertheless helped to preserve its existence; for all the belligerent States were equally interested in keeping the Swiss factories at work. A *modus vivendi* with Germany was devised in 1915 by the institution of the *Treuhandstelle* at Zürich, and with the Allies by the creation of the S.S.S. (*Société suisse de surveillance économique*). These bodies gave each side a guarantee that the goods which it exported to Switzerland would not be re-exported, and in this way Switzerland was enabled, however inadequately, to obtain supplies.

Financially the war cost the Confederation dear. The whole or part of the army had to be kept under arms throughout the war, and the total expense of this amounted to 1,220 million francs, or nearly Fr. 400 per head of the population. The Swiss nation was therefore asked in 1915 to vote a Federal war tax—the first direct tax to be levied by the Confederation—and a similar tax was voted again in 1919. By this means Switzerland was able to avoid the inflation of its currency and the depreciation of the exchange.

From the political point of view, the Confederation endeavoured to practice the most scrupulous neutrality between the belligerents. Its task was rendered difficult by the fact that public opinion in Switzerland was neither neutral nor united. French-speaking Switzerland was violently anti-German and pro-Ally, and in these districts the Federal Council was severely criticized for not having protested against the violation of Belgian neutrality in 1914. Feeling ran less high in German-speaking Switzerland, but was rather in favour of Germany, to which country Switzerland was bound by a number of economic and cultural interests. This explains, though it does not justify, the fact that pro-German sympathies were manifested, against the will of the Government, in high political and military circles in the Confederation. The affair of the colonels in 1916, when information was supplied by the Staff to foreign military attachés, and the Hoffmann affair in 1917 (an attempt to negotiate peace between Germany and Russia) were not, it is true, actually breaches of neutrality, but they nevertheless aroused the greatest indignation among the public, which insisted that the persons involved should be punished. On the resignation of the Federal councillor Hoffmann, Gustave Ador (*q.v.*), chairman of the International Red Cross Committee, became a member of the Federal Council. M. Ador stood for all that was best and most constructive in the work of Switzerland in the international sphere—for active charitable work, for the relief of prisoners of war and of the men in internment camps.

For the population of Switzerland, the war years were years of privation on the material side, and on the moral side of constant agitation without definite aim, especially in the German-speaking districts. It is not surprising that symptoms of exhaustion and moral strain should have appeared; and as a result there broke out in Switzerland a general strike of a political character as an echo of the German Revolution. This necessitated the mobilization of the army on the day of the Armistice (Nov. 11, 1918); and a large number of soldiers lost their lives as a result of influenza.

Peace, and the Post-War Period.—As the Swiss Confederation had not taken part in the war, it was not able to participate in drawing up the Treaty of Peace. It was, however, represented at the Peace Conference by a number of official delegates, and its interests were in several respects affected by the Treaty of Versailles. The Federal Council devoted special efforts to obtaining recognition of the perpetual neutrality of Switzerland within the framework of the League of Nations. The city of Geneva was selected as the headquarters of the League. New international rules for the navigation of the Rhine were drawn up, and the Gotthard Convention of 1909 which had aroused such strong feeling in Switzerland before the war was repealed.

The population of Vorarlberg, an Austrian district adjoining Switzerland on the east, expressed by a large majority its desire for union with Switzerland, but was unable to succeed in having its claim recognized by the Treaty of Saint-Germain.

From the international point of view, the post-war period was one of great activity for Switzerland. On Feb. 13, 1920 the Federal Council succeeded in obtaining from the Council of the League of Nations, which was then meeting in London, recognition of the fact that the maintenance of the perpetual neutrality of Switzerland was not incompatible with the Covenant of the League. As a result of that decision, after a hotly contested electoral campaign, the Swiss nation decided on May 16, by a small majority, to enter the League of Nations. From that time the Swiss delegation, headed by M. Motta, played a useful part in the successive Assemblies of the League.

The Principality of Liechtenstein, a district with 13,000 inhabitants which had previously maintained a customs union with Austria, adopted the Swiss currency in 1920, and on Nov. 10 of that year concluded a number of economic agreements with that country. On March 29, 1923 a customs union was concluded. After 1920 the representation of Liechtenstein in foreign countries was undertaken by Switzerland.

The representative of Soviet Russia at the Lausanne Conference, which was held for the negotiation of peace with Turkey, was assassinated on May 10, 1923, and this led to a diplomatic dispute between Switzerland and the Soviet Government and the breaking off of relations. The situation between the two countries continued to be extremely strained until the conclusion of the Berlin agreement on April 14, 1927.

The zones dispute arose out of the denunciation by France in 1918 of the régime of the free tariff zones created about Geneva by the treaties of 1815. A convention concluded between Switzerland and France on Aug. 7, 1921 was rejected by a large majority by a popular vote on Feb. 18, 1923. France unilaterally abolished the zones régime on Nov. 11, 1923, but an arbitration compromise was concluded by the two Governments on Oct. 30, 1924. The French senate refused to ratify this compromise agreement, conditioning its acceptance on Switzerland's abandonment of the neutrality of the Haute Savoie (to which France attaches strategic importance). Switzerland agreed in 1927 to hand over the document of the abandonment in exchange for the French ratification. The French senate acted in March, 1928, and ratifications were exchanged a few days later.

Switzerland signed the optional clause of the rules of the Permanent Court of International Justice, and concluded arbitration treaties with 19 countries, in most cases without any reservation.

The internal history of Switzerland in the years immediately following the war, as in the corresponding period of the Restoration, was characterized by a grave economic crisis. There was at first a short period of prosperity, during which the eight hour day was introduced in factories (Jan. 1920). Soon, however, the general European economic crisis spread to Switzerland, where it was aggravated by a high exchange rate. In 1922 the number of unemployed was 130,000; these, together with their families, amounted to nearly one-fifth of the total population. Various remedies, including protection, were tried without success, and considerable financial sacrifices were necessary on the part of the community to provide relief for the unemployed. The idea of a capital levy was mooted; a proposal to that effect was put forward by the parties of the extreme Left, but was rejected by an enormous majority by a popular vote on Dec. 3, 1922. Since that time there has been a great improvement in the situation both from the economic and social points of view. (W. MA.)

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SWOLD (or Swold), **BATTLE OF,** the most famous of the sea-fights of the ancient Norsemen. It took place on Sept. 9, 1,000. The place cannot now be identified. Swold was an island probably on the North German coast, near Rügen. The battle was fought between Olaf Trygvesson, king of Norway, and a coalition of his enemies—Eric Hakonson, his cousin and rival; Olaf, king of Sweden; and Sweyn Forkbeard, king of Denmark.

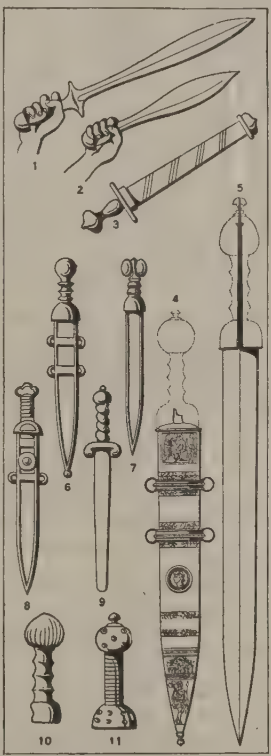
Olaf had been during the summer in the eastern Baltic. The allies lay in wait for him at the island of Swold on his way home. The Norse king had with him seventy-one vessels, but part of them belonged to an associate, Sigwald, a chief of the Jomsburg vikings, who was an agent of his enemies, and who deserted him. The allies allowed the bulk of the Norse ships to pass, and then stood out to attack Olaf.

The Norse writers, who are the only authorities, gave all the credit to their own countrymen, and according to them all the intelligence of Olaf's enemies, and most of their valour, were to be found in Eric Hakonson. They say that the Danes and Swedes rushed at the front of Olaf's line without success. Eric Hakonson attacked the flank. His vessel, the "Iron Ram," was "bearded," that is to say, strengthened across the bows by bands of iron, and he forced her between the last and last but one of Olaf's line. In this way the Norse ships were carried one by one, till the "Long Serpent" alone was left. At last she too was overpowered. Olaf leapt into the sea holding his shield edgeways, so that he sank at once and the weight of his hauberk dragged him down. A legend of later days has it that at the last moment a sudden blaze of light surrounded the king, and when it cleared away he had disappeared. King Olaf is one of that company of legendary heroic figures in whose death the people would not believe, and whose return was looked for.

See the *Heims-Kringla,* in the Saga Library, trans. by W. Morris and E. Magnússon (1893) and the *Saga of King Olaf Tryggwason,* trans. by J. Sephton (1895).

SWORD, a general term for a hand weapon of metal, characterized by a longish blade, and thus distinct from all missile weapons on the one hand, and on the other hand from staff weapons—the pike, bill, halberd, and the like—in which the metal head or blade occupies only a fraction of the effective length. The handle of a sword provides a grip for the hand that wields it, or sometimes for two hands; it may add protection, and in most patterns does so to a greater or less extent.

Early Forms.—Of the actual origin of swords we have no direct evidence. Neither does the English word nor any of the equivalent words in other languages, Aryan or otherwise, throw any light on the matter. Daggers shaped from reindeer antlers occur among the earliest relics of man, and there are flint daggers of the Neolithic period, which may be supposed to have been the model for the first hand weapons made of copper. Bronze took the place of copper about 2000 B.C., and the transition from bronze to iron in Europe is assigned to the period 1000 to 700 B.C. Whatever the further discoveries of archaeologists, we know that swords are found from the earliest times of which we have any record among all people who have acquired any skill in metal-work. There are two very ancient types, which we may call the straight-edged and the leaf-shaped. Assyrian monuments represent a straight and narrow sword, better fitted for thrusting than cutting. Bronze swords of this form have been found in many parts of Europe, at Mycenae, side by side with leaf-shaped specimens, and more lately in Crete. We have also from Mycenae some very curious and elaborately wrought blades, so broad and short that they must be called ornamental daggers rather than swords. The leaf-shaped blade is common everywhere among the remains of men in the "Bronze Period" of civilization, and this was the shape used by the Greeks in historical times, and is the shape familiar to us in Greek works of art. It is impossible, however, to say whether the Homeric heroes were conceived by the poet as wearing the leaf-shaped sword, as we see it, for example, on the Mausoleum sculptures, or a narrow straight-edged blade of the Minoan and Mycenaean pattern. In any case, the sword holds a quite inferior position with Greek warriors of all times. Strange as it is to a modern swordsman, representations in Minoan art seem to show that not only the bronze daggers but the long swords were used with an overhand stabbing action like a modern Asiatic dagger. The handles are too short for any but a rigid grip without finger-play. Before about 1500 B.C. the rapier type was the prevailing one; but there is no evidence of historical connection between the Assyrian and the Minoan rapiers. It is thought that the leaf-shaped blade came to the Mediterranean countries from the north. So far as we know from works of art, it was mostly used with a downright cutting blow, regardless of the consequent exposure of the swordsman's body; this, however, matters little when defence is left to a shield or armour, or both. Attic vases also show warriors giving point, though less often. The use of the sword as a weapon of combined offence and defence—swordsmanship as we now understand it—is quite modern. If the sword was developed from a spearhead or dagger, it would naturally have been (and it seems in fact to have been) a thrusting weapon before it was a cutting one. But when we come to historical times we find that uncivilized people use only the edge, and that the effective use of the point is a mark of advanced skill and superior civilization. The Romans paid special attention to it, and Tacitus tells us how Agricola's legionaries made short work of the clumsy and pointless arms of the Britons when battle was fairly joined. Asiatics to this day treat the sword merely as a cutting weapon, and most Asiatic swords cannot be handled in any other way.



FROM LINDENSCHMIDT, "TRACHTEN UND BEWAFFNUNG DES RÖMISCHEN HEERES" (VIEWEG)

FIG. 1.—GREEK AND ROMAN SWORDS 1–3. Greek, of the classical type. 4. So-called "Sword of Tiberius" from Mainz (British Museum). 5. Bonn (private collection), length 765mm. 6. Legionary monument at Wiesbaden. 7. Cavalry (monument at Mainz). 8. Cavalry (monument at Worms). 9. From Trajan's column. 10. & 11. Sword handles (Kiel and Mainz)

Historical Types.—The normal types of swords which we meet with in historical times, and from which all forms now in use among civilized nations are derived, may be broadly classified as straight-edged or curved. In the straight-edged type, in itself a very ancient one, either thrusting or cutting qualities may predominate, and the blade may be double-edged or single-edged. The double-edged form was prevalent in Europe down to the 17th century. The single-edged blade, or back-sword as it was called in England, is well exemplified among the Scottish weapons commonly but improperly known as claymores (the real claymore, *i.e.* great sword, *claidheamh mór,* is an earlier mediaeval form), and is now all but exclusively employed for military weapons. But these, with few exceptions, have been more or less influenced by the curved Oriental sabre. Among early double-edged swords the Roman pattern (*gladius,* the thrusting sword, contrasted with the barbarian *ensis*) stands out as a workmanlike and formidable weapon for close fight. In the middle ages the Roman tradition disappeared, and a new start was made from the clumsy barbarian arm which the Romans had despised. Gradually, the broad and all but pointless blade was lightened and tapered, and the thrust, although its real power was unknown, was more or less practised from the 12th century onwards. St. Louis anticipated Napoleon in calling on his men to use the point; and the heroes of dismounted combats in the *Morte d'Arthur* are described as "foining" at one another. In the first half of the 16th century a well-proportioned and well-mounted cut-and-thrust sword was in general use, and great artistic ingenuity was expended, for those who could afford it, on the mounting and adornment. The growth and variations of the different parts of the hilt would alone be matter enough for an archaeological study. One peculiar form, that of the Scottish basket-hilt, derived from the Venetian pattern known as *schiavone,* has persisted without material change.

Quite different from the European models is the crescent-shaped Asiatic sabre, commonly called scimitar. We are not acquainted with any distinct evidence as to the origin of this in time or place. The fame of the Damascus manufacture of sword-blades is of great antiquity, as is also that of Khurāsān. Whoever first made these blades had conceived a very definite idea—that of gaining a maximum of cutting power regardless of loss in other qualities—and executed it in a manner not to be improved upon. The action of the curved edge in delivering a blow is to present an oblique and therefore highly acute-angled section of the blade to the object struck, so that in effect the cut is given with a finer edge than could safely be put on the blade in its direct transverse section. In a well-made sabre the setting of the blade with regard to the handle ("leading forward") is likewise ordered with a view to this result. And the cutting power of a weapon so shaped and mounted is undoubtedly very great. But the use of the point is abandoned, and the capacities of defensive use (to which Orientals pay little or no attention) much diminished. These drawbacks have caused the scimitar type, after being in fashion for European light cavalry during the period of Napoleon's wars and somewhat longer, to be discarded in our own time. But, as long as Easterns adhere to their rigid grasp of a small handle and sweeping cut delivered from the shoulder, the Persian scimitar or Indian talwar will remain the natural weapon of the Eastern horseman. Indian and Persian swords are often richly adorned; but their true beauty is in the texture of the steel itself, the "damascening" or "watering" which distinguishes a superior from a common specimen.

There are special Asiatic varieties of curved blades of which the origin is more or less uncertain. Among these the most remarkable is perhaps the yataghan, a weapon pretty much coextensive with the Mohammedan world, though it is reported to be not common in Persia. It was imported from Africa, through a French imitation, as the model of the sword-bayonets which were common for about a generation in European armies. A compact and formidable hand weapon was thus turned into a clumsy and top-heavy pike. The double curve of the yataghan is substantially identical with that of the Gurkha knife (*kukri*), though the latter is so much broader as to be more like a woodman's than a soldier's instrument. It is doubtful, however, whether there is any historical connection. Similar needs are often capable of giving rise to similar inventions without imitation or communication. There are yet other varieties which have acquired a strong individuality. Such are the swords of Japan, which are the highly perfected working out of a general Indo-Chinese type; they are powerful weapons and often beautifully made, but a European swordsman would find them ill-balanced, and the Japanese style of sword-play, being

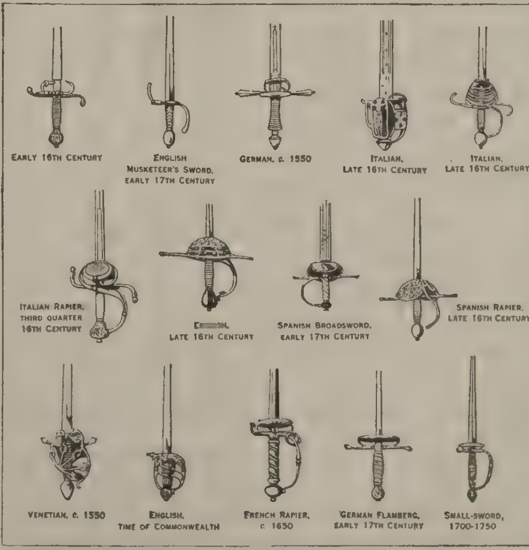

EARLY 16TH CENTURY
ENGLISH MUSKETEER'S SWORD, EARLY 17TH CENTURY
GERMAN, c. 1550
ITALIAN, LATE 16TH CENTURY
ITALIAN, LATE 16TH CENTURY
ITALIAN RAPIER, THIRD QUARTER 16TH CENTURY
ENGLISH, LATE 16TH CENTURY
SPANISH BROADSWORD, EARLY 17TH CENTURY
SPANISH RAPIER, LATE 16TH CENTURY
VENETIAN, c. 1550
ENGLISH, TIME OF COMMONWEALTH
FRENCH RAPIER, c. 1650
GERMAN FLAMBERG, EARLY 17TH CENTURY
SMALL-SWORD, 1700-1750
FROM CASTLE, "SCHOOL AND MASTERS OF FENCE" (BELL & SONS)

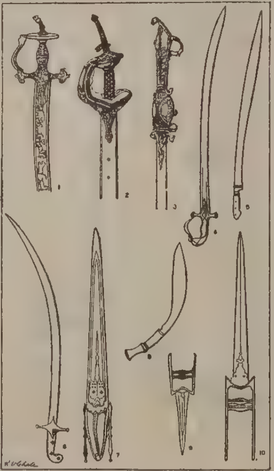
FIG. 2.—TYPICAL EUROPEAN SWORDS, 16TH AND 17TH CENTURIES

two-handed, has little to teach us.

Other sorts of weapons, again, are so peculiar in form or historical derivation, or both, as to refuse to be referred to any of the normal divisions. The long straight gauntlet-hilted sword (*paṭá*) found both among the Mahrattas in the south of India and among the Sikhs and Rajputs in the north, is an elongated form of the broad-bladed dagger with a cross-bar handle (*katár*), as shown by a transitional form, much resembling in its shape and the size of blade the mediaeval English anlace and furnished with a guard for the back of the hand. When once the combination of a long blade with the gauntlet hilt was arrived at, any straight blade might be so mounted; and many appear on examination to be of European workmanship—German, Spanish or Italian. There are various other Oriental arms, notably in the Malay group, as to which it is not easy to say whether they are properly swords or not. The Malay "parang latok" is a kind of elongated chopper sharpened by being bevelled off to an edge on one side, and thus capable of cutting only in one direction. The anlace incidentally mentioned above seems to be merely an overgrown dagger; the name occurs only in English and Welsh; in which language first, or whence the name or thing came, is unknown.

Later European Developments.—In the course of the 16th century the straight two-edged sword of all work was lengthened, narrowed, and more finely pointed, till it became the Italian and Spanish rapier, a weapon still furnished with cutting edges, but used chiefly for thrusting. We cannot say how far this transition was influenced by the *estoc* or *Panzerstecher,* a late mediaeval thrusting weapon carried by horsemen rather as an auxiliary lance than as a sword. The Roman preference for the point was rediscovered under new conditions, and fencing became an art. Its progress was from pedantic complication to lucidity and simplicity and the fashion of the weapon was simplified also. Early in the 18th century, the use of the edge having been finally abandoned in rapier-play, the two-edged blade was supplanted by the bayonet-shaped French duelling sword, on which no improvement has since been made except in giving it a still simpler guard. The name of rapier was often but wrongly given to this by English writers. About the same time, or a little earlier, the primacy of the art passed from Italy to France. There is still a distinct Italian school, but the rest of the world learns from French masters. It is unnecessary here to consider the history of fencing (*q.v.*).

Meanwhile a stouter and broader pattern, with sundry minor varieties, continued in use for military purposes, and gradually the single-edged form or broadsword prevailed. The well-known name of Ferrara, peculiarly associated with Scottish blades, appears to have originally belonged to a Venetian maker, or family of makers, towards the end of the 16th century. The Spanish blades made at Toledo had by that time acquired a renown which still continues. Somewhat later Oriental examples, imported probably by way of Hungary, induced the curvature found in most recent military sabres, which, however, is such as not to interfere with the effective use of the point. An eccentric specialized variety of the sabre is the narrow and flexible "Schläger" with which German students used to fight their duels, under highly conventional rules almost identical with those of the old English "back-swording" practised within living memory, in which, however, the swords were represented by sticks.

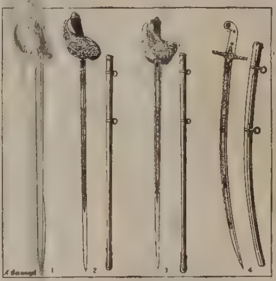


FROM EGERTON, "ILLUSTRATED HANDBOOK OF INDIAN ARMS" (HIGH COMMISSIONER FOR INDIA)

FIG. 3.—ORIENTAL SWORDS

1, 2. Decorated Persian Arms. 3. Gauntlet Sword. 4. Common type of talwar (North West Provinces). 5. Yataghan type. 6. Persian talwar. 8. Kukri (Nepal). 7, 9 & 10. Mahratta, showing transition to gauntlet sword

Modern Swords.—The present military swords are descended from the straight "back-sword" and the Eastern scimitar or talwar. The difference between the curved "sabre" and straight "sword" has been preserved in some languages (*e.g.,* in German, *Degen* stands for the straight, and *Säbel* for the curved, sword), though in English the single word "sword" covers both varieties. The shape of the sword has varied considerably at different times; this is due to the fact that it is practically impossible to decide by trial whether a straight or a curved sword is the better under all circumstances. The trooper can use his sword in three different ways—to cut, to guard and to point; and his success depends upon the training of his horse, his skill in horsemanship, and, above all, upon the dexterity and methods of his adversary. The result is that changes have often been made in cavalry armament under the erroneous impression that the arm used has been the main cause of success. The Ottoman cavalry up to the end of the 18th century was regarded as one of the best in Europe. The curved European cavalry sabre so long in use may undoubtedly be traced to this cause, the superiority of the Turks being put down to their curved scimitars, though horsemanship and dash were really the dominating factors.



BY COURTESY OF (2-4) THE WILKINSON SWORD CO.

FIG. 4.—TYPES OF GERMAN AND BRITISH SWORDS

1. German cavalry sword (men) pattern, 1889, 35in. long. 2. British cavalry sword (officers), 35⅛in. long. 3. British infantry sword (officers), 32½in. long. 4. British general officer's sword, 32½in. long

The shape of the sword to be chosen depends obviously on the purpose for which it is mainly intended. In this much-debated matter the facts appear to be as follows: A determined thrust, especially when delivered by a horseman at full speed, is difficult to parry: if it gets home, it will probably kill the recipient outright or disable him for the rest of the campaign. That this is the case is borne out by the very large proportion of killed as compared with wounded in the British cavalry when engaged with that of the French in the Peninsular War, the French making much use of the point, and their heavy cavalry being armed with a long straight sword. On the other hand, to deliver a bold thrust, while disregarding the uplifted sword of the adversary, and leaving one's own body and head open to an impending blow, demands complete confidence that the thrust will get home before the blow can descend. Such confidence can only be the fruit of long training, especially as it is the natural tendency of all men to cut when excited; therefore, in view of the excitement of the *mêlée,* it is considered by many unwise to adopt a sword with which a powerful cut cannot be delivered as well as an effective thrust. The swords adopted by most nations in recent times have represented a compromise. They have blades which are nearly straight, but of sufficient weight towards their points to enable an efficient cut to be delivered with them. France, however, in 1898 decided on a long straight sword designed wholly for thrusting practically identical with that which was in use about a century ago. The following year Great Britain introduced a slightly curved weapon, but in 1908 a new sword was adopted which has a long straight blade and is intended to be used chiefly for thrusting.

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Swordsmanship: Egerton Castle, *Schools and Masters of Fence from the Middle Ages to the Eighteenth Century* (with a critical bibl., 1892); C. A. Thimm, *Bibliography of Fencing and Duelling* (1896).

Technology: H. Williamson, *Engines of War* (1841); G. S. Marey Monge, *Mémoire sur les armes blanches* (Strassburg, 1841; trans. by Lt.-Col. Maxwell, 1860). For the technique of Japanese swords, *see* A. Dobrée, "Japanese Sword Blades" in the *Archaeological Journal*, vol. lxii., pp. 1–18 and pp. 218–255 (1905); and for the export of European blades to India *see* Lord Dillon, *ibid.*, p. 67 and pp. 69–72.

SWORDFISH (*Xiphias gladius*), a large fish, widely distributed in warm seas, purplish in colour, and with the snout prolonged to form a long, flat "sword." As in the mackerels, to which it is related, the caudal peduncle is slender and the caudal fin is widely forked. It reaches a weight of over 600 lb. It swims swiftly at the surface and feeds on other fishes, especially mackerel, and is said to dash into a school, killing a number with slashes of its sword. The flesh is red and oily and is valued as food; fisheries exist in the Mediterranean and off the Atlantic coast of America, the usual method being harpooning.

Related to the swordfish are the spear-fishes (*Tetrapturus*) and sail-fishes (*Histiophorus*): in these the rostrum is not flattened, but is spear-like, rounded in transverse section. Each genus has two or three species, all large fishes of warm seas. *Histiophorus nigricans* of the Atlantic is a beautiful fish, silvery and blue-backed, with the very large sail-like dorsal fin deep blue, with numerous round black spots. The members of this group are said to attack whales in company with killers (*Orca*) and it is certain that they frequently attack ships, presumably mistaking them for whales. The sword or spear may be driven into a wooden ship with such force that the fish, in order to get free, has to break it off short. In the Natural History Museum in London is a piece of timber, less than a foot square, containing the broken ends of three spears.

SWOYERSVILLE, an anthracite-mining borough of Luzerne county, Pennsylvania, U.S.A., 3 m. N. of the public square of Wilkes-Barre, with which it is connected by trolley and motor-bus lines. Pop. (1920) 6,876 (32% foreign-born white); 1928 local estimate 9,000.

SWYNFORD, CATHERINE (*c.* 1350–1403), wife of John of Gaunt, duke of Lancaster, was a daughter of Sir Payne Roelt, a knight who came to England from Hainault in the train of Edward III.'s queen, Philippa. About 1367 she married Sir Hugh Swynford (1340–1372), a Lincolnshire man, by whom she had a son, Thomas (*c.* 1368–1433), who was a friend and companion of Henry IV. Soon after her husband's death in 1372 Catherine became the mistress of John of Gaunt, and in 1396 she was married to him at Lincoln. She died at Lincoln on May 10, 1403. By John of Gaunt Catherine had four children, all of whom were born before their marriage. They were declared legitimate in 1397 and took the name of Beaufort from one of their father's castles in Anjou. (*See* BEAUFORT.)

SYAGRIUS (d. 487), the last of the independent Roman administrators of Gaul, was the son of Aegidius, who had seized Gaul while Ricimer was master of Italy. Defeated in 486 by Clovis, king of the Salian Franks, at the battle of Soissons, Syagrius fled, leaving his land at the mercy of the Franks. He sought refuge with Alaric II., king of the Visigoths, at Toulouse, but Alaric imprisoned him instead of granting him refuge, and delivered him up to Clovis. He was executed in 487, secretly and by the sword, according to Gregory of Tours.

SYBARIS, a city of Magna Graecia, on the Gulf of Tarentum, between the rivers Crathis (Crati) and Sybaris (Coscile), which now meet 3 m. from the sea, but in ancient times had independent mouths, was the oldest Greek colony in this region. It was an Achaean colony founded by Isus of Helice (about 720 B.C.), but had among its settlers many Troezenians, who were ultimately expelled. Placed in a very fertile, though now most unhealthy, region, and following a liberal policy in the admission of citizens from all quarters, the city became great and opulent, with a vast subject territory and daughter colonies even on the Tyrrhenian sea (Posidonia, Laus, Scidrus). For magnificence and luxury the Sybarites were proverbial throughout Greece, and in the 6th century no Hellenic city could compare with its wealth and splendour. At length contests between the democrats and oligarchs in which many of the latter were expelled and took refuge at Crotona, led to a war with that city, and the Crotoniats, with very inferior forces, were victorious. They razed Sybaris to the ground and turned the waters of the Crathis over its ruins (510 B.C.). Explorations have so far failed to lead to a precise knowledge of the site. The only discoveries have been (1) that of an extensive necropolis, some 8 m. to the west of the confluence of the two rivers, of the end of the first Iron age, known as that of Torre Mordillo, the contents of which are now preserved at Potenza; (2) that of a necropolis of about 400 B.C.—the period of the greatest prosperity of Thurii (*q.v.*)—consisting of tombs covered by tumuli, in some of which were found fine gold plates with mystic inscriptions in Greek characters.

SYBEL, HEINRICH VON (1817–1895), German historian, was born on Dec. 2, 1817, at Düsseldorf. Sybel was educated at the gymnasium of his native town, and then at the University of Berlin, where he came under the influence of Savigny and of Ranke, whose most distinguished pupil he was to become. In 1841 he settled at Bonn as *Privatdozent* in history. He was already known by his *Geschichte des ersten Kreuzzuges* (Düsseldorf, 1841; new ed., Leipzig, 1881; Eng. trans. by Lady Duff-Gordon, 1861). This was followed by a study on the growth of German kingship (*Die Entstehung des deutschen Königtums*, Frankfurt, 1844, and again 1881), after which he was appointed professor. In the same year (1844) Sybel came forward as an opponent of the Ultramontane party. In 1846 he was appointed professor at Marburg, while a seat in the Hessian Landtag gave him his first experience of political affairs. In 1848 he was present at Frankfurt, but did not sit in the National Assembly. His opposition to the revolutionary party made him unpopular with the mob, who broke his windows, as his liberalism made him suspected at court. He sat in the Erfurt parliament of 1850, and was attached to the Gotha party, which hoped for the regeneration of Germany through the ascendancy of Prussia. During the years of reaction that followed all political activity was impossible, but he was fully occupied with his great work, *Geschichte der Revolutionszeit 1789–1800*, for which he had made prolonged studies in the archives at Paris and elsewhere. The later editions of the earlier volumes are much enlarged and altered, and a new edition was published at Stuttgart in 1882. The first three volumes have been translated into English by W. C. Perry (1867–69). In this work he for the first time showed the connection between the internal and external history of France; he was also the first, by a systematic study of the records, to check and correct the traditional accounts of numerous episodes connected with the internal history.

In 1856 Sybel accepted the post of professor at Munich. Here he founded the *Historische Zeitschrift*, the original and model of the numerous technical historical publications which now exist. In the political excitement which followed the war of 1859 he found that he could not hope for the unreserved support of the king, and therefore in 1861 he accepted a professorship at Bonn, which he held till 1875. He was at once elected a member of the Prussian Lower House, and during the next three years was an active member, opposing the policy of Bismarck, not only on financial but also on the Polish and Danish affairs. In 1864 he did not stand for re-election. In 1866 he was one of the first to point out the way to a reconciliation between Bismarck and his former opponents. He had a seat in the Constituent Assembly of 1867, and while he joined the National Liberals he distinguished himself by his opposition to the introduction of universal suffrage, the effects of which he, as did many other Liberals, much distrusted. In 1874 he again accepted a seat in the Prussian parliament, supporting the Government against the Clericals, and after 1878 against the Socialists. In 1880 he retired.

In 1875 he had been appointed by Bismarck director of the Prussian archives. Under his superintendence was begun the great series of publications, besides that of the correspondence of Frederick the Great, in the editing of which he himself took part. His last years were occupied on his great work, *Die Begründung des deutschen Reiches durch Wilhelm I.* (Munich, 7 vols., 1889–94; Eng. trans., 1890–91), for which he was allowed to use the Prussian state papers, and was therefore enabled to write a history of his own time with full access to the most secret sources of information. As a history of Prussian policy from 1860 to 1866 it is of incomparable value. After the fall of Bismarck permission to use the secret papers was withdrawn, and therefore vols. vi. and vii., which deal with the years 1866 to 1870, are of less importance. He died at Marburg on Aug. 1, 1895.

SYCOPHANT, in ancient Greece the counterpart of the Roman delator (*q.v.*), a public informer (Gr. *συκοφάντης*). According to ancient authorities, the word (derived by them from *σῦκον*, "fig" and *φαίνειν*, "to show") meant one who informed against another for exporting figs (which was forbidden by law). This derivation is doubtful and the question is still contested. Any Athenian citizen was at liberty to accuse another of a public offence. Allusions to the sycophants are frequent in Aristophanes and the Attic orators. The word is now generally used in the sense of a cringing flatterer of the great.

See L. Whibley, *Companion to Greek Studies* (1916).

SYDENHAM, CHARLES EDWARD POULETT-THOMSON, 1st Baron (1799–1841), British statesman, was born on the 13th of September 1799, being the son of John Buncombe-Poulett-Thomson, a London merchant. After some years spent in his father's business in Russia and in London he was returned to the House of Commons for Dover in 1826. In 1830 he joined Lord Grey's ministry as vice-president of the board of trade and treasurer of the navy. A free-trader and an expert in financial matters he was elected M.P. for Manchester in 1832, a seat which he occupied for many years. He was continuously occupied with negotiations affecting international commerce until 1839, when he accepted the governor-generalship of Canada, where it fell to his lot to establish the union of Upper and Lower Canada. His services in establishing the Canadian constitution were recognized in 1840 by a K.C.B. and a peerage. He took the title of Baron Sydenham of Sydenham in Kent and Toronto in Canada. He died unmarried on the 4th of September 1841, when his peerage became extinct.

His *Memoirs* were published by his brother, G. J. Poulett Scrope, in 1843.

SYDENHAM, GEORGE SYDENHAM CLARKE, 1st Baron (1848–), British soldier and administrator, a leading authority on fortification, was born in Lincolnshire on July 4, 1848. Educated at Haileybury and Wimbledon, and afterwards at the Royal Military Academy, in 1868 he entered the Royal Engineers. Having served in various expeditions abroad, he returned to England in 1885, and was employed at the War Office until 1892. From 1894 to 1901 he was superintendent of the royal carriage factory at Woolwich. Sydenham earned a great reputation as an authority on military questions, particularly fortification. On his retirement from Woolwich he was made a member of the committee on War Office reorganization. In 1901 he was appointed governor of Victoria (Australia), and on his retirement in 1904 he became secretary to the Committee of Imperial Defence. From 1907 to 1913 he was governor of Bombay. He had been created G.C.M.G. in 1905, and in 1913 was raised to the peerage. In addition to his classic work on *Fortification* (1890; 2nd ed. 1907), his publications include *The Navy and the Nation* (1897), *Imperial Defence* (1898) and *Studies of an Imperialist* (1928).

SYDENHAM, THOMAS (1624–1689), English physician, was born on Sept. 10, 1624, at Wynford Eagle, Dorset, the son of a country gentleman. He received his M.B. from Oxford in 1648, and about the same time became a fellow of All Souls. After further study and a period of service in the Puritan army, Sydenham continued his researches at Montpellier. In 1663 he passed the examinations of the College of Physicians and was thereby able to practise in London. In 1676 he became M.D. of Cambridge. He died in London on Dec. 29, 1689.

Sydenham's fame among his contemporaries rested on his successful cooling treatment of smallpox, on his laudanum (the first form of a tincture of opium), and on his use of Peruvian bark in quartan agues. But his more important contributions to medicine soon became recognized, and he himself regarded as the English Hippocrates. He revived the Hippocratic idea of Epidemic Constitutions, and made an elaborate study of the variations in epidemics of different diseases according to different seasons, years and ages. Further, rejecting the traditional dogmas of medicine and insisting that observation should have precedence over theory, Sydenham diligently studied the natural histories of diseases and contended that most forms of ill-health could be ranked in certain definite species. His title of the founder of modern clinical medicine is warranted by his clear accounts of the diseases of his day, especially of malaria, plague, smallpox, hysteria and gout. Sydenham is also credited with the first diagnosis of scarletina and with the modern definition of cholera. Acute diseases, such as fevers and inflammations, he regarded as a wholesome effort of the organism to resist injurious influences operating from without, but chronic diseases he held to be due to a depraved state of the humours arising from errors of diet and methods of life.

Sydenham's chief works are: *Methodus curandi febres* (1666), which appeared in a 3rd edition under the better-known title of *Observationes medicae* (1676); two *Epistolae responsoriae* (1680), one "on Epidemics" and one "on the Lues venerea"; *Dissertatio epistolaris* (1682), an account of hysteria, and *Tractatus de podagra et hydrope* (1683), his famous description of gout. His last completed work, *Processus integri*, is an outline sketch of pathology and practice; twenty copies of it were printed in 1692, and, being a compendium, it has been more often republished both in England and in other countries than any other of his writings separately. A fragment on pulmonary consumption was found among his papers. His collected writings occupy about 600 pages 8vo, in the Latin, though whether that or English was the language in which they were originally written is disputed. The collected works appeared at Amsterdam (1683), and lastly in London (1846, edit. W. A. Greenhill). An Eng. trans., together with a biography, was produced by R. G. Latham (2 vols., London, 1848).

See also F. Picard, *Sydenham, sa vie, ses oeuvres* (1889); J. F. Payne, *T. Sydenham* (1900); and M. Greenwood, "Sydenham as an Epidemiologist," in the *Proceedings* of the Royal Soc. of Medicine (vol. xii., 1919).

SYDENHAM, a large residential district in the south of London, England, partly within the metropolitan borough of Lewisham (*q.v.*). The Crystal Palace (*q.v.*) is in this district.

SYDNEY, a city situated in the Sydney Basin (County Cumberland) is the capital of New South Wales, Australia, and lies (lat. 33° 52′ S., 151° 12′ E.) mainly on the south shore of Port Jackson somewhat south of the central east of the State. The oval-shaped area which extends from about Broken Bay (Hawkesbury River estuary) on the north to a little beyond Port Hacking on the south, and from the coast east of Sydney *c.* 40 miles inland (near Glenbrook) forms the lower part of a geological and tectonic basin which is disposed fairly symmetrically about the line Botany Bay–Penrith.

The Sydney Basin is enclosed on three sides by flattish highlands which are, moreover, deeply dissected and seamed with gorges by streams which now, for the most part, form part of the Hawkesbury system but which formerly had different (westward and north-westward) courses and were dislocated by the late (Tertiary?) uplift which raised the plateaux. On the seaward side, also, recent earth-movements have resulted in the drowning of river valleys and created spacious inlets—Port Hacking, Botany Bay, Port Jackson, Broken Bay—but here also the basin-edge structure is apparent in the upstanding cliffs which form an outer rampart along the coast and give rise, at the entrance of Port Jackson, to the famous Sydney Heads, great sandstone cliffs which admit between them a deep (80 ft. low-water) sea passage of a minimum breadth of ¾ mile.

The Sydney Basin is one of the largest coastal lowlands of the State, but its lack of easy land communications makes the presence and growth of Sydney seem somewhat surprising. The reasons are partly physical but more historical: the superiority of the deep and sheltered harbour, defensible yet easily accessible from the sea, gave it an advantage over the shallower and more open Botany Bay and the semi-silted Port Hacking, and when Governor Phillip, in 1788, removed the early settlement from Botany Bay, he chose the small deep-water cove at the head of which now stands Circular Quay, but where was then a fresh-running stream (Tank Stream) now obliterated.

Port Jackson, sheltered from the southerly gales, covers an area of 22 sq.miles and has a highly embayed coastline—a succession of romantic low bluffs and coves, still often densely wooded, giving a total shore-line of nearly 190 miles. It opens a way into the heart of the lowlands and upon its southern and lower shores (elevation 100 ft.) the original settlement grew. For some time it was, from the point of view of its founders, not only "the State," but "all Australia," and from it emanated, and upon it centred, much of the energy and initiative which built up the growing colony. Hence its triumph over physical obstacles, for the roads and the railways have had to cross the highlands at one of their most difficult sections, and, outside the basin, and apart from a few special areas—*e.g.*, mining centres, and also the tourist resorts (Katoomba, etc.) attracted by elevation and scenery—the barren and rugged highlands at a distance of 50 miles are still almost unoccupied. The city expanded rapidly (pop. 1861: 97,061; 1901: 487,932; 1921: 906,103) until (1926/7) the total Metropolitan Area counted 1,070,510 inhabitants (1927/8; 1,101,190) or *c.* 45·5% of the total population of the State. The metropolitan area includes the city proper (3,244 ac.; pop. 1926/7: 107,880) surrounded by an extensive group of suburbs (40 municipalities, together with the Ku-ring-gai Shire, and the islands, giving the total, 1,070,510 in 181 sq. miles.

The Metropolitan Area, however, as defined in 1919, now includes 7 additional municipalities and 3 shires giving a total pop. (1926/7) of 1,201,750 in 685 sq. miles. Thus what is virtually the Sydney Basin contains 50·7% of the total population of the State and has a density of 1,700·3 per sq. mile. (Sydney and suburbs alone: 5,742·5; other municipalities, etc., alone: 248·6 per sq. mile.) As the city grows, industrial and commercial occupation advances and the residential areas are pushed farther out. Thus the higher and less accessible northern shores of the harbour have developed mainly as residential areas (*e.g.*, Ryde, pop. 21,630). Industries are expanding along the south—Redfern (24,100), Paddington (26,750), Balmain (32,660)—and also westwards—Granville (16,800), Parramatta (16,400), Lidcombe (13,540)—so that residential areas are now developing further afield—along the south-east coast (Randwick: 66,870) and in the Botany Bay (*q.v.*) area—Bexley (18,100), Kogarah (25,000), Hurstville (18,390), Canterbury (60,450). The climate is in general healthy and invigorating, cool and bracing with westerly winds in winter (May to September inclusive), hot and sometimes unpleasantly humid in summer. The prevailing winds from October–April (inclusive) are from the north-east. Mean temps. range from 70·1° F in summer to 56·2° F in winter, with extremes 108·5° F and 35·9° F. Sydney is a city of sunshine: 2,168 hr. per annum. Rainfall is distributed throughout the year but shows an autumn and winter maximum (Feb.–July) and averages 47½ in. Sydney, besides its splendid site, has had the advantage of fine and easily procured building stone, the sandstones of Pyrmont and other local quarries. The old town had winding, narrow and relatively enclosed streets. In spite of much recent rebuilding—notably along the water-fronts—some of these persist and give the city an old-world flavour. The public buildings are, in many cases, notably fine, the two Cathedrals (Anglican and Roman Catholic), the University, Post Office, several of the Government offices, besides some of the public galleries, etc., being worthy of note. The main streets also offer excellent specimens of modern lay-out and substantial architecture, while many other buildings (Government House, etc.) have historical interest. The city is unusually well endowed with parks, recreation grounds, and pleasure resorts generally. The 647 ac. of parks, etc., within the city boundaries include Moore Park, the fine Botanic Gardens, the Domain, Hyde Park which commands many splendid views; in addition the Sydney Cricket Ground, the Royal Agricultural Society's Ground where is held annually the most famous agricultural show in the State. There are 6,000 ac. of similar reserves in the municipalities, and two national reserves: National Park, 16 miles south of Sydney (33,800 ac.) around Port Hacking, and the Kuringgai Chase (35,300 ac.) 15 miles north on Broken Bay—both with magnificent scenery—besides reserves at Parramatta and Botany Bay, making a total (1926) of 240,200 ac. reserves besides 440,000 ac. commons within the (greater) metropolitan area.

The harbour of Sydney, with its coves, creeks and bays, is a favourite pleasure resort, as are also such beaches as Manly for surf-bathing, etc. Sydney has an excellent and assured water-supply derived chiefly from the Nepean, Cataract and Cordeaux Rivers (347 sq.miles catchment), the reservoirs containing (1927) 80,000 million gal. Trams (375 m. of track of which 288 miles are electric, the remainder steam) and electric and steam railways serve the city and suburbs, ferries ply in the harbour, and the great Sydney Bridge now being constructed will span the harbour from Dawes Point (south) to Milson Point (north), have a total length of 3,770 ft.—(main arches' span, 1,675 ft.; headway for vessels passing beneath: 170 ft.)—and will carry a roadway (57 ft.), 2 footways, and 4 lines of railway. The bridge when completed (*c.* 1931) will probably be the largest bridge in existence. The city is, in respect of its social, educational and artistic life a leading city of the southern hemisphere.

There are 5,170 factories employing 135,500 hands in the Sydney Basin area (Cumberland County) and of these 4,880 factories and 128,500 hands are in the metropolitan area. Clothing, metal, machinery (including railway engineering) industries are the most important, food and drink preparation coming next. (For industrial areas and suburbs: *v. sup.*) Sydney is also the chief commercial, banking, warehousing and shipping centre of the State. Upon it are centralized the lines, not only from its own basin, but from a very large part of the State. Wheat, meat, butter, fruit and many other primary products find their way to the city, from inland or by coasting steamers, for consumption or for export, but most important and most characteristic is wool. Sydney is by far the largest wool-selling centre in Australia and its sales, which begin in Sept. and last for 8–9 months, are world-famous. Sales range from 107·5 mill.–374 mill. lb. (1913/4–1926/7), valued at £5·6–£26·4 mill. annually. Port Jackson (*v. sup.*) offers unrivalled opportunities for harbour development.

The Sydney Harbour Trust (constituted in the year 1901) has pursued a vigorous policy of development and improvement and largely transformed the earlier unsatisfactory state of much of the water-front. The principal wharves lie 4–5 miles from the Heads and close to the business centre of the city. The Trust controls *c.* 63,000 ft. of wharfage which is leased to shipping companies, etc. Woolloomooloo Bay (6,000 ft. wharfage) is the principal overseas harbour; Circular Quay (3,600 ft.) is used both for ferry and overseas traffic; Glebe Island (4,800 ft.) is the wheat-exporting harbour with modern appliances including an elevator of 6,500,000 bu. capacity, and there are also wool, timber, and other special cargo wharves, warehouses, etc. All these are on the southern shores and do not include ferry wharves, private jetties, etc. The Islands (9) in Port Jackson are either pleasure resorts or used for special (naval, fire-station, etc.) purposes. On Cockatoo Is. and at Woolwich are large graving docks. Some 7,500–8,500 vessels (7,500,000–9,130,000 tons) have entered Sydney Harbour in recent years, of which *c.* 2,400 (7,200,000 tons) are engaged in overseas, the remainder in inter-State (coasting), trade. In 1925/6, 1,765,000 tons of cargo were shipped (1,100,000 tons, £52,193,000, overseas) and 2,779,000 tons were discharged (1,936,000 tons, £62,180,000) from overseas. The total overseas trade is valued at £114,374,000, constituting Sydney easily the first port in Australia and one of the foremost in the British Empire.

See Griffith Taylor, "The Warped Littoral Around Sydney" in *Proc. Royal Soc. N.S.W.*, vol. lvii., 1923, and also in *Commonwealth Year Book*, No. 20, 1927, etc.; K. Ussher, *The Cities of Australia* (1928); *Official Year Book of N.S.W.* (1926–27).

SYDNEY, the chief city of Cape Breton county, Nova Scotia, on a good harbour, the eastern terminus of the Canadian National railway. Pop. (1921) 22,545. Formerly a quiet country town, it became between 1891 and 1901 the chief shipping port of the Dominion Coal company, and the site of the large works of the Dominion Iron and Steel company. On the opposite side of the harbour are the flourishing towns of North Sydney and of Sydney Mines. It is the starting point for the line of steamers to the Bras d'Or lakes, and a favourite summer resort.

SYED AHMAD KHAN, SIR (1817–1898): *see* SAYYID AHMAD KHAN, SIR.

SYENITE, in petrology, the group name for a class of plutonic rocks composed essentially of an alkali felspar and a ferromagnesian mineral. A special group of alkali-syenites is characterized by the presence of a felspathoid mineral (nepheline, leucite, analcime or sodalite).

The name was first used by Pliny for the rock occurring at Syene (Assuan) on the Nile in Upper Egypt. This rock, so extensively worked in ancient times for monumental structures, is a hornblende-granite with abundant quartz; Werner subsequently adopted the name for the class of rocks defined above, of which the type example is the hornblende-syenite of the Plauen'scher Grund, near Dresden. As essential constituents there occur soda-orthoclase and green hornblende with subordinate amounts of oligoclase felspar. The texture of syenites is like that of the granites, hypidiomorphic-granular. Mineralogically these rocks differ from granites only by the absence or scarcity of quartz. The alkali-felspars include orthoclase, perthite or albite, more rarely microcline, while the ferromagnesian mineral may be biotite, hornblende or pyroxene. In the alkali-syenites, the amphiboles or pyroxenes are frequently soda-bearing varieties. The more normal syenites are divisible into augite-, hornblende-, and biotite-syenites according to their prevalent dark-coloured mineral, but syenites are also divisible, as in the case of granites, into potash and soda syenites, according to the type of alkali-felspar. The accessory constituents include sphene, apatite, zircon, magnetite and pyrites. Quartz, except in the special group of alkali-syenites, is rarely absent, but never abundant. A special suite of accessory minerals, cancrinite, eudialyte eucolite, katapleiite, melanite, corundum, etc., is found in this latter class. Syenites are by no means common, and are not of equal importance with granites and diorites from a geological standpoint.

Among the potash syenites, are classed the original hornblende-syenite (Plauen), and the well known hornblende-syenite of Biella, Piedmont, of which analyses are given below.

The rocks known as nordmarkite, akerite, larvikite and pulaskite are classed among the soda syenites. Of these the first two are quartz-bearing and were originally described from the Oslo region (Norway). Nordmarkite is built up of pink microperthite and subordinate aegirine and arfvedsonite together with some quartz. Akerite is a quartz bearing augite-syenite with considerable plagioclase. The larvikites are augite-syenites with large cryptoperthitic (anorthoclase) felspars possessing a remarkable schiller structure. They are coarse-grained rocks, originally described from Larvik (Norway), and their great freshness and iridescent appearance when polished make them favourite ornamental stone for façades and pillars. The subordinate constituents are titaniferous augite, olivine, and barkevikitic hornblende. The pulaskite syenites, first described from the Fourche mountains, Ark., consist of soda-orthoclase, alkali-hornblende together with some biotite. The occasional presence of nepheline indicates their close relation to the nepheline-syenites (*q.v.*). Rocks transitional between syenites and diorites are known as monzonites (*q.v.*).

The following analyses show the chemical composition of a few of the principal types of syenite. They are characterized by a moderate amount of silica, relatively high alkalis and alumina, while lime and magnesia are more variable, but never in great amount.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O
1	60·52	16·65	2·97	2·15	2·32	4·73	4·43	4·39
2	59·37	17·92	6·77	2·02	1·83	4·16	1·24	6·68
3	59·88	17·87	2·67	1·50	1·04	2·01	7·96	5·69
4	58·88	20·30	3·63	2·58	0·79	3·03	5·73	4·50
5	58·97	16·33	2·72	4·14	2·72	4·29	4·10	4·54

1. Hornblende-syenite, Plauen'scher Grund, Dresden
2. Hornblende-syenite, Biella, Piedmont
3. Nordmarkite, Oslo, Norway
4. Larvikite, Larvig, Norway
5. Syenite (mean of 12 analyses).

(C. E. T.)

SYKES, SIR MARK, 6TH BARONET (1879–1919), English traveller and politician, was born on March 16, 1879, in London, the only son of Sir Tatton Sykes, 5th baronet. He was educated at Beaumont college, Windsor, at Monaco, at Brussels and at Jesus college, Cambridge. He served with the Yorkshire Militia in the South African War (1902). On his return he travelled for some time in Syria, Mesopotamia and southern Kurdistan, and, after a short period (1904–05) as secretary to George Wyndham in Ireland, was appointed honorary attaché to the British embassy in Constantinople.

At the outbreak of the World War he raised a battalion of the Yorkshire Regiment, but did not accompany it to France. He was sent by the Government on important special missions to Bulgaria, Serbia, Russia, Mesopotamia and Syria. His special knowledge and qualifications led, in 1915, to his participation in the Anglo-French conversations in London on the Syrian question. He was an enthusiastic advocate of Arab independence. The settlement arrived at is known as the "Sykes-Picot Agreement." Sykes then became attached to the Foreign Office and was on several occasions sent on missions to Egypt. He was on friendly terms with the Arabs and designed the flag under which they marched to Damascus. In 1918, hoping to reconcile the aims of the French and the Arabs, he established himself at Aleppo, and his diplomacy in a difficult position rendered valuable service to the Government. His efforts, however, told on his health and he died in Paris of influenza on Feb. 16, 1919.

His publications include: *Through Five Turkish Provinces* (1900); *Dar-ul-Islam* (1904); *Five Mansions of the House of Othman* (1909); *The Caliph's Last Heritage* (1915).

See Shane Leslie, *Mark Sykes, his Life and Letters* (1923); for the terms of the Sykes-Picot Agreement, *see* Temperley, *History of the Peace Conference at Paris* (vol. vi., 1924).

SYKES, SIR PERCY (MOLESWORTH) (1867–), British soldier, was born on Feb. 28, 1867, and educated at Rugby and Sandhurst. In 1888 he obtained a commission in the 16th Lancers, afterwards being transferred to the 2nd Dragoon Guards. In 1893 he began his travels in Baluchistan and Persia, in the course of which he founded the consulates for Kerman and Persian Baluchistan (1894) and in Seistan (1899). During the South African War, he was a member of the Intelligence department, and also commanded with distinction the Montgomery Imperial Yeomanry. After holding appointments as consul-general for Khurasan (1905–13), and for Chinese Turkistan (1915) he was created K.C.I.E. in 1915. In 1916 he was appointed with the rank of brigadier-general and the title of inspector-general, to organize a force of Persian troops to restore order in Southern Persia. This step was taken in consultation with the Persian Government. The force was to be 11,000 strong, and the Cossack brigade was to be raised to a similar strength. He landed at Bandar Abbas in March 1916. For an account of the campaign *see* PERSIA, CAMPAIGNS IN. Sykes held the post of G.O.C. in Southern Persia until the end of 1918. In 1919 he received the C.B., and he retired in Sept. 1920.

He has published accounts of his travels in *Ten Thousand Miles in Persia* (1902); *The Glory of the Shia World* (1910); *Through Deserts and Oases of Central Asia* (with Ella Sykes, 1920). He has also written a *History of Persia* (1915), a biography of Sir Mortimer Durant (1926) and articles for this *Encyclopædia.*

SYLHET, a town and district of British India, in the Surma valley division of Assam. The town is on the right bank of the river Surma, on rising ground, embowered in groves, and has a station on the Assam-Bengal railway. With a population (1921) of 16,912, it is, next to Shillong, the largest town in Assam. The chief institutions are the Murarichand college, Sanskrit college, Madrasa and leper asylum.

The DISTRICT OF SYLHET has an area of 5,680 sq. miles. It consists of the lower valley of the Surma or Barak river, and for the most part is a uniform level, broken only by scattered clusters of sandy hillocks called *tilas,* and intersected by a network of rivers and drainage channels. It is a broad and densely-cultivated plain. The rainfall is heavy, reaching an annual average of 159 in., of which over 100 in. fall between June and October.

In 1921 the population was 2,541,341. The normal cultivated area is 2,400,000 ac., giving an average of nearly an acre a head, but much of the district is low lying and subject to floods. Tea cultivation is a flourishing industry in the southern hills. The tea gardens had a population in 1921 of 169,000, with 90,000 ac. under tea and an output of 29,000,000 pounds. Lime is extensively quarried; under the Mogul Government Sylhet lime was a monopoly of the nawabs of Bengal. Other industries are boat-building and the manufacture of fine reed mats, buttons from fresh-water shells, ironwork inlaid with brass, and perfume: the perfume is exported to Turkey, Arabia and China.

SYLLABUS, literally something taken together, a collection (Late Lat. *syllabus*), hence a compendium, table or abstract giving the heads, outline or scheme of a course of lectures, teaching, etc. The word in the sense of a list or catalogue is used of a collection of eighty condemned propositions, addressed by order of Pius IX. to all the Catholic episcopate, under the date of the 8th of December 1864. The official title is: "A collection (*syllabus*) containing the principal errors of our times as noted in the Allocutions, Encyclicals and other Apostolic Letters of our Holy Father Pope Pius IX." Discussion of disputed doctrines began in 1849. All aspects were thoroughly debated by clerical and lay theologians gathered in a commission in 1861. The result of it was the Syllabus, in eighty propositions, arranged under the distinct heads; the propositions are not accompanied by any theological censure, but simply by a reference to the Allocution, Encyclical or Letter from which each had been more or less textually extracted. This was addressed to the episcopate together with a letter from Cardinal Antonelli, and dated the 8th of December 1864, the same date as the Encyclical *Quanta cura,* from which, however, it remains quite distinct. Its publication aroused the most violent polemics; what was then called the Ultramontane party was loud in its praise; while the liberals treated it as a declaration of war made by the Church on modern society and civilization. Napoleon III.'s government forbade its publication, and suspended the newspaper *l'Univers* for having published it. Controversies were equally numerous as to the theological value of the Syllabus. Most Catholics saw in it as many infallible definitions as condemned propositions; others observed that the pope had neither personally signed nor promulgated the collection, but had intentionally separated it from the Encyclical by sending it merely under cover of a letter from his secretary of state; they said that it was hastily, and sometimes unfortunately drawn up (*cf.* prop. 61); they saw in it an act of the pontifical authority, but without any of the marks required in the case of dogmatic definitions; they concluded, therefore, that each proposition was to be appreciated separately, and in consequence that each was open to theological comment. That such is the true view is proved by the fact that Rome never censured the theologians who, like Newman, took up this position. (The condemned propositions are given in convenient form in Latin and English in Schaff, *Creeds of Christendom,* vol. ii., "Greek and Latin Creeds," pp. 213 *sqq.*)

BIBLIOGRAPHY.—The documents from which the propositions of the Syllabus were borrowed have been collected together in the *Recueil des allocutions consistoriales,* etc., *citées dans l'encyclique et le syllabus* (Paris, 1865). For the history of the Syllabus: P. Hourat, *Le Syllabus, étude documentaire* (Paris, 1904); and P. Rinaldi, *Il Valore del sillabo* (Rome, 1888). For its theological value: Newman, *A Letter Addressed to his Grace the Duke of Norfolk* (London, 1875); P. Viollet, *L'Infallibilité du pape et le syllabus* (Paris, 1904); L. Choupin, *Valeur des décisions doctrinales et disciplinaires du Saint Siège* (Paris, 1907). *See* also Mgr. Dupanloup, *La Convention du 15 septembre et l'encyclique du 8 décembre* (Paris, 1865); and for the opposite view, *see* Trarieux, *Le Syllabus et la déclaration des droits de l'homme* (Paris, 1902).

SYLLOGISM, in logic, denotes a mediate argument, that is an argument in which an inference is drawn about the relation between two terms from two premises which state the relation of each of the two terms to the same third term. For instance, "The morning star is Venus; the evening star is Venus; therefore the evening star is the morning star" (or *vice versa*). It is usual to say that syllogism is not only mediate but also deductive reasoning, that is to say that it requires the application of a general premiss to relevant cases. For example, "All planets move in elliptical orbits; Venus is a planet; therefore Venus moves in an elliptical orbit." This argument is mediate, like the previous example; but it is also deductive (or involves the application of a general premiss, or a premiss concerning a whole class of objects) whereas the previous example was not deductive. Now, it is true that syllogisms are mostly deductive as well as mediate, but there is no sufficient reason for restricting the term to deductive cases only. Moreover, just as an argument may be mediate without being also deductive, so an inference may be deductive without being mediate. For instance, "All watches have a hair-spring; therefore my watch has one." It is also customary to restrict the term syllogism to arguments the propositions of which involve only relations of substance and attribute, as in the above examples. But for this also there is no good reason. The arguments (1) "$x=y$; $y=z$; therefore $x=z$," and (2) "M is north of P; S is west of M; therefore S is north-west of P," are also syllogisms. For, after all, "syllogism" means "thinking together" or, as one might say, "putting two and two together." It is true, however, that syllogisms involving other relationships than those of identity or of substance and attribute require special care, much more than the others. *See* LOGIC.

SYLT, the largest German island in the North Sea, being about 38 sq.m. in area and nearly 23 m. long. It is, however, very narrow, being generally about half a mile in width, except in the middle, where it sends out a peninsula to the east 7 m. across. It lies from 7 to 12 m. from the Schleswig coast. The chief places are Keitum, Tinnum, Morsum, Rantum and Westerland. The latter is a favourite pleasure resort. During the Danish War of 1864 the island was in the hands of the Danes but was occupied by the Prussians later in that year. (*See* FRISIAN ISLANDS.)

SYLVANITE, a mineral consisting of gold and silver telluride, $AuAgTe_4$, containing gold 24·2 and silver 13·3%; an important ore of gold. Crystals are monoclinic and often very rich in faces; they are frequently twinned, giving rise to branching forms resembling written characters; on this account the mineral was early known as "graphic gold" or "graphic tellurium" (Ger. *Schrifterz*). It was also known as "white gold," the colour being tin-white with a brilliant metallic lustre. The hardness is 2, specific gravity 8·2. It occurs with native gold in veins traversing porphyry at Offenbánya (=Baia de Arieș) and Nagyág (=Săcărâmb) in Transylvania (from which country it takes its name); also at several places in Boulder county, Colorado, and at Kalgoorlie in Western Australia. Sylvanite may be readily distinguished from calaverite, $AuTe_2$, by its perfect cleavage in one direction (parallel to the plane of symmetry), but in this character it resembles the very rare orthorhombic mineral krennerite ($[Au, Ag]Te_2$).

SYLVESTER, JOSHUA (1563–1618), English poet, the son of a Kentish clothier, was born in 1563. He was in 1591 in the service of the Merchant Adventurers' Company, and from 1606 had a small pension from Prince Henry. He was stationed, in his business capacity, at Middelburg, in the Low Countries, where he died on Sept. 28, 1618. He translated into English heroic couplets the scriptural epic of Guillaume du Bartas. His *Essay of the Second Week* was published in 1598; and in 1604 *The Divine Weeks of the World's Birth.* Sylvester's popularity ceased with the Restoration, and Dryden called his verse "abominable fustian."

His works were reprinted by Dr. A. B. Grosart (1880) in the "Chertsey Worthies Library." *See* also C. Dunster's *Considerations on Milton's early Reading* (1800).

SYLVIIDAE: *see* WARBLER.

SYLVITE, a mineral consisting of potassium chloride, KCl, first observed in 1823, as an encrustation on Vesuvian lava. Well-formed crystals were subsequently found in the salt deposits of Stassfurt in Prussia and Kałusz in Poland. It crystallizes in the cubic system with the form of cubes and cubo-octahedra and possesses perfect cleavages parallel to the faces of the cube. Although the crystals are very similar in appearance to crystals of common salt, they are proved by etching experiments to possess a different degree of symmetry, namely plagihedral-cubic, there being no planes of symmetry but the full number of axes of symmetry. Crystals are colourless (sometimes bright blue) and transparent; the hardness is 2, specific gravity 1·98. Like salt, it is highly diathermanous. The name sylvite or sylvine is from the old pharmaceutical name, *sal digestivus sylvii,* for this salt. (L. J. S.)

SYMBIOSIS, a mutually beneficial internal partnership between two organisms of different kinds, such as sea-anemone and unicellular algae. It differs from commensalism, where the partnership is external, as in the case of some hermit-crabs (e.g., *Pagurus bernhardus*) which have as constant companions certain sea-anemones (e.g., *Adamsia rondeletii*). It also differs from endoparasitism, which is not beneficial to the host; though it is possible that some symbionts or symbions, *e.g.,* the bacteria in the root-tubercles of Leguminosae, began as parasites; and that some parasites began as symbionts. The term mutualism is often used to cover both symbiosis and commensalism; and the term commensalism is sometimes used as equivalent to mutually beneficial symbiosis. This unnecessary confusion is increased when parasitism is called "antagonistic symbiosis."

The idea of symbiosis first became clear in regard to lichens, which were shown to be mutually beneficial combinations of an alga and a fungus. This was demonstrated analytically by De Bary (1866) and others, while Rees and Stahl were subsequently successful in building up a lichen synthetically from the appropriate alga and fungus. Symbiosis between two different plants is also illustrated by the numerous cases of mycorhiza (*q.v.*), where a fungus has entered into intimate and profitable partnership with the roots of other plants, such as oaks, pines and orchids. Sometimes, as in the case of heather, the partner fungus spreads through the whole plant, from root to stem, from leaf to flower, and even into the seed. It is this partnership with a fungus that enables the heather to flourish on the soil of the moorland where few other plants can survive. This mycorhiza-relation is now known to be very common, and it occurs in various forms. Thus the fungus may be ectotrophic, investing the roots externally, as in the beech; or it may be endotrophic, penetrating into the internal tissue, as in orchids. Also symbiotic is the occurrence of tubercle-forming bacteria (e.g., *Bacillus radicicola*) in the roots of leguminous plants, a linkage of great importance, inasmuch as the bacteria are able, in some way not yet clear, to capture and fix the free atmospheric nitrogen.

A second form of symbiosis is between an animal and an included unicellular green alga, such as *Zoochlorella.* The plant is sheltered, and it may be borne about by the animal, whose respiratory carbon dioxide it can utilize in its photosynthesis. The animal profits by the oxygen given off by its minute partners, and it can also utilize the carbon-compounds which the algae build up. Some green animals—green because of the included algae—can flourish for a long time without any extraneous food, being sufficiently sustained by what their symbionts supply. Most animals of a green colour are green because of these partner-plants, many of which are included in the genera *Zoochlorella* and *Zooxanthella.* This was first made clear by Cienkowsky, Geddes and Brandt in regard to the "yellow cells" found inside radiolarians, whose symbiosis probably contributes to the great wealth of numbers and of species exhibited by these pelagic Protozoa. While there seem to be some Protozoa, such as euglenids and *Vorticella viridis,* which have chlorophyll corpuscles of their own, most of the green or greenish Protozoa, e.g., *Stentor,* owe the colour to their symbionts. The same is true for freshwater sponges, *Hydra viridis,* some sea-anemones, most reef-corals, numerous Alcyonarians, some Turbellarians, and a few higher forms, *e.g.,* a polyzoon and a sea-slug. Very interesting is the small turbellarian worm, *Convoluta roscoffensis,* which creeps from the sand and forms green patches on the flat beach at Roscoff, in Brittany, when the tide goes out. Its life has become intimately wrapped up with a symbiotic alga, one of the Chlamydomonadineae. As Keeble has well shown, there are four chapters in the history of *Convoluta.* The very young worm feeds independently. Then green symbionts appear and multiply, and the worm is nourished from within as well as from without. Thirdly *Convoluta* ceases to take any solid food and depends entirely on the photosynthetic activity of the symbions. Finally, the animal digests its partners, and, having done so, dies.

A third type of symbiosis, especially studied by Buchner, is seen in many insects where fungoid plants, *e.g.,* bacteria and yeasts, live in the lining cells of the food-canal and assist in some obscure way in the process of digestion. These intracellular symbionts are known in at least seven orders of insects, especially in types that feed on dry wood and the like. The fungoid infection usually takes place in the egg-cell. In some cases there is a special organ or "mycetome" for the multiplication of the symbionts. In a few luminescent marine animals, *e.g.,* some cuttlefish, (such as *Sepiola elegans*) there is considerable evidence that the light is produced by symbiotic bacteria.

A similar type of symbiosis is illustrated by the wood-eating species of termites, which have remarkable infusorians in their food-canal. These are essential to the health of the termites which die when bereft of them. Their symbiotic function is to digest the wood, which no higher animal is able to do. Thus there may be symbiosis between plant and plant, between plant and animal, or between animal and animal.

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SYMBOL, the term given to a visible object representing to the mind the semblance of something which is not shown but realized by association with it. One of the first symbols of the Saviour, the fish, was derived from an acrostic of the Greek word *ἰχθύς*, the component letters of which were the initials of the five words *’Ιησοῦς Χριστός, Θεοῦ Υἱός, Σωτήρ,* Jesus Christ, Son of God, Saviour. The ship, another early symbol, represented the Church, in which the faithful are carried over the sea of life. Other symbols are those which were represented by animals, real or fabulous, and were derived from Scripture: thus the lamb typified Christ from St. John's Gospel (i. 29 and 36), and the lion from the Book of Revelation, where (v. 5) Christ is called the "Lion of the tribe of Juda." The peacock stood for immortality; the phoenix for the Resurrection; the dragon or the serpent for Satan; the stag for the soul thirsting for baptism. The sacred monogram Chi Rho, ☧ supposed to have been the celestial sign seen by the emperor Constantine on the eve of the defeat of Maxentius, represents the two first letters of the Greek word Χριστός which Constantine figured on his labarum, or standard, and is found on early Christian coins bearing also the favourite decoration of the Byzantine sarcophagi.

SYMBOLISM: *see* Painting.

SYMBOLISTS, THE, the name given to a large but loosely connected group of French poets (many of them of foreign extraction) writing in the 1880's. The term *décadent* was often used as an alternative, especially of the extreme manifestations of the movement. In 1888 the critic Brunetière suggested that the history of French poetry from the 17th century could be plotted in three phases, the architectural, the pictorial and the musical. Bearing this programme in mind and taking as examples from his own literature Dryden's *Ode to Mistress Anne Killigrew,* Keats's *Ode on a Grecian Urn* and Tennyson's *Claribel,* the English reader will best understand the scope and extension of the Symbolist movement. In its origin the movement was a revolt against Naturalism as being too concrete, and against Parnassianism as being too clear-cut, to satisfy young minds who had caught from E. A. Poe and Baudelaire, from Wagner, and to some extent from the Pre-Raphaelites, the "sense of the ineffable" and were seeking a medium for its expression. Their object was not to declaim, not to depict, and least of all to transcribe, but to suggest: to communicate in their lost subtlety the most intimate and evanescent tones of experience. Baudelaire himself, Banville, Gérard de Nerval and Villiers de l'Isle Adam had already been engaged in the same quest. The common stock of poetic symbolism has been accumulated to serve common uses: a private symbolism, unless it is forced into currency by a great poet, is bound to be largely unintelligible and will often be suspected at least to be nonsense. It is not surprising therefore that the French public was at first half inclined to regard the new poetry as a hoax, and on the other hand to take seriously a volume of parodies *Les Déliquescences d'Adoré Floupette* (1885) which first made it popularly familiar. But in the meantime Verlaine had entered the circle; he gave it a watchword: "Pas de couleur, rien que la nuance," and in his book *Trois Poètes Maudits* introduced the young decadents to their true masters, Rimbaud, Corbière, Mallarmé. The year 1885 may be taken as the centre of the movement; besides the three already mentioned, Rodenbach, Verhaeren and Jean Moréas had then already appeared: Laforgue, H. de Régnier and Vielé Griffin published their first volumes in 1885, and they were followed by Rémy de Gourmont in 1886, Maeterlinck in 1889, Claudel in 1890, Robert de Montesquieu in 1893. With Samain's first volume in this last year the movement may be said to rejoin the main stream. Its principal representative, in prose, had been J. K. Huysmans: as poets, Rimbaud, Verlaine and Mallarmé, still after 40 years dominant influences in French literature. It was Mallarmé who provided the symbolists with their aesthetic theory and the most accomplished models of metric style, and in the whole course of the movement his weekly conversations were probably the most effective influence at work—an influence not unfelt in England, where it coincided with the aesthetic movement and the Celtic renascence.

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SYME, JAMES (1799–1870), Scottish surgeon, was born in Edinburgh on Nov. 7, 1799. His chemical experiments at the university led to the discovery that a substance obtainable from coal tar would dissolve india-rubber, and could be used for waterproofing silk and other textile fabrics, an idea patented a few months afterwards by Charles Mackintosh, of Glasgow. From 1818 he held resident appointments in the infirmary and the fever hospital, and in 1823 took charge of the anatomy classes of Robert Liston. In 1824–25 he started the Brown Square school of medicine, and later a surgical hospital of his own, Minto House hospital, which he carried on from 1829 to 1833 with great success as a surgical charity and one of the first schools of clinical instruction. In 1833 he became professor of clinical surgery in the university, a post which he held until his acceptance of the chair of clinical surgery at University college, London, in 1847. Misunderstanding concerning the conditions of this appointment led him to return to his old position in Edinburgh, where he was recognized as the leading consulting surgeon of Scotland. In 1849 he broached the subject of medical reform in a letter to the lord advocate and in 1854 and 1857 addressed open letters to Lord Palmerston. In 1858 a Medical Act was passed which largely adopted his suggestions, and he became a member of the general medical council called into existence by the act. In April 1869 he had a paralytic seizure and died near Edinburgh on June 26, 1870.

Among Syme's labours may be mentioned his early papers on the nature of inflammation, his demonstrations of the function of the periosteum in the repair of bone, his introduction into Britain of excision of the elbow and of amputation at the ankle-joint, his treatment of ulcers by blistering, his study of diseases of the rectum and his general improvements in plastic surgery.

In 1831 he published *On the Excision of Diseased Joints* (the celebrated ankle-joint amputation is known by his name); in 1832 *Principles of Surgery; Diseases of the Rectum* in 1838; *Stricture of the Urethra and Fistula in Perineo* in 1849 and *Excision of the Scapula* in 1864; *Contributions to the Pathology and Practice of Surgery* in 1848 and *Observations in Clinical Surgery* in 1861.

See R. Paterson, *Memorials of the Life of James Syme* (1874).

SYMEON, "the Great," Bulgarian tsar (? –927) succeeded his father Boris (*q.v.*) in 893, after the short intervening reign of his dissolute elder brother, Vladimir. Educated in Constantinople, Symeon was probably destined by his father for the archbishopric of Bulgaria, and at one time took monastic orders.

His dominant ambition, himself to ascend the imperial throne of Byzantium—an aspiration afterwards shared by many Bulgarian tsars—led Symeon to embark on many wars with the empire (894, 896, 913, 917, 923). He never took Constantinople, although it was more than once at his mercy; but he took for himself the title of "Tsar of all the Bulgarians" (918) and raised the archbishop of Bulgaria to the rank of a patriarch. In the Balkans he extended the power of Bulgaria over south Macedonia, south Albania and Serbia, which became his vassal; but Bulgaria's shadowy dominion north of the Danube was probably lost during his reign. Symeon was twice married, and left four sons, of whom the second, Peter, succeeded him.

SYMEON METAPHRASTES, the most renowned of the Byzantine hagiographers. The menology of Metaphrastes, who is thought to have lived in the second half of the 10th century, is a collection of lives of saints for the twelve months of the year, consisting of about 150 distinct pieces, some of which are taken bodily from older collections, while others have been subjected to a new recension (μετάφρασις). Among other works attributed (though with some uncertainty) to Symeon are a *Chronicle,* a canonical collection, some letters and poems, and other writings of less importance. The Greeks honour him as a saint on Nov. 28, and an office has been composed in his honour.

See A. Ehrhard, *Die Legendensammlung des Symeon Metaphrastes* (Rome, 1897).

SYMMACHUS, QUINTUS AURELIUS (*c.* 345–410), was a brilliant representative of 4th-century paganism in Rome. He was educated in Gaul, and in 373 was pro-consul of Africa (for his official career see *C.I.L.* vi. 1699). His public dignities, which included that of pontifex maximus, his great wealth and high character, added to his reputation for eloquence, marked him out as the champion of the pagan senate against the Christian emperors. In 382 he was banished from Rome by Gratian for his protest against the removal of the statue and altar of Victory from the senate-house, and in 384, when he was prefect of the city, he addressed to Valentinian II. a letter praying for the restoration of these symbols. After this Symmachus was involved in the rebellion of Maximus, but obtained his pardon from Theodosius, and appears to have continued in public life up to his death. In 391 he was Consul ordinarius. His honesty, both in public and in private affairs, and his amiability made him very popular. As his letters do not extend beyond the year 402, he probably died soon after that date.

Of his writings we possess: (1) *Panegyrics,* written in his youth, two on Valentinian I. and one on the youthful Gratian. (2) Nine books of Epistles. (3) Parts of *Complimentary Orations,* five from a palimpsest (also containing the *Panegyrics*), of which part is at Milan and part in the Vatican, discovered by Mai, who published the Milan fragments in 1815, the Roman in his *Scriptorum veterum nova collectio,* vol. i. (1825), and the whole in 1846. (4) The *Relationes,* which contain an interesting account of public life in Rome, composed for the emperor. All earlier editions are now superseded by that of O. Seeck in *Monumenta Germaniae historica. Auctores antiquissimi* (1883), vi. 1, with introductions on his life, works and chronology.

SYMMACHUS, pope from 498 to 514, had Anastasius II. for his predecessor and was himself followed by Hormisdas. He was a native of Sardinia, apparently a convert from paganism, and was in deacon's orders at the time of his election. The choice was not unanimous, another candidate, Laurentius, having the support of a strong Byzantine party; and both competitors were consecrated by their friends, the one in the Lateran Church and the other in that of St. Mary, on Nov. 22, 498. A decision was obtained in favour of Symmachus from Theodoric, to whom the dispute had been referred; but peace was not established until 505 or 506, when the Gothic king ordered the Laurentian party to surrender the churches of which they had taken possession. An important incident in the protracted controversy was the decision of the "palmary synod." The remainder of the pontificate of Symmachus was uneventful; history speaks of various churches in Rome as having been built or beautified by him.

SYMMETRIC FUNCTIONS: *see* EQUATIONS, THEORY OF.

SYMMETRY, due proportion of parts; in geometry, the metrical correspondence of parts with reference to a median plane or line or point; and, in algebra, the correspondence of terms in a function in such a way that the function is unaltered when any two variables on which it depends are interchanged. (*See* FUNCTION.) The word is derived from the Greek *συμμετρία, symmetri'a,* due proportion, from *σύν, syn,* with, and *μέτρον, metron,* measure. In botany it implies agreement in number and distribution of parts among the organs of a flower; and, in zoology, it implies symmetrical disposition of parts around a line in the body or on opposite sides of a plane through the body. The term is also used with various derived meanings in architecture, aesthetics, crystallography, etc., and it appears even in certain ancient theories (as that of Herodotus, for instance) concerning the distribution of rivers, etc., on the earth.

SYMONDS, JOHN ADDINGTON (1840–1893), English critic and poet, was born at Bristol, on Oct. 5, 1840. He was the only son of John Addington Symonds, M.D. (1807–71), and was educated at Harrow and at Balliol college, Oxford, where he won many distinctions. In 1862 he became a fellow of Magdalen. His health broke down under the strain of study, and he went to Switzerland to recuperate. There he met Janet Catherine North, whom he married in 1864. They lived at Clifton, where he lectured in the well-known schools. At Clifton he wrote his *Introduction to the Study of Dante* (1872) and his admirably vivid *Studies of the Greek Poets* (1873–76). Meanwhile he was occupied upon his *Renaissance in Italy* (7 vols., 1875–86), which remains a classic authority in English on its subject. His work, however, was again interrupted by illness, and in 1877 his life was in acute danger. He recovered at Davos Platz, and from that time onwards he practically made his home there.

His works written in his Swiss exile include biographies of Shelley (1878), Sir Philip Sidney (1886), Ben Jonson (1886), and Michelangelo (1893), several volumes of poetry and of essays, and a fine translation of the *Autobiography of Benvenuto Cellini* (1887). There, too, he completed his study of the *Renaissance,* the work by which he will be longest remembered. For many years he spent the autumn in the house of his friend, Horatio F. Brown, on the Zattare, in Venice. He died at Rome on April 19, 1893, and was buried close to Shelley.

See Horatio F. Brown, *Life of John Addington Symonds* (from his letters) (2 vols., 1895), and V. W. Brooks, *Biographical Study of John Addington Symonds* (1914).

SYMOND'S YAT, one of the most famous view points on the river Wye, England. It stands on the river Wye 9 m. above Monmouth and 12 m. below Ross, on a deeply incised meander nearly 5 m. long and 600 yd. across the neck. The peninsula forms Huntsham Hill (Carboniferous limestone), in which there are caverns. The Yat or Gate is situated on the west side of the neck (height 500 ft.) and a road from the east drops to a ferry, which was of early importance. The Yat is in Herefordshire, but the railway station (G.W.R.) is in Gloucestershire. There are cottages and inns on both banks, New Weir is opposite the Yat and a little above it is Whitchurch, both small villages. The river banks are densely wooded, except where they become sheer cliffs, as at the Coldwell rocks above the station. The views from the Yat embrace the Forest of Dean to the south and east, and are backed by the mountains of the Welsh border in the west.

SYMONS, ARTHUR (1865–), English poet and critic, was born in Wales on Feb. 28, 1865, of Cornish parents. He was educated privately, spending much of his time in France and Italy. In 1884–86 he edited four of Quaritch's *Shakespeare Quarto Facsimiles,* and in 1888–89 seven plays of the "Henry Irving" Shakespeare. He became a member of the staff of the *Athenaeum* in 1891, and of the *Saturday Review* in 1894. His first volume of verse, *Days and Nights* (1889), consisted of dramatic monologues. His later verse is influenced by a close study of modern French writers (of Baudelaire, and especially of Verlaine) whose work he was one of the first Englishmen to appreciate and to introduce to English readers. He reflects French tendencies both in the subject-matter and style of his poems.

His volumes of verse include: *Silhouettes* (1892), *London Nights* (1895), *Amoris victima* (1897), *Images of Good and Evil* (1899), *A Book of Twenty Songs* (1905). In 1902 he made a selection from his earlier verse, published as *Poems* (2 vols.). He translated from the Italian of Gabriele d'Annunzio *The Dead City* (1900) and *The Child of Pleasure* (1898), and from the French of Émile Verhaeren *The Dawn* (1898). To *The Poems of Ernest Dowson* (1905) he prefixed an essay on the deceased poet, who was a kind of English Verlaine and had many attractions for Symons. Among his volumes of collected essays are: *Studies in Two Literatures* (1897), *The Symbolist School in Literature* (1899), *Cities* (1903), word-pictures of Rome, Venice, Naples, Seville, etc., *Plays, Acting and Music* (1903), *Studies in Prose and Verse* (1904), *Spiritual Adventures* (1905), *Studies in Seven Arts* (1906). His later works include: *Studies in Elizabethan Drama* (1920); *Charles Baudelaire* (1921); *Translations from Baudelaire* (1925); *A Study of Thomas Hardy* (1927); *Studies in Strange Souls* (*Rossetti and Swinburne*) (1929).

See T. E. Welby, *Arthur Symons, A Critical Study* (1925) pp. 147.

SYMPATHETIC SYSTEM, in physiology. By the "sympathetic system" is understood a set of nerves and ganglia more or less sharply marked off from the cerebro-spinal, both functionally and anatomically. (For anatomy *see* NERVOUS SYSTEM.) Formerly it was thought more independent from the rest of the general nervous system than recent discoveries have found it actually to be. The sympathetic system is now known to consist entirely of conducting paths which, like the nerve-trunks of the cerebro-spinal system, merely conduct nerve impulses either toward the great nervous centres of the spinal cord and brain, or, on the other hand, away from those great centres. In the cerebro-spinal nerves the preponderance of the conduction is toward the centres, in the sympathetic system the preponderance of conduction is away from the centres.

More is known of the sympathetic system from its efferent aspect than its afferent, and we shall consider the former first. One great difference between the efferent paths of the sympathetic and those of the ordinary cerebro-spinal system is that the former carry nervous impulses not only to muscular tissue but to secreting glands, whereas the latter convey them to muscle only, indeed only to muscle of the striated kind. Another difference is that the efferent path which the sympathetic affords from the great central nervous centres to its muscles and glands consists always of *two* nerve-cells or neurones, whereas the efferent path afforded by the cerebro-spinal motor nerves consists of one neurone only. The two neurones forming the sympathetic path are so arranged that one of them whose cell-body lies in the spinal cord has a long axon-process passing out from the cord in the motor spinal root, and this extends to a group of nerve-cells, a sympathetic ganglion, quite distant from the spinal cord and somewhere on the way to the distant organ which is to be innervated. In this ganglion the first sympathetic neurone ends, forming functional connection with ganglion cells there. These ganglion cells extend each of them an axon-process which attains the organ (muscular cell or gland cell), which it is the office of the sympathetic path to reach and influence. The axon-process of the first nerve cell is a myelinated nerve-fibre extending from the spinal cord to the ganglion; it constitutes the pre-ganglionic fibre of the conduction chain. The axon-process of the second nerve-cell, that is the neurone whose bell-body lies in the ganglion, is usually non-myelinate and constitutes the post-ganglionic fibre of the chain.

This construction, characteristic as it is of the sympathetic efferent path, has been found also in certain other efferent paths outside the sympathetic proper. And as these other efferent paths convey impulses to the same kind of organs and tissues as do those of the sympathetic itself, it has been proposed to embrace them and the sympathetic under one name, the *autonomic* system. This term includes all the efferent paths of the entire body excepting only those leading to the voluntary muscles.

That the term "autonomic system" is not merely a convenience of nomenclature, but really represents a physiological entity, seems indicated by the action of nicotine. This drug acts selectively on the autonomic ganglia and not on the cerebrospinal. In the former it paralyses the nexus between pre-ganglionic and post-ganglionic fibre. It is by taking advantage of this property that many of the recent researches which have done so much to elucidate the sympathetic have been executed.

The term "autonomic system" must not be taken to imply that this system is independent of the central nervous system. As mentioned above in regard to the sympathetic, that is not the case. The autonomic system is closely connected with the central nervous system through the ordinary channel of the nerve-roots, spinal and cranial. It may, in fact, be regarded as an appendage of certain of the cranial and spinal roots.

The sympathetic is that part of the autonomic system which is connected with the spinal roots from the second thoracic to the second lumbar inclusive (man). Its ganglia are divided by anatomists into the vertebral, those which lie as a double chain on the ventral face of the vertebral column, and those which lie scattered at various distances among the viscera, the pre-vertebral. Langley has shown that there is no essential difference between these except that the vertebral send some of their post-ganglionic fibres into the spinal nerves, whereas the latter send all their fibres to the viscera. The sympathetic sends its post-ganglionic fibres—

1. To the muscular coats of the whole of the alimentary canal from the mouth to the rectum; to the glands opening into the canal from the salivary glands in front back to the intestinal glands; to the blood vessels of the whole of the canal from mouth to anus inclusive.
2. To the generative organs, external and internal, and to the muscular coats of the urinary bladder.
3. To the skin; (*a*) to its blood vessels; (*b*) to its cutaneous glands; (c) to unstriated muscle in the skin; *e.g.*, the erectors of the hairs.
4. To the iris muscles and blood vessels of the eyeball.

The sympathetic nervous system is sometimes called the visceral. It will be seen from what has been said that this term is not well suited in some respects, because the sympathetic supplies many structures which are not visceral. Another objection is that a great deal of important nerve-supply to the viscera is furnished by parts of the autonomic system other than sympathetic. That the sympathetic does, however, of itself constitute a more or less homogeneous entity is indicated by a curious fact. The substance adrenalin has the property when introduced into the circulation of exciting all over the body just those actions which stimulation of the efferent fibres of the sympathetic causes, and no others. It is possible that when a nerve is stimulated some body at the nerve ending is set free, and this by combining with another chemical substance induces activity in the end organ (gland or muscle). It may be that when a sympathetic nerve is excited adrenalin is set free and combines with some substance which induces activity. (*See* ADRENALIN; SUPRA-RENAL EXTRACT.)

The rest of the autonomic system consists of two portions, a cranial and a sacral, so called from their proceeding from cranial and sacral nerve-roots respectively. The cranial portion is subdivided into a part belonging to the mid-brain and a part belonging to the hind-brain. The ciliary ganglion belonging to the eyeball is the ganglion of the former part, and its post-ganglionic fibres innervate the iris and the ciliary muscles. The hind-brain portion gives pre-ganglionic fibres to the facial (intermedius), glossopharyngeal and vagus nerves; its post-ganglionic distribution is to the blood vessels of the mucous membrane of the mouth and throat, to the musculature of the digestive tube from the oesophagus to the colon, to the heart, and to the musculature of the windpipe and lungs.

The sacral part of the autonomic system issues from the spinal cord with the three foremost sacral nerves. Its ganglia are scattered in the neighbourhood of the pelvic organs, which they innervate. The distribution of its post-ganglionic fibres is to the arteries of the rectum, anus and external genitalia and to the musculature of the colon, rectum, anus, bladder and external genitalia.

The part played by the sympathetic and the rest of the autonomic system in the economy of the body is best considered by following broad divisions of organic functions.

Movements of the Digestive Tube.—It is those movements of alimentation not usually within range of our consciousness which the autonomic system regulates and controls. Nor is its control over them apparently essential or very complete. For instance, the pendular and peristaltic movements of the intestine still go forward when all nerves reaching the viscus have been severed. Extirpation of the abdominal sympathetic has not led to obvious disturbance of digestion or nutrition in the dog. It is noteworthy that the sympathetic inhibits contraction of the musculature of the stomach and intestine, while the other, the vagus, portion of the autonomic system excites it.

Action on the Circulation.—The arterial blood supply of most organs is under the control of vaso-constrictor nerves. All vaso-constrictor nerves are sympathetic. Organs to which vaso-constrictor nerves are supplied either poorly or not at all are the lungs, heart, liver and probably the skeletal muscles. In some parts the capillary vessels are supplied with sympathetic constrictor nerves. The blood vessels of certain parts of the body have, in addition to vaso-constrictor nerves, nerves which relax their muscular wall, vaso-dilatory nerves. The latter are never furnished by the sympathetic, they are in the mucous membranes and glands at the oral end of the body furnished by the cranial portion of the autonomic system. In regions at the aboral end of the body they are furnished by the sacral portion of the autonomic system. Elsewhere the vaso-dilatators when present are derived from the nerve-cells of the spinal ganglia (Bayliss).

The control of the calibre of the blood vessels by the autonomic system is of importance in several well-ascertained respects. By constricting the blood vessels of the viscera the system is able to favour an increase of blood supply to the brain. A noteworthy instance of such an action occurs when the erect attitude is assumed after a recumbent posture. Were it not for vaso-constriction in the abdominal organs the blood would then, under the action of gravity, sink into the more dependent parts of the body and the brain would be relatively emptied of its supply, and fainting and unconsciousness result. Again, it is essential to the normal functioning of the organs of warm-blooded animals that their temperature, except in the surface layer of the skin, should be kept constant. Part of the regulative mechanism for this lies in nervous control of the quantity of blood flowing through the surface sheet of the skin. That sheet is a cool zone through which a greater or smaller quantity of blood may, as required, be led and cooled. By the sympathetic vaso-constrictors the capacity of these vessels in the cool zone can be reduced, and thus the loss of heat from the body through that channel lessened. In cold weather the vaso-constrictors brace up these skin vessels and lessen the loss of heat from the body's surface. In hot weather the tonus of these nerves is relaxed and the skin vessels dilate; a greater proportion of the blood then circulates through the comparatively cool skin-zone.

The heart itself is but a specialized part of the blood-vascular tubing, and its musculature, like that of the arteries, receives motor nerves from the sympathetic. These nerves to the heart from the sympathetic are known as the accelerators, since they quicken and augment the beating of the cardiac muscle. The heart receives also nerves from the cranial part of the autonomic system, and the influence of these nerves is antagonistic to that of the sympathetic supply. The cranial autonomic nerves to the heart pass via the vagus nerves and lessen the beating of the heart both as to rate and force. These inhibitory nerves of the heart are analogous to the dilatator nerves to the blood vessels, which, as mentioned above, come not from the sympathetic, but from the cranial and sacral portions of the autonomic system. The spleen which functions as a blood-reservoir (Barcroft) for the general circulation, discharges its reserves by contraction of its capsule and septa; its muscle is innervated by the sympathetic.

Skin-glands.—In close connection with the temperature regulating function of the sympathetic stands its influence on the sweat secreting glands of the skin. Secretory nerves to the sweat glands are furnished apparently exclusively by the sympathetic.

Pilomotor Nerves.—The skin in many places contains muscle of the unstriped kind. Contraction of this cutaneous muscular tissue causes knotting of the skin as in "goose-skin," and erection of the hairs as in the cat, or of the quills as in the hedgehog and porcupine. The efferent nerve-fibres to the unstriped muscles of the skin are always furnished by the sympathetic (pilomotor nerves, etc.). In this case the sympathetic contributes to emotional reactions and perhaps further to the regulation of temperature, as by ruffling the fur or feathers in animals exposed to the cold.

The Respiratory Tube.—The windpipe and the air passages of the lungs contain in their walls much unstriped muscular tissue, arranged so as to control the calibre of the lumen. The nerve-supply to this muscular tissue is furnished by the cranial autonomic system via the vagus nerves.

Eyeball.—An important office of the sympathetic is the controlling of the brightness of the visual image by controlling the size of the pupil. The sympathetic sends efferent fibres to the dilatator muscle of the pupil. In this case, as in others noted above, the cranial part of the autonomic system sends nerves of antagonistic effect to those of the sympathetic, first through the third cranial nerves from the efferent fibres to the constrictor muscle of the pupil. This same part of the cranial autonomic system supplies also motor fibres to the ciliary muscle, thus effecting the accommodation of the lens for focusing clearly objects within the range of what is termed near-vision.

Of the afferent fibres of the sympathetic little is known save that they are, relatively to the efferent, few in number, and that they, like the afferents of the cerebro-spinal system, are axons of nerve-cells seated in the spinal ganglia. (C. S. S.)

SYMPHONIC POEM (*Symphonische Dichtung, Tondichtung, Poème symphonique*, etc.). This term was first used by Liszt in his 12 *Symphonische Dichtungen.* It implies a large orchestral composition which, whatever its length and changes of tempo, is not broken up into separate movements, and which, moreover, gratuitously illustrates a train of thought external to the music and to its conditions of performance. The form of the symphonic poem is dictated by its written or unwritten programme; and so it is not every piece of "programme music" that can be called a symphonic poem. Beethoven's sonata "Les Adieux" and his "Pastoral Symphony" are, for instance, works in which the poetic idea does not interfere with the normal development of sonata style.

Great disturbances in musical art have always been accompanied by appeals to external ideas. New art-forms are not born mature, and in their infancy their parent arts naturally invite other arts to stand godfather. It is certain, first, that no theorizing can long prevent musical ideas from growing where and how they please; secondly, that musical ideas are just as likely to be inspired by literature and other arts as by any other kind of experience; and lastly, that, as musicians gain in mastery, their music outstrips their literary analysis. Hence the frequent ability of great composers to set inferior words to music which is not only great, but evidently based upon those words. Hence the disgust of great composers at unauthorized literary interpretations of their works. Hence, on the other hand, the absence of any strain on the classical composer's conscience as to making his music gratuitously illustrative. Accordingly, the importance of the symphonic poem lies, not in its illustrative capacity, but in its tendency towards a new instrumental art of to-morrow.

The symphonic poem has been described elsewhere (*see* MUSIC, section 9, and PROGRAMME MUSIC) as the application of the Wagnerian time-scale to symphonic music. Liszt is successful only where he is writing on a hardly more than lyric scale, as in *Orpheus*, or, at the utmost, on a scale less than that of the earliest and best of all symphonic poems, Schubert's Wanderer Fantasia (op. 15). Schubert had not the slightest idea that he was writing a symphonic poem; but in that piece he achieved everything that Liszt attempted, even to the metamorphosis of whole sections. Liszt's efforts on a larger time-scale do not even begin to solve the problem; they achieve no sense of movement at all, and the device of deriving all their themes from a single figure is totally irrelevant. Saint-Saëns and César Franck are incapable of such failure, and their symphonic poems flow very convincingly, though not on a very large scale. They also illustrate their subjects amusingly enough. The first achievement of real Wagnerian symphonic art belongs to Richard Strauss. The power of composition in his *Also sprach Zarathustra, Ein Heldenleben*, the ostentatiously but deceptively patchy *Don Quixote*, and the *Symphonia Domestica*, will carry conviction long after we have forgotten all about their programmes. (D. F. T.)

SYMPHONY, in music. (1) The term συμφωνία was used by the Greeks, first, to denote concord, in general, whether in successive or simultaneous sounds; secondly, in the special sense of concordant pairs of successive sounds (*i.e.*, the "perfect" interval of modern music; the 4th, 5th and octave); and thirdly, as dealing with ἀντιφωνον, the concord of the octave, thus meaning the art of singing in octaves, or *magadizing*, as opposed to ὁμοφωνία, or singing and playing in unison. In Roman times the word appears in the general sense, which still survives in poetry, viz., as a harmonious concourse of voices and instruments. It also appears to mean a concert. In St. Luke xv. 25, it is distinguished from χόροι and translated as signifying "music and dancing." Polybius and others seem to use it as the name of a musical instrument.

(2) In the 17th century the term is used, like "concerto," for certain vocal compositions accompanied by instruments, *e.g.*, the *Symphoniae sacrae* of Schütz. The modern use of the word symphony for the instrumental ritornello of a song is also found in Schütz's *Kleine geistliche Concerte.*

(3) The principal modern meaning of the word is a sonata for orchestra (*see* SONATA FORMS). The orchestral symphony originated in the operatic overture (*q.v.*), which in the middle of the 18th century began to assimilate the essentials of the sonata style. Mozart's overture to his early opera, *La Finta Giardiniera*, marks the breaking-point between three-movement symphony and operatic overture, since it contains the usual first movement and slow movement, and the curtain rises with what sounds like the beginning of its third movement.

Though the sonata style is dramatic the stiffness of its early forms did not help Gluck towards his ideal of an overture that should prepare the listener for the drama. Hence the overtures of Gluck are based on the contrast of loosely knit passages of various textures in vague forms which he learned from San Martini. These are no less evident in the symphonies of Philipp Emmanuel Bach.

The differentiation between symphony and overture raised the dignity of the symphony; but the style was more essential than the form; and in Mozart's and Haydn's mature works we find the sonata form as firmly established in the overture as in the symphony, while the styles are quite distinct. Mozart's most elaborate overture, that of *Die Zauberflöte,* could not possibly be the first movement of one of his later symphonies; nor could the finale of his "Jupiter" symphony be taken for a prelude to an opera.

See also MUSIC; SONATA FORMS; INSTRUMENTATION; OVERTURE; SCHERZO; VARIATIONS. (D. F. T.)

SYMPHOSIUS or **SYMPOSIUS,** the name given to the author of a collection of 100 riddles of uncertain date, but probably composed in the 4th or 5th century A.D. They have been attributed to Lactantius, and identified with his *Symposium,* but this view is not generally accepted. The style and versification of the riddles, each of which consists of three hexameter lines, are good. They were written to form part of the entertainment at the Saturnalia.

Text in E. Bährens, *Poetae latini minores,* vol. iv.; there is a good French metrical version by E. F. Corpet (1868); monograph by W. T. Paul (Berlin, 1854); *see* also Teuffel, *Hist. of Roman Literature,* 449 (Eng. trans., 1900).

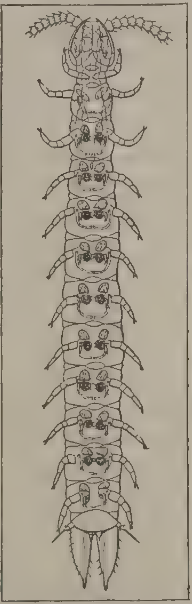
SYMPHYLA. A class of soil-dwelling Arthropoda, it forms with Diplopoda (Millipedes, *q.v.*) and Pauropoda (*q.v.*) the super-class Progoneata.

Symphyla comprise but one family, the Scolopendrellidae.

The white body, never more than eight millimetres long, is invested with thin chitin and consists of a distinct head with one pair of many jointed antennae and an elongated trunk bearing twelve pairs of legs, of which the first is often much reduced. At the hind end of the body are a pair of backwardly directed conical appendages, the cerci, which function as spinning organs.

Symphyla have been described from all the continents of the globe. They are occasionally injurious to the delicate tissues of cultivated plants.

See C. Attems, "Symphyla" in *Handbuch der Zoologie,* vol. 4, p. 11 (1926). On economic status *see* J. Feytaud, *Revue de Zoologie Agricole, Bordeaux,* Sept. 1925, p. 192.



FROM VERHOEFF IN "DIPLOPODA," BRONN, "KLASSEN UND ORDNUNGEN DES TIER-REICHS" (AKEDEMISCHE VERLAGSGESELLSCHAFT)

A SYMPHYLE, (SCOLOPENDRELLA IMMACULATA), SHOWING LOWER SURFACE AND A FEW OF THE BASAL JOINTS OF THE ANTENNAE

SYNAGOGUE, denotes either a congregation of Jews (*συναγωγή* lit. "assembly"), or their place of worship, or, more generally, Judaism as contrasted with Christianity; the last sense is exemplified by the famous pair of statues, Church and Synagogue, in the porch of Strasbourg cathedral. (Illustrations and explanation of the allegory on pp. xii., xxxvi. of *Legacy of Israel,* 1927.) The usual Hebrew term for synagogue is כְּנֶסֶת or בֵּית־הַכְּנֶסֶת (*Kenéseth* or *Beth hak-Kenéseth*): in Ps. lxxiv., 8, מוֹעֲדֵי־אֵל (assemblies of God) is assumed to refer to synagogues. There can be no doubt but that the synagogue, Ezra's main work, grew up with the Temple and developed from it. By the time of the fall of the Temple, synagogues were well established, for differences of synagogal and Temple liturgy are known and when the Temple fell, the synagogue remained unaffected: it had long become an independent institution. The synagogue was the place of study: the law was read on Sabbaths (Acts xv., 21), Festivals and market days in an annual, and also in a triennial cycle (on this *see* articles in *Jew. Quart. Rev.* by A. Büchler [v. 420–68: vi., 1–73] and by J. Abrahams [xvi., 579–83] and "Triennial Cycle" in *Jew. Enc.*). The lessons from the Pentateuch were translated by a *Meturgemān* or translator (from the same root as *Targūm* and dragoman *qqv.*): lessons from the prophets (see *Haftāra*) concluded the service, in which preaching and exposition were included. On Jesus and the synagogue, *see* I. Abrahams (*Studies,* I. 1, 1917).

The synagogue was not limited to Palestine, it has, in fact, been termed the "child of the dispersion," but this does not imply that it was the product of the Hellenic diaspora exclusively. In Egypt there are references to three altars or temples, that at Assouan in the 5th cent. B.C., which Cambyses spared when he invaded the country (on this *see* A. Cowley's *Aramaic Papyri* [Oxford, 1923], especially p. 113); the altar and the pillar named in Is. xix., 19; and the Onias Temple built at Leontopolis about 154 B.C. (on this *see* S. A. Hirsch, pp. 39 *sqq.* in *Jews' Coll. Jub. Vol.;* London, 1906). It is most unlikely that at these sacred places, services were not held. Congregations existed in most parts of the Roman empire. Acts xv., 21, speaks of "synagogues in every city from generations of old": from Cicero's *Pro Flacco,* the rich contributions to the Temple in 62 B.C. from the synagogues of Apamea, Laodicea and Pergamon—towns in Asia Minor—are known. Under the term Proseuche (*προσευχή* place of prayer), Roman authors speak of synagogues, and their allusions show that these places were common. The officials of the synagogue were the *ἀρχισυνάγωγοι* Luke xiii., 14; Acts xiii., 15; the *gabbā'im* or treasurers who collected charitable contributions in cash and kind (*Quppāh and Ṭamhui*); the *ὑπηρέτης* (Luke xiii., 14) or *Ḥazzān* (lit. overseer, *ἐπίσκοπος*) a teacher, reader or beadle who inflicted scourging (*Malqūth,* Matt. x., 17) when decreed by the elders (*πρεσβύτεροι, γερουσία*) through their *ἄρχουτες* or chief members. Major disciplinary punishments were excommunication (*Ḥērem*) and exclusion (*Niddui*). The ancient Galilean synagogues ran north and south (modern buildings are orientated) and possessed a nave and twin aisles.

BIBLIOGRAPHY.—On the synagogue generally *see* the various articles on synagogue liturgy, etc., in *Jew. Enc.* and Hastings *D.B.* and *E.R.E.* On the internal and external architecture *see* numerous illustrations in *Jew. Enc.* under the names of towns with famous synagogues: W. G. Tachau, *Architecture of Syn.* (numerous illustrations), in *Am. Jew. Year Book,* vol. 28 (1926); H. Kohl and C. Watzinger, *Antike Syn. in Galilaea* (1916). On the ancient "Men of the Great Synagogue" *see* excursus ii. in Taylor, *op. cit. sup.*

SYNAPSE, the functional conjunction between two neurons, making conduction of nervous impulses continuous from one to the other. Synapses occur between the axone terminations of one neuron, and the cell body of an adjacent cell. This type of synapse is called axo-somatic. Synapses also occur between axone terminations of one neuron and the dendrites of the next, and are then termed axo-dendritic. Adjacent neurons may be connected by both types of synapse. There are two theories of the actual cell structures participating in the synapse, the contact theory and the continuity theory. The contact theory, which is most generally accepted, holds that a nerve impulse in passing from one neuron to another traverses the neurofibrils, the perifibrilar substance and the cell membrane of the axone of the first neuron; possibly a glious intercellular substance; and finally the cell membrane, the perifibrilar substance and the neurofibrils of the second neuron receiving the impulse. The continuity theory holds that minute protoplasmic threads establish neurofibrilar continuity between the adjacent cells. A number of very important phenomena of nerve conduction are attributable to the synapse; among them irreversibility of direction, after discharge, slower speed of conduction, fatigability, temporal summation, inhibition, facilitation and increased susceptibility to drugs. (*See* NEUROPATHOLOGY; CONSCIOUSNESS, PSYCHOLOGY OF.) (W. M. M.)

SYNCRETISM, the act or system of blending, combining or reconciling inharmonious elements. The term is used technically in politics, as by Plutarch, of those who agree to forget dissensions and to unite in the face of common danger, as the Cretans were said to have done; in philosophy, of the efforts of Cardinal Bessarion and others in the 16th century to reconcile the philosophies of Plato and Aristotle; and in theology, of a plan to harmonize the hostile factions of the Church in the 17th century, advocated by Georg Calixtus, a Lutheran professor of theology at Helmstadt. Its most frequent use, however, is in connection with the religious development of antiquity, when it denotes the tendency, especially prominent from the 2nd to the 4th centuries of the Christian era, to simplify and unify the various pagan religions. During this period, as a result of the intimate knowledge of the world's religions made possible by the gathering of every known cult of importance into the religious system of the Roman Empire, belief in the identity of many deities which resembled each other, and indeed in the essential identity of all, received a special impulse. Not only were various forms of the same deity, such as, for example, Jupiter Capitolinus and Jupiter Latiaris, recognized as being really the same under different aspects, but even the gods of different nations were seen to be manifestations of a single great being. Roman Jupiter, Greek Zeus, Persian Mithras and Phrygian Attis were one. The Great Mother, Isis, Ceres, Demeter, Ops, Rhea, Tellus, were the same great mother deity under different masks (*see* Great Mother of the Gods). Venus and Cupid, Aphrodite and Adonis, the Great Mother and Attis, Astarte and Baal, Demeter and Dionysus, Isis and Serapis, were essentially the same pair. Syncretism even went so far as to blend the deities of paganism and Christianity. Christ was compared with Attis and Mithras, Isis with the Virgin Mary, etc. Isis, perhaps more than any other deity, came to be regarded as the great maternal goddess of the universe whose essence was worshipped under many different names.

Naturally, the influence of Greek philosophy was very pronounced in the growth of syncretism. Plutarch and Maximus of Tyre affirmed that the gods of the different nations were only different aspects of the same deity, a supreme intelligence and providence which ruled the world. The Neoplatonists, however, were the first school to formulate the underlying philosophy of syncretism: "There is only one real God, the divine, and the subordinate deities are nothing else than abstractions personified, or celestial bodies with spirits; the traditional gods are only demons, that is, beings intermediate between God and man. . . . All, like every other created being, are emanations from the absolute God" (Jean Réville, *La Religion à Rome sous les Sévères*). Care must be taken, however, not to place too much emphasis upon syncretism as a conscious system. The movement which it represented was not new in the 2nd century A.D. The identification of Latin with Etruscan gods in the earliest days of Rome, and then of Greek with Italian, and finally of Oriental with the Graeco-Roman, were all alike syncretistic movements, though not all conscious and reasoned. The ideal of the common people, who were unreflecting, as well as of philosophers who reflected, was "to grasp the religious verity, one and constant, under the multiplex forms with which legend and tradition had enveloped it" (Réville). The advent of Greek philosophy only hastened the movement by conscious and systematic effort.

Syncretism, being a movement toward monotheism, was the converse of the tendency, so prominent in the early history of Rome, to increase the number of deities by worshipping the same god under special aspects according to special activities. In the hands of the Neoplatonists it was instrumental in retarding somewhat the fall of paganism for the time, but in the end contributed to the success of Christianity by familiarizing men with the belief in one supreme deity.

See Jean Réville, *op. cit.*, especially pages 104–127, 159–174, 284–295. For other examples of syncretism, *cf.* that of Buddhism Zoroastrianism in the state religion of the Indo-Scythian kingdom of Kanishka (*see* Persia: *Ancient History*, "The Parthian Empire"); *see* articles on almost all the religions of the East, *e.g.*, Mithras; Zoroaster.

(G. S.)

SYNDERESIS, a term in scholastic philosophy applied to the inborn moral consciousness which distinguishes between good and evil. The word is really *synteresis* (Gr. *συντήρησις*, from *συντηρεῖν*, to look after, take care of), but synderesis is the commoner form. Diogenes Laërtius in his account of the Stoics uses the phrase *τηρεῖν ἑαυτό* to describe the instinct for self-preservation, the inward harmony of Chrysippus, the recognition of which is *συνείδησις*. The term *synderesis*, however, is not found till Jerome, who in dealing with Ezek. i. 4–15, says the fourth of the "living creatures" of the vision is what the Greeks call *συντήρησις*, *i.e.*, *scintilla conscientiae* the "spark of conscience." Here apparently synderesis and conscience (*συνείδησις*) are equivalent. By the schoolmen, however, the terms were differentiated, conscience being the practical envisaging of good and evil actions; synderesis being, so to speak, the tendency toward good in thought and action. The exact relation between the two was, however, a matter of controversy, Aquinas and Duns Scotus holding that both are practical reason, while Bonaventura narrows synderesis to the volitional tendency to good actions.

SYNDICALISM. "Syndicalism" is the name given to a form of socialist doctrine elaborated by, and born from the experience of, the members of the French *syndicats* or trade unions. The French word *syndicalisme* means originally no more than trade unionism and is still frequently used in that restricted sense. Syndication before the World War was a doctrine of wide influence, but it has now largely been absorbed within the Communist Parties or other organizations. On the one hand it is a body of social doctrine or theory of social organization; on the other it is a plan of action for the realization of this ideal. Of all the social theories competing for existence it is the most purely proletarian in origin. One writer indeed has described it as "working-class socialism" (*le socialisme ouvrier*) in contradistinction to the types of socialism originated and propagated by middle-class "intellectuals."

The syndicalist starts from the assumptions common to most schools of socialist thought. He affirms the inherent injustice of the wage system and the fundamental immorality of capitalist society, which is based, in his belief, on the exploitation of labour. He accepts and pushes to its logical conclusion the Marxian dogma of the class war; he therefore affirms that solidarity of interests does not, and cannot, exist as between employer and employed, between capitalist and wage-earner. From these premises he draws the usual socialist conclusion, namely, that individual ownership of the instruments of production must be abolished and communal ownership and control substituted for it. But at this point syndicalism and socialism (as usually understood) part company. Whereas the orthodox socialist demands control by the consumers acting through the State and its dependent organs such as the municipalities, the syndicalist demand, until very recently, was for producers' control, acting through the organizations of their own creation—the trade unions.

State organization and control of industry are, in their view, incompatible with true working-class emancipation. The State is, and must be, an instrument of class domination; it is indeed "the executive committee of the capitalist class." It exists to defend the interests of that class, and is consequently as much the enemy of labour as capital itself. To extend its powers would be to twine the bonds of wage slavery ever more firmly about the workers' limbs. The State is, moreover, hopelessly wedded to an uncreative bureaucracy, incapable of initiative and ignorant of industrial technique. Its control, even if it were benevolent (which the syndicalist denies it could be), would necessarily be despotic and inefficient; the spirit of routine would combine with inexperience to crush out the possibility of economic progress. Here, as will be seen, the syndicalist endorses the ordinary individualistic criticism of State socialism. Producers' control, exercised through the *syndicats*, would combine freedom with efficiency.

The form of social organization in which this ideal could be realized was, until recently, conceived somewhat as follows: The unit of organization would be the local *syndicat*. This would be brought into touch with the local groups by means of the *Bourse du Travail*, the present function of which is to act at once as an employment agency and a general centre for trade-union activities. When all the producers were thus linked together by the *bourse*, the administration of the latter would be able to estimate the economic capacities and necessities of the region, could co-ordinate production, and, being in touch through other *bourses* with the industrial system as a whole, could arrange for the necessary transfer of materials and commodities, inwards and outwards. A species of "economic federation" would thus replace the structure of capitalist industry, with which would necessarily disappear the political and administrative machinery of the State. Two features of this Utopia need to be emphasized; consumers as such were excluded from any share in industrial control, and a localized system of industry was envisaged. This latter feature was a direct reflection of French economic circumstances; both industry and trade-unionism were much more local in range than in other and more highly developed countries. But the movement towards large-scale organization which has so profoundly affected every aspect of economic life in recent years has produced a corresponding modification in syndicalist ideals. At the same time it has begun to be recognized by the theorists of the movement that the consumers' point of view cannot wholly be disregarded.

Syndicalist theory starts, as has been said, from the idea of a class war which must be waged relentlessly till a complete social transformation has been accomplished. The essential weapon in this struggle is the power of the organized workers. As the cause of the conflict is economic it must necessarily be fought out in the economic sphere. Syndicalist congresses have persistently repudiated political action and pinned their faith to a general strike as the grand instrument of social revolution. This reliance upon industrial or "direct" methods of action flows necessarily from the fundamental notions of syndicalism as to the nature of the State, and also from strictly practical considerations. Outside the mine or factory, working men hold divergent religious or political opinions which make effective mass action difficult, if not impossible. Inside, the nature of their employment gives them a sense of solidarity which overrides minor differences and bands them together in the *syndicat* for common defence; to persuade them to pass from the defensive to the offensive is the syndicalist's task, and in the accomplishment of this political labels and controversies would be a hindrance. The strike, therefore, is the characteristic syndicalist weapon. However limited in its scope and object, it is an educative experience; successful, it inspires the workers with a sense of power; unsuccessful, it impresses upon them the servility of their lot and the necessity for better organization and wider aims. Thus every strike is a preparation for the revolutionary "day," when the workers, or a fighting minority of them (for syndicalism repudiates as *bourgeois* the dogma of the sacredness of majority rule), shall seize the instruments of production by an "expropriatory" strike. In the meantime, they are working out from day to day, in the ordinary course of their employment, the ethics and the jurisprudence of the new social order.

The strike, of course, is not the only weapon in the syndicalist armoury. Various other means of waging the class war, known collectively as *sabotage*, are both preached and practised. These range from bad or slow work to the *grève perlée* (destruction of goods or machinery) and the *chasse aux renards* (assaults on "black-legs" or *jaunes*). It is fair to say that many syndicalist leaders criticize these methods as destructive of the worker's *moral* and technical competence.

Syndicalism is essentially French in origin and reflects French working-class experience and conditions of life; nevertheless the history of Great Britain shows interesting foreshadowings of it. The idea of industrial self-government by the producers attracted for a time the mobile mind of Robert Owen; and the Grand National Consolidated Trades Union of 1834 was an attempt to realize it in practice. James Morrison, a young, self-taught operative builder, seems to have originated the syndicalist conception of class antagonism on the part of the working-classes. The Operative Builders' Union had developed the same notion in the previous year. The plan of a general strike—originated by one Benbow—for a time, under the strange title of the "Sacred Month," made part of Chartist propaganda. There is no evidence, however, that these projects had any echo on the European continent. The syndicalist idea, as understood in France, may be said to have originated in the discussions of the International Working Men's Association. A French delegate to the Congress of Basle in 1869, for instance, prophesied that "the grouping of different trades in the city will form the commune of the future" when "government will be replaced by federated councils of *syndicats* and by a committee of their respective delegates regulating the relations of labour—this taking the place of politics." These tendencies manifested themselves with increasing strength during the '90s in the two great labour organizations of the period—the General Confederation of Labour (or "C.G.T." under its French initials) and the Federation of *Bourses du Travail*. The secretary of this latter organization, Pelloutier, did more perhaps than any other individual to work out the characteristic doctrines of syndicalism and spread them among his fellow-workers. When these two bodies joined forces in 1902 trade-unionism in general and syndicalism in particular received an immense accession of strength, and the doctrine subsequently remained—in spite of the efforts of political socialists to capture the *syndicats* for their own purposes—the characteristic expression of French revolutionary idealism.

Syndicalist doctrine has had considerable influence outside France. In the United States a movement of somewhat similar character arose with the organization of the Industrial Workers of the World (*q.v.*).

The influence of these ideas on the trade-union movement in Great Britain and Ireland has been very pronounced, though they have taken a different direction, modified by the traditional conservative instinct of the British working-class. In Great Britain the real cause of the permeation of certain unions by syndicalist ideas was the absorption of trade-union leaders in administration or in politics, which caused them to lose touch with the rank and file. Especially is this the case with regard to the miners, the railwaymen's unions and the engineers.

Daniel De Leon was a leader of the Socialist Labour Party in the United States from 1880 onwards, and his writings influenced British socialist thought, particularly in the Clyde and in the mining valleys of South Wales. Though not a syndicalist in the strict sense, he advocated organization by industry and the general strike. It is significant that 1903 saw in England the secession of the Socialist Labour Party from the Social Democratic Federation. After that date, in addition to the growing educational influence of the Independent Labour Party (though this was never syndicalist), was seen the promotion of the Workers' Socialist Federation, the British Socialist Party (in the post-war period) and the Communist League, all of which advocated practically the same structure of organization and policy. They all agreed in a lack of faith in political action, though not always refusing to utilize it, but their real *politik* was industrial action. After the Russian Revolution of 1917 they secured greater prominence; they became the stormy petrels of the labour world in Great Britain, and their effect on the political action of the Labour Party was seen in the Council of Action in August 1920.

In England, between 1900 and 1910, there was a growing dissatisfaction among the rank and file with political action. Despite the fact that the influence of the Labour Party in the House of Commons secured to a greater degree than ever before the trade-union movement freedom of industrial and political action by the Trades Disputes Act of 1906 and the Trade Union Act of 1913, it was felt by the far-sighted among the rank and file that a speeding-up was necessary, and State collectivism as a way out towards industrial democracy was discredited. James Connolly, the Irish Labour leader who was executed after the Easter rising in Ireland in 1916, started a similar organization to that of Daniel De Leon on the Clyde in 1905. In his pamphlet *Socialism made Easy*, he enunciated the syndicalist principles "that they who rule industrially will rule politically," and that "the functions of Industrial Unionism is to build up an industrial republic inside the shell of the political state, in order that when the industrial republic is fully organized it may crack the shell of the political state and step into its place in the scheme of the universe." Tom Mann, while in France and Australia, to which had been imported ideas of the I.W.W. from America, was powerfully influenced by the same theories, while on the Rand, in South Africa, a small but very influential group of leaders was working out the structure, forms and policy of a movement similar in character. In 1910 Tom Mann preached the new faith in all the big industrial centres and rapidly won many followers. Then followed the railway strike of 1911 and the great coal strike of 1912. It is quite clear that the National Union of Railwaymen and the Miners' Federation of Great Britain became organized as two of the most powerful unions in consequence of the new thought, *not* because their leaders had adopted syndicalism in the form taught by De Leon and the French group of thinkers, but because they adapted it in the peculiar British way; they made it practical and definite; they shaped it in alliance with the political and trade-union structure of Britain. They disagreed with the syndicalist view of the State, but they recognized the driving power of the theories that stated "that political power is a reflex of industrial power." The transport workers soon had a similar federation, and after the strikes of 1911 and 1912 and the Irish transport workers' strike of 1913, the Triple Alliance (of railwaymen, transport workers and miners) was formed in 1915.

The alliance was brought to a test in 1921 by the coal dispute. The other sections of the Triple Alliance, the leaders of the railwaymen and transport workers, withdrew from their agreement to take part in the general strike called for on April 15, 1921, because the miners had refused to consider temporary district settlements. On April 1, 1921, over one million miners were "locked out" for refusing to accept drastic reductions in wages. Again, so far from accepting any syndicalist notions of power, it is clear that the miners fought then, not for any change in the economic system of capitalism, but for the preservation of a tolerable standard of living. Exactly the same position arose again on May 3, 1926, when the general strike actually took place, not because of any revolutionary object of overthrowing the State, but in defence of the miners' standard of life.

The Trade Disputes and Trade Unions Act of June 1927 brought out clearly the two points of view: the trade-union view that sympathetic strikes even on a national scale need not necessarily be syndicalist in aim, but a legitimate weapon in defence of their standard of life; and the opposite view that whenever a strike inflicts "hardship upon the community," whatever that may mean, it may be declared illegal if it can be adjudged to be political in its object.

The classic controversy between the reformist and the revolutionary conception of working-class action has again been demonstrated by the emergence of Communist propaganda among the trade unions. The "National Minority Movement," after its first conference on Aug. 25, 1924, sent a manifesto to the Trade Union congress in which occurs the following: "For the first time in the history of the congress a definite and organized opposition within the unions faces the existing leadership and raises unreservedly the banner of revolutionary working-class politics in British trade unionism."

The promoters of the movement sought to show that it was the successor of the forces at work in trade unionism to bring about more efficiency, such as the shop stewards' movement, the amalgamation movement and the workshop committees' movement. The trade unions are convinced that this minority movement is disruptive, that its purpose is to set the rank and file of the working class movement in bitter opposition to its elected and responsible representatives, that it has no affinity with syndicalism or the pre-war revolutionary trade union of the Continental type, that in short it simply represents Communist activity and propaganda within the unions. Its power for mischief is deemed to be great, and, although unimportant in numbers and of little influence, because of this steps have been taken to deal with it.

See also DIRECT ACTION; SABOTAGE; and GENERAL STRIKE.

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SYNDICATE. Originally the name of a council of syndics, the word syndicate has in modern times come to be used to describe a body of men associated for commercial or financial purposes, especially when the body is temporary and *ad hoc.* The word has also been used to describe the combined use of news or articles by newspaper proprietors, as when an arrangement is made to circulate an article throughout a series of newspapers, when it is termed a "syndicated article."

In the Italian fascist economic structure, the local trade associations are termed syndicates, and all workers have to subscribe to them, whether they become members or not. These syndicates are juridical bodies and integral parts of the new Italian constitution. (*See* FASCISM, ECONOMICS OF.) (L. C. M.)

Press Syndicates are editorial organizations based on the modern business concept of large sales, wide distribution, relatively small cost to each purchaser but large aggregate cost and profits. They supply to numerous newspapers fiction, cartoons, illustrated articles in single or series form often signed by well-known names. They exist partly by virtue of the fact that they are able to supply to any one newspaper material which that newspaper could not afford to collect for itself, and partly because some of the cleverest journalists are engaged in the business. Press syndicates are highly developed in the United States, where they supply more than 80% of the reading matter, and in Great Britain, where individuality still counts in the newspaper world, this method of mass production and dissemination of news is making headway.

Major O. J. Smith is the inventor (1882) of the syndicate which first expressed itself by means of the distribution of stereotyped plates manufactured at central points and served to newspapers in the form of metal castings. In connection with this enterprise the American Press Ass'n. which at one time served as many as 12,000 newspapers, also sent out material in manuscript proof and electrotype shell form, and made hundreds of small country newspapers possible. The distribution by stereotype matrices, to-day so important, came later. The prosperity of press syndicates since 1900 is instanced by the special foreign service of the *Chicago Daily News,* and the local and general services of the United Press (1907), the Associated Press (1900), the International News Service and others.

Two well known syndicate pioneers were S. S. McClure and Edward Marshall. McClure introduced Robert Louis Stevenson and Rudyard Kipling to American readers. (W. S. HI.)

SYNEDRIUM, a Rabbinic or legal body in Jerusalem, the Sanhedrin: the form *Sanhedrim* is based on false etymology, suggesting a Hebrew masc. plural ending *-im* added to a non-existent noun *Sanhēder*. The *Oxford English Dictionary* (cited in H. W. Fowler's *Mod. Eng. Usage,* 1926, p. 512) makes the following erroneous statement: "the incorrect form *Sanhedrin* . . . has always been in England (from the 17th cent.) the only form in popular use." As no Hebrew noun ending in M occurs, the only correct equivalent to סַנְהֶדְרִין must be *Sanhedrin.* The existence of a court at Jerusalem is indicated in II Chron. xix., 8. An aristocratic Council of Elders and priests is mentioned both before and during the Maccabaean age (*e.g.*, Josephus, *Ant.*, xii, 3, 3). Probably the High Priest presided from early times.

The accounts in the Mishnah do not entirely agree with those of Josephus and with New Testament references but the amount of divergence is a matter of dispute. There are two lines of thought among modern scholars, some supporting the Mishnah, others maintaining that its information is an "academic reconstruction," hence unhistorical. That the Jewish court early lost its power is generally admitted (*cf.* John xviii., 31). Forty years before the fall of the Temple it could no longer inflict capital punishment (Jer. Sanh. 18a) and the right of deciding financial cases had been abrogated during the reign of Alexander Jannaeus (*cf.*, T. B. Sanh. 41a). Nevertheless legal tradition was well preserved and the evidence of authorities such as Jose b. Ḥalafta cannot easily be brushed aside. Büchler (*cit. infr.*) reconciles the conflicting evidence by assuming that there were two bodies, one, that of Josephus and the Gospels, possessing civil authority and one, that of the *Mishnah,* with purely religious functions, *e.g.*, the fixing of the calendar or the purity of priests. The former sat in the town or on the west edge of the Temple hill; the latter, called "the great Sanh.," sat in the Xystus or

Lishkath hag-Gāzith (chamber of hewn stone) and was composed of 71 members, mostly Pharisees, over whom the *Nasī'* and *Ab Beth Dīn* (Rabbis) presided. The lesser Sanhedrin of 23 members, mostly Sadducees and priests, was under the leadership of the High Priest.

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SYNESIUS (*c.* 373–*c.* 414), bishop of Ptolemais in the Libyan Pentapolis after 410, was born of wealthy parents, who claimed descent from Spartan kings, at Cyrene between 370 and 375. While still a youth (393) he went with his brother Euoptius to Alexandria, where he became an enthusiastic Neoplatonist and disciple of Hypatia (*q.v.*). On returning to his native place about the year 397 he was chosen to head an embassy from the cities of the Pentapolis to the imperial court to ask for remission of taxation and other relief.

After Aurelian had granted the petition of the embassy, Synesius returned to Cyrene in 400, and spent the next ten years partly in that city, when unavoidable business called him there, but chiefly on an estate in the interior of the province, where in his own words "books and the chase" made up his life. His marriage took place at Alexandria in 403; in the previous year he had visited Athens. In 409 or 410 Synesius, whose Christianity had until then been by no means very pronounced, was popularly chosen to be bishop of Ptolemais, and, after long hesitation on personal and doctrinal grounds, he ultimately accepted the office thus thrust upon him, being consecrated by Theophilus at Alexandria. One personal difficulty was obviated by his being allowed to retain his wife, to whom he was much attached; but as regarded orthodoxy he expressly stipulated for personal freedom to dissent on the questions of the soul's creation, a literal resurrection, and the final destruction of the world, while at the same time he agreed to make some concession to popular views in his public teaching (*τὰ μὲν οἴκοι φιλοσοφῶν, τὰ δ' ἔξω φιλομυθῶν*). His tenure of the bishopric was troubled by domestic bereavements and by barbarian invasions of the country (in repelling which he proved himself a capable military organizer) and by conflicts with the prefect Andronicus, whom he excommunicated for interfering with the Church's right of asylum. The date of his death is unknown; it is usually given as *c.* 414.

His extant works are—(1) a speech before Arcadius, *De regno;* (2) *Dio, sive de suo ipsius instituto*, in which he signifies his purpose to devote himself to true philosophy; (3) *Encomium calvitii* (he was himself bald), a literary *jeu d'esprit*, suggested by Dio Chrysostom's *Praise of Hair;* (4) *De providentia*, in two books; (5) *De insomniis;* (6) 157 *Epistolae;* (7) 12 *Hymni*, of a contemplative, Neoplatonic character; and several homilies and occasional speeches. The *editio princeps* is that of Turnebus (Paris, 1553); it was followed by that of Morell, with Latin translation by Petavius (1612; greatly enlarged and improved, 1633; reprinted, inaccurately, by Migne, 1859).

See a life by W. S. Crawford (London, 1901); also G. Grützmacher, *Synesios von Kyrene* (1913).

SYNGE, JOHN MILLINGTON (1871–1909), Irish dramatist, was born at Rathfarnham near Dublin April 16, 1871. Educated at Trinity college, Dublin, he travelled for some years on the Continent, spending much of his time in Paris. He returned in 1898 to the Aran Isles. Here he wrote a number of sketches dealing with the life of the islanders, which were later collected in *The Aran Islands* (1907). In these and other sketches of the same period he had not quite shaken off the obsession of stylism, and still had a wish "to do for the west of Ireland what Pierre Loti had done for the Bretons." Gradually, however, Ireland took hold of him, and, turning to the dramatization of incidents in the life he now knew intimately, he began to elaborate, partly from his notebooks and partly from the writings of Lady Gregory and Douglas Hyde, that richly imaginative Anglo-Irish dialect which he used with such complete success. When, in 1904, he became a director of the newly opened Abbey Theatre, Dublin, he had already produced two one-act plays, *The Shadow of the Glen* (1903) and *Riders to the Sea* (1904), published in one volume (1905). *The Well of the Saints*, a beautiful three-act play produced in 1905, was regarded by some as an affront to Irish morals, and when *The Playboy of the Western World* appeared in Jan. 1907, it was interrupted every night for a week by an organised disturbance. When the real merits of the play became known, it contributed largely to the fame of the Abbey Theatre. Time has shown how deeply Synge penetrated into the soul of the Irish peasant. The richness of the dialogue and the suggestion which it conveys of a permanent human enigma combine to make it a masterpiece. Synge's latest volumes were a collection of his poetical works entitled *Poems and Translations* (1909), and another play, *Deirdre of the Sorrows* (1910) which he all but completed before his death. Synge's greatest work is probably *The Playboy*, though some critics give pride of place to *Deirdre.* Synge died in Dublin March 24, 1909.

Bibliography.—W. B. Yeats, *Synge and the Ireland of His Time* (1911); M. Bourgeois, *John Millington Synge and the Irish Theatre* (1912); P. P. Howe, *J. M. Synge. A Critical Study* (1912); J. Masefield, *John M. Synge: A Few Personal Recollections, with Biographical Notes* (1915); J. Thorning, *J. M. Synge: etc.* (1921).

SYNOPTIC GOSPELS and **SYNOPTIC PROBLEM.** The first three Gospels, Matthew, Mark, Luke, are known as the Synoptic Gospels because, in matter, language, and order, they have much in common, and can, therefore, be viewed together or synoptically. The Synoptic Problem is the problem of the relations between these Gospels, whether of influence, interdependence, or common origin, arising from their common features. (*See* Gospel, Bible: New Testament, section *Modern Criticism*, and the articles on the several Gospels.)

SYNTHETIC RUBBER: *see* Rubber in Industry.

SYPHAX, king of the Massaesyli, a tribe of western Numidians, played an important part in the later stages of the Second Punic War. In 213 a quarrel was in progress between him and Carthage; the Scipios leaped at this chance of establishing an ally in Africa, and sent a military mission to Syphax.

SYRA or **SYROS** (anc. *Σύρος*, perhaps Homeric *Συρίη*), a Greek island in the middle of the Cyclades (length about 10 m., breadth 5, area 42½ sq.m.). The prehistoric importance of the island is attested by early Aegean antiquities. In ancient times it was remarkably fertile, but the destruction of its forests has led to loss of alluvial soil, and left it a brown and barren rock, with scanty aromatic scrub, pastured by sheep and goats. In the 19th century Syra became the commercial centre of the Archipelago, and is also the residence of the nomarch of the Cyclades and the seat of the central law courts. The population rose to about 33,700, but is said to have declined though Hermoupolis has 21,156 inhabitants (1928). It suffers from the competition of Piraeus, and latterly of Salonika. Syra is also a province of the department of the Cyclades.

Hermopolis (better Hermoupolis), the chief town, is built in a bay of the east coast. Old Syra, on a conical hill behind the port town, was built by the Capuchins, who in the middle ages chose Syra as the headquarters of a mission. On the outbreak of the war of Greek independence about 40,000 refugees from Chios, after being scattered throughout Tenos, Spezia, Hydra, etc., and rejected by Ceos, rallied at Syra under the protection of the French flag till the freedom of Greece was achieved. The harbour, with a breakwater 273 yd. long, has a depth of 25 ft. diminishing to 12 ft.

SYRACUSE, a city of Sicily (Gr. Συράκουσαι; Lat. *Syracusae*, Ital. *Siracusa*), the capital of a province of the same name, situated on the east coast of the island, 54m. by rail S. by E. of Catania, and about 32m. direct. Pop. (1881), 21,739; (1906), 23,250 (town), 35,000 (commune); (1921), 45,946 (town), 49,662 (commune).

Syracuse was the chief Greek city of ancient Sicily, and one of the earliest Greek settlements in the island. It was founded from Corinth, and Thucydides, who gives the date as the year after the foundation of Naxos (*i.e.*, 734 B.C.), mentions that the leader Archias expelled the Sicel inhabitants from Ortygia. (*See* under SICILY.) Their presence there was definitely proved by the discovery of traces of huts and of a rock-cut tomb of the beginning of the second Sicel period on Ortygia, while similar tombs may be seen both on the north and south edges of the terrace of Epipolae, and on the peninsula of Plemmyrium. (For this and other prehistoric sites in the neighbourhood of Syracuse *see* SICILY, *Pre-Hellenic Archaeology*.)

Till the beginning of the 5th century B.C. our notices of Syracuse history are fragmentary, and we do not even know when the mole connecting the island with the mainland was constructed. In its external development Syracuse differed somewhat from other Sicilian cities. Although it lagged in early times behind both Gela and Acragas (Agrigentum), it very soon began to aim at a combination of land and sea power. In 663 it founded the settlement of Acrae, in 643 Casmenae, and in 598 Camarina, of which the first was unusually far inland. The three together secured for Syracuse a continuous dominion to the south-east coast. They were not strictly colonies but outposts; Camarina indeed was destroyed after a revolt against the ruling city.

Gelon and Hieron.—Hippocrates, tyrant of Gela (492–485), threatened the independence of Syracuse as well as of other cities, and it was saved only by the joint intervention of Corinth and Corcyra and by the cession of the vacant territory of Camarina. In 485 the *Gamoroi*, or landowners (*i.e.*, the descendants of the original settlers, who formed an aristocratic body), who had been expelled by the Demos and the Sicel serfs and had taken refuge at Casmenae, craved help of Gelon, the successor of Hippocrates, who took possession of Syracuse, without opposition, and made it the seat of his power. He gave citizenship both to mercenaries and to settlers from Greece and added to the population the inhabitants of other cities conquered by him, so that Syracuse became a city of mixed population in which the new citizens had the advantage. He then extended the city by including within the fortifications the low ground (or at any rate the western portion of the low ground) between Upper Achradina and the island and making the agora there; at the same time (probably) he was able to shift the position of the crossing to the island by making a new isthmus in the position of the present one, the old mole being broken through so as to afford an outlet from the Little Harbour on the east. The island thus became the inner city, the stronghold of the ruler. Gelon's general rule was mild, and he won fame as the champion of Hellas by his great victory over the Carthaginians at Himera. He is said to have been greeted as king; but he does not seem to have taken the title in any formal way.

Gelon's brother and successor, Hieron (*q.v.*) (478–467), kept up the power of the city and won himself a name by his encouragement of poets, especially Aeschylus and Simonides, and philosophers; while his Pythian and Olympian victories made him the special subject of the songs of Pindar and Bacchylides. But in his internal government he was suspicious, greedy and cruel. After family disputes the power passed to his brother Thrasybulus, who was driven out next year by a general rising. Syracuse thus became a democratic commonwealth. Renewed freedom was celebrated by a colossal statue of Zeus Eleutherius and by a yearly feast in his honour. But when the mercenaries and other new settlers were shut out from office new struggles arose. The mercenaries, as in the last rising, held Ortygia and Achradina. The people now walled in the suburb of Tyche to the west of Achradina. The mercenaries were at last got rid of in 461. Although we hear of attempts to seize the tyranny and of an institution called *petalism*, like the Athenian ostracism, designed to guard against such dangers, popular government was not seriously threatened for more than 50 years. The part of Syracuse in general Sicilian affairs has been traced in the article SICILY (*q.v.*). We hear of a naval expedition to the Etruscan coast and Corsica about 453 B.C. and of the great military and naval preparations of Syracuse in 439.

The Athenian Siege.—The Athenian siege (415–413) is of the deepest importance for the topography of Syracuse. (The chief authorities for the siege are Thucydides [bks. vi. and vii.], Diodorus [bk. xiii.] and Plutarch, *Nicias*.) Through the whole siege there was a treasonable party within the city, which kept up a correspondence with the besiegers. When the Athenian fleet under Nicias, Alcibiades and Lamachus was at Rhegium in Italy, Athens had the prize within her grasp, and she lost it wholly through the persistent dilatoriness and blundering of Nicias (*q.v.*). It was at his advice that the summer and autumn of 415 were frittered away, and the siege not begun till the spring of 414. By that time the Syracusans had built a wall from north to south across Epipolae, taking in Tyche and Temenites, so as to screen them from attack on the side of Epipolae on the north-west. They did not, however, occupy Euryelus, at the western extremity of the high ground of Epipolae, and this omission allowed the Athenians to obtain possession of the whole plateau and to begin the investment of the city. The Syracusans then carried a counterwork up the slope of Epipolae, which, if completed, would cut in two the Athenian lines and frustrate the blockade. At this point Nicias showed considerable military skill. The Syracusans' work was destroyed by a prompt and well-executed attack; and a second counterwork carried across marshy ground some distance to the south of Epipolae and near to the Great Harbour was also demolished after a sharp action, in which Lamachus fell, an irretrievable loss. However, the blockade on the land side was now almost complete, and the Athenian fleet had at the same time entered the Great Harbour. The citizens began to think of surrender, and Nicias was so confident that he neglected to push his advantages. He left a gap to the north of the circular fort which formed the centre of the Athenian lines, the point where Epipolae slopes down to the sea, and he omitted to occupy Euryelus. He made a final and irretrievable blunder in letting the Spartan Gylippus first land in Sicily and then march at the head of a small army, across the island, and enter Syracuse by way of Epipolae, past Euryelus. Just before his arrival a few ships from Corinth had made their way into the harbour with the news that a great fleet was already on its way to the relief of the city. The tables were now completely turned. The military skill of Gylippus enabled the Syracusan militia to meet the Athenian troops on equal terms, to wrest from them their fortified position on Plemmyrium, which Nicias had occupied as a naval station shortly after Gylippus's arrival, and thus to drive them to keep their ships on the low beach between their double walls, to take Labdalum, an Athenian fort on the northern edge of Epipolae, and make a third counterwork right along Epipolae in a westerly direction, to the north of the circular fort. The Athenians were thus reduced to such a plight that, as Nicias said in his despatch towards the close of 414, they were themselves besieged rather than besieging. The naval preparations of the Syracusans, under the advice of Hermocrates, had led them, too, to confidence in their powers of giving battle to the Athenian fleet. In the first sea-fight, which took place simultaneously with the capture of Plemmyrium, they had been unsuccessful; but in the spring of 413 they actually won a victory over the Athenians in their own element.

On the very next day, however, a second Athenian fleet arrived under Demosthenes and Eurymedon, with 73 ships of war and a large force of heavy infantry and light troops. Demosthenes decided at once to make a grand attack on Epipolae, with a view to recovering the Athenian blockading lines and driving the Syracusans back within the city walls. The assault was made by night by way of Euryelus under the uncertain light of the moon, and this circumstance turned what was very nearly a successful surprise into a ruinous defeat. The army was now thoroughly out of heart and Demosthenes was for at once breaking up the camp, embarking the troops, and sailing back to Athens. But Nicias could not bring himself to face the Athenian people at home, nor could he be prevailed on to retire promptly to some position on the coast, such as Catania or Thapsus. He dallied till the end of August, many weeks after the defeat, when the coming of Syracusan reinforcements decided him to depart; but on Aug. 27 was an eclipse of the moon, on the strength of which he insisted on a delay of almost another month. The Syracusans now blocked the mouth of the Great Harbour, and the Athenian fleet, after a frantic effort to break out and a desperate conflict, was utterly defeated and half destroyed. The broken and demoralized army, its ranks thinned by fever and sickness, at last began its hopeless retreat, attempting to reach Catania by a circuitous route; but, harassed by the numerous Syracusan cavalry and darters, after a few days of dreadful suffering it was forced to lay down its arms. The Syracusans sullied the glory of their triumph by putting Nicias and Demosthenes to death.

Dionysius I.—Her great deliverance and victory naturally stirred up the energies of Syracuse at home and abroad. Syracusan and Selinuntine ships under Hermocrates now play a distinguished part in the warfare between Sparta and Athens on the coast of Asia. Under the influence of Diocles the constitution became a still more confirmed democracy, some at least of the magistracies being filled by lot. Diocles appears also as the author of a code of laws of great strictness. Under these influences Hermocrates was banished in 409. In 407 he was slain in an attempt to enter the city, and with him was wounded Dionysius, son of another Hermocrates and an adherent of the aristocratic party, but soon afterwards a demagogue, though supported by some men of rank, among them the historian Philistus. By accusing the generals engaged at Acragas in the war against Carthage, by obtaining the restoration of exiles, by high-handed proceedings at Gela, he secured his own election as sole general with special powers. He next procured from a military assembly at Leontini a vote of a bodyguard; he hired mercenaries and in 406–405 came back to Syracuse as tyrant of the city. Dionysius kept his power till his death 38 years later (367). But it was well-nigh overthrown before he had fully grasped it. After his defeat before Gela (*see* Sicily) his enemies in the army reached Syracuse before him, plundered his house, and horribly maltreated his wife. He came and took his vengeance, slaying and driving out his enemies, who established themselves at Aetna. In 397 Syracuse had to stand a siege from the Carthaginians under Himilco, who took up his quarters at the Olympieum, but his troops in the marshes below suffered from pestilence, and a masterly combined attack by land and sea by Dionysius ended in his utter defeat. Dionysius, however, allowed him to depart without further pressing his advantage. This revolution and the peace with the Carthaginians confirmed Dionysius in the possession of Syracuse, and left it the one great Hellenic city of Sicily, which, however enslaved at home, was at least independent of the barbarian. Dionysius was able, like Gelon, though with less success and less honour, to take up the rôle of the champion of Hellas.

During the long tyranny of Dionysius the city grew greatly in size, population and grandeur. Syracuse absorbed the population of Gela, Camarina and Acragas, and received large accessions from some of the Greek cities of southern Italy, from Hipponium on its west and Caulonia on its east coast, both of which Dionysius captured in 389 B.C. There had also been an influx of free citizens from Rhegium. Dionysius largely extended the fortifications of Syracuse. The island (Ortygia) had been provided with its own defences, converted, in fact, into a separate stronghold. Dionysius, to make himself perfectly safe, drove out a number of the old inhabitants and turned the place into a barracks, he himself living in the citadel. Profiting by the experience gained during the Athenian siege, he included in his new lines the whole plateau of Epipolae, with a strong fortress at Euryelus, its apex on the west; the length of the outer lines (excluding the fortifications of the island) is about 12m. Syracuse was now the most splendid and the best fortified of all Greek cities. Its naval power, too, was vastly increased; the docks were enlarged, and 200 new warships were built. The fleet of Dionysius was the most powerful in the Mediterranean. It was doubtless fear and hatred of Carthage, from which city the Greeks of Sicily had suffered so much, that urged the Syracusans to acquiesce in the enormous expenditure which they must have incurred under the rule of Dionysius. Much, too, was done for the beauty of the city as well as for its strength and defence. Several new temples were built, and gymnasia erected outside the walls.

Dionysius' Successors.—Under his son, the younger Dionysius—an easy, good-natured, unpractical man—a reaction set in amongst the restless citizens of Syracuse. His uncle, Dion, was for a time the trusted political adviser of his nephew Dionysius II. Dion's idea seems to have been to make Dionysius something like a constitutional sovereign, and with this view he brought him into contact with Plato. But Dionysius had Philistus and others about him, who were opposed to any kind of liberal reform, and the result was the banishment of Dion from Syracuse as a dangerous innovator. Ten years afterwards, in 357, the exile entered Achradina a victor. A siege and blockade followed, till Dion made himself finally master of the mainland city. Ortygia, provisions failing, was also soon surrendered. Dion's rule lasted only three years, for he perished in 354 by the hand of an assassin.

Of what took place in Syracuse during the next ten years we know but little. The younger Dionysius came back and from his island fortress again oppressed the citizens. Sicily, too, was again menaced by Carthage. Syracuse, in its extremity, asked help from the mother-city, Corinth; and Timoleon (*q.v.*) delivered Syracuse from the younger Dionysius and from Hicetas, who held the rest of Syracuse, and won a decisive triumph over Carthage and the safe possession of Sicily west of the river Halycus, the largest portion of the island. From 343 to 337 he was supreme at Syracuse, with the hearty good will of the citizens. Syracuse, with an influx of a multitude of new colonists from Greece and from towns of Sicily and Italy, once more became a prosperous city. Timoleon, having accomplished his work, accepted the position of a private citizen. After his death (337) a splendid monument, with porticoes and gymnasia surrounding it, known as the Timoleonteum, was raised to his honour.

In the interval of 20 years between the death of Timoleon and the rise of Agathocles (*q.v.*) to power another revolution at Syracuse transferred the government to an oligarchy of 600 leading citizens. It was shortly after this revolution, in 317, that Agathocles, with a body of mercenaries from Campania and a host of exiles from the Greek cities, backed up by the Carthaginian Hamilcar, became tyrant of the city, and the senate and the heads of the oligarchical party were massacred wholesale, while a unanimous vote of the people gave him absolute control over the fortunes of Syracuse. His wars in Sicily and Africa left him time to do something for the relief of the poorer citizens at the expense of the rich, as well as to erect new fortifications and public buildings; and under his strong government Syracuse seems to have been at least quiet and orderly. After his death in 289 comes another period of revolution and despotism; and but for the brief intervention of Pyrrhus in 278 Syracuse, and indeed all Sicily, would have fallen a prey to the Carthaginians.

A better time began under Hieron II., who had fought under Pyrrhus and who rose from the rank of general of the Syracusan army to be tyrant—king, as he came to be soon styled—about 270. During his reign of more than 50 years (*see* Hieron) Syracuse enjoyed tranquillity, and seems to have grown greatly in wealth and population. Hieron's rule was kindly and enlightened, combining good order with a fair share of liberty and self-government. His financial legislation was careful and considerate; his laws as to the customs and the corn tithes were accepted and maintained under the Roman government, and one of the many bad acts of Verres was to set them aside. It was a time, too, for great public works—works for defence at the entrance of the Lesser Harbour between the island and Achradina, and temples and gymnasia. Hieron through his long reign was the stanch friend and ally of Rome in her struggles with Carthage.

Capture by the Romans.—Hieronymus, the grandson of Hieron, thought fit to ally himself with Carthage, but he soon fell in a conspiracy. There was a fierce popular outbreak and more bloodshed; the conspirators were put to death and Hieron's family was murdered; whilst the Carthaginian faction, under the pretence of delivering the city from its tyrants, got the upper hand and drew the citizens into open defiance of Rome. M. Claudius Marcellus was then in command of the Roman army in Sicily, and he threatened the Syracusans with attack unless they would get rid of Epicydes and Hippocrates, the heads of the anti-Roman faction. Marcellus struck his first blow at Leontini, which was quickly stormed; and its sack roused the feeling of the Syracusans against any negotiations with the Roman general, and, putting themselves under Epicydes and Hippocrates, they closed their gates on him. Marcellus, after an unsuccessful attempt to negotiate, began the siege in regular form (214 B.C.) by both land and sea, establishing a camp on Polichne, where stood the old temple of Olympian Zeus; but he made his chief assault on the northern side and on the defences of Tyche. The city was defended by a numerous soldiery and by the ingenious contrivances of Archimedes, whose engines dealt havoc among the Roman ships and frustrated the attack on the fortifications on the northern slopes of Epipolae. Marcellus had recourse to a blockade, and at last, in 212, information was given him that the Syracusans were celebrating a great festival to Artemis. Making use of this opportunity, he forced the *Hexapylon* entrance by night and established himself in Tyche and on the heights of Epipolae. The strong fortress of Euryelus held out for a time, but, being now isolated, it soon had to surrender. The "outer" and the "inner" city of Thucydides still held out, whilst a Carthaginian fleet was moored off Achradina and Carthaginian troops were encamped on the spot. But a pestilence broke out in the autumn of 212, which swept them clean away and thinned the Roman ranks. The ships sailed away to Carthage; on their way back to Syracuse with supplies they could not get beyond Cape Pachynus owing to adverse winds, and they were confronted by a Roman fleet. All hope for the city being now at an end, the Syracusans threw themselves on the mercy of Marcellus; but Achradina and the island still held out for a brief space under the Syracusan mercenaries, till one of their officers, a Spaniard, betrayed the latter position to the enemy, and at the same time Achradina was carried and taken. Marcellus gave the city up to plunder, and the art treasures in which it was so rich—many of the choicest of them, no doubt—were conveyed to Rome. Archimedes perished in the confusion of the sack while he pursued his studies.

Syracuse was now simply one of the provincial cities of Rome's empire. It retained much of its Greek character and many of its finest public buildings. Its importance and historic associations naturally marked it out as the residence of the Roman praetor or governor of Sicily. Cicero often speaks of it as a particularly splendid and beautiful city, as still in his own day the seat of art and culture. Caligula restored its decayed walls and some of its famous temples. It was plundered by Frankish pirates about A.D. 286. In the 4th century it is named by the poet Ausonius, chiefly, perhaps, on the strength of its historic memories; and there was a purple factory here under an imperial procurator. In 665 Heraclius Constans fixed his capital here, but owing to his oppressive government was assassinated in 668. Syracuse has been a place of comparatively little importance since the year 878, when it was destroyed by the Saracens.

Archaeology.—The mediaeval and modern town of Syracuse (with the exception of a new quarter which has sprung up since the construction of the railway between the station and the island) is confined to the island. This contains the remains of two Doric temples. The older, belonging probably to the beginning of the 6th century B.C., appears, from an inscription on the uppermost step, to have been dedicated to Apollo. It was a peripteral hexastyle of 42 columns; the portion excavated shows that its total width is 74½ft., the width of the cella 38½ft., the lower diameter of the columns 6¼ft. The other temple, into which the cathedral was built in A.D. 640, is to be dated 474–460 B.C. It was a peripteral hexastyle of 36 columns, with a total length of 180ft. and a total breadth of 72ft.; the columns have a lower diameter of 5¾ft., and the intercolumniation is 13½ft. It is almost certainly the temple of Athena. The site was previously occupied by buildings of the 7th and 6th centuries B.C., including an archaic temple and a great sacrificial altar, which were destroyed to make room for it. Their terra-cotta decorations were, however, carefully buried under the pavement of the space which surrounded it; and they are of the highest importance in the history of design, showing that even if the method was Corinthian in origin it was in Sicily that it reached its highest development.

Near the west coast of the island is the famous fountain of Arethusa. According to the legend, the nymph Arethusa was changed into the fountain by Artemis to deliver her from the pursuit of the river-god Alpheus (*q.v.*); and the spring, which was fresh until an earthquake broke the barrier and let in the salt water, was supposed to be actually connected with the river. There are interesting remains of mediaeval architecture in the closely built town with its narrow streets; the beautiful 14th-century windows of the Palazzo Montalto may be especially noticed, and also the 13th-century Castello Maniace at the southern extremity of the island. The town also contains the large and well arranged archaeological museum which is the creation of Prof. Orsi, and is of the highest importance for both pre-Hellenic and Hellenic archaeology. The discoveries of recent years in the south-eastern portion of Sicily, including especially the objects found in Sicel and Greek cemeteries, may be studied there. The isthmus connecting the island with the mainland, which was defended by strong fortifications erected by Charles V. and Philip II. (now demolished), does not occupy the site of the mole erected in the 6th or 7th century B.C., running due north from the north point of the island. On the landward side of the new isthmus was the agora, in which remains of a colonnade of the Roman period have been found. To the west are the remains of an extensive building of the Roman period, probably a palaestra with a small Odeum attached. To the west-north-west is an extensive necropolis, mostly of the 7th and 6th centuries B.C. (For the cemeteries see *The Year's Work in Classical Studies*, p. 123 [1924–25].) This necropolis was included within the defensive wall of Dionysius, a portion of which, no less than 18½ft. thick, was found running diagonally across the new cemetery, and later an outwork in front of it was discovered. East of this point it probably followed the edge of the low terrace above the marsh (the ancient Lysimeleia), while in the other direction it ran north-north-west, making straight for the western edge of the gorge known as the Portella del Fusco, which was thus included within the fortifications, as it would otherwise have afforded a means of access to the enemy. Here the wall gained the top of the cliffs which mark the southern edge of the plateau of Epipolae, which from this point onwards it followed as far as Euryelus. The south wall of Epipolae, considerable remains of which exist, shows traces of different periods in its construction, and was probably often restored. It is built of rectangular blocks of limestone generally quarried on the spot. Euryelus, the point where the terrace of Epipolae narrows down to a ridge about 60yds. wide, which is its only link with the hills to the west, had thrice proved during the Athenian siege to be the key to Syracuse. It now bears the ruins of a mighty fortress, finer than that which defends the entrance to the acropolis of Selinus—the most imposing, indeed, that has come down to us from the Greek period—which there is no doubt is the work of Dionysius. The total length of the works is about 440yds. In front of the castle proper are three ditches, the innermost of which can be reached from the interior of the castle by a complicated system of underground passages. The front of the castle is formed by five massive towers; behind it are two walled courtyards, to the north of the easternmost of which is the well-guarded main entrance to the plateau of Epipolae (narrower minor entrances are to be seen on both the north and the south sides) communicating by a long underground passage with the inner ditch in front of the castle proper. On the north side of Epipolae the cliffs are somewhat more abrupt; here the wall, of a similar construction to that on the south, is also traceable, but here it is apparently all of one period. It is, indeed, recorded by Diodorus that Dionysius built the north wall from Euryelus to the *Hexapylon* in 20 days for a length of 2¾m., employing 60,000 peasants and 6,000 yoke of oxen for the transport of the blocks.

The most important buildings of which we have any remains are to be found in the lower part of Achradina and in Neapolis, a quarter of which we hear first in the time of Dionysius, and which at first was confined to the lower ground below Temenites; but in Roman times included it and the theatre also, though it did not extend beyond the theatre to the uppermost part of the plateau. In lower Achradina remains of Roman private houses have been found, and it is in this district that the early Christians constructed their catacombs. (St. Paul tarried at Syracuse three days on his way to Rome [Acts xxviii. 12].) Those which are entered from near the 12th-century church of S. Giovanni, situated near an ancient temple, are extensive and important, and include the ancient crypt of S. Marcianus, and the type is different from that of the Roman catacombs, the galleries being far larger (partly owing to the hardness of the limestone in which they are excavated), and having circular chambers at the points of junction. In Neapolis, on the other hand, public buildings predominate. The temple of Apollo Temenites has entirely disappeared, but the theatre, entirely hewn in the rock, is still to be seen. It is the largest in Sicily, being 138½yds. in diameter, and having 59 rows of seats; the 11 lower tiers were originally covered with marble. Each of the nine *cunei* or divisions bore a name; the inscriptions of five of them, still preserved on the rock, are in honour of Zeus, Heracles, King Hieron II., his wife Philistis, and his daughter-in-law Nereis. It was restored after 238, after her marriage to Gelon. Of the stage nothing but cuttings in the rock and foundations are visible. (*See* G. E. Rizzo, *Il Teatro Greco di Siracusa* [1923] for a most careful study. *See* also THEATRE.) The situation is well chosen, commanding a splendid view over the Great Harbour, and it is often used for classical performances. Not far off to the south-east is the amphitheatre, probably erected by Augustus when he founded a colony at Syracuse; it is partly cut in the rock and partly built. It is inferior in size only to the Colosseum and the amphitheatres of Capua and Verona, measuring about 153 by 130yds. over all: the arena is 76 by 43yds. To the west of the amphitheatre is the foundation of the great altar erected by Hieron II., 217yds. long by 24 wide, and about 6yds. in height. To the north-west of the theatre a winding road ascends through the rock, with comparatively late tomb chambers on each side of it. In this district are seen hundreds of small niches cut in the rock, as a rule about 2ft. square and a few inches deep, which served for containing inscriptions or reliefs, sometimes of a sepulchral character, but sometimes relating to the cult of a divinity. Both the districts just described also contain huge quarries, the famous Lautumiae (from Gr. λᾶας, stone, and τεμεῖν, to cut; hence λατομία, quarry) of Syracuse, over 100ft. deep and of great extent (though through the collapse of the pillars supporting the undermined rock they have become still larger than they were in ancient times).

We have already seen that immediately outside Lower Neapolis on the south the marshes of Lysimeleia begin, which proved fatal to more than one besieging force. They are traversed by the Anapus, with its tributary the Cyane, the latter famous for the papyrus planted by the Arabs, which here alone in Europe grows wild in the stream. To the south of the Anapus is the hill of Polichne, on which stood the Olympieum, attributed on stylistic grounds to 581 B.C. Its monolithic columns, of which two are still standing, are about 21ft. in height and 6ft. in lower diameter: its length is estimated at 197ft., its breadth at 66⅔ft. This and the temple of Apollo are the earliest known examples of peripteral temples in stone. The hill was frequently occupied in attacks on Syracuse by the besieging force. The hill of Dascon is to be sought a trifle to the south-east, to the south of the mouth of the Anapus, on the edge of the Great Harbour, at the Punta Caderini. From this point southwards the shore of the Great Harbour, previously low and marshy, begins to rise, until the rocky promontory of Plemmyrium is reached.

See A. Holm and F. S. and C. Cavallari, *Topografia archeologica di Siracusa* (Palermo, 1883), or the more handy German translation by B. Lupus, *Topographie von Syrakus* (Strassburg, 1887); P. Orsi, in *Atti del congresso di scienze storiche*, v. 181 (1904), in *Monumenti dei Luicei*, xxv. (1918) 353 sqq. and in *Notizie degli scavi, passim;* E. Mauceri, *Siracusa* (Palermo, 1904); J. Führer and V. Schultze, "Die altchristlichen Grabstätten Siziliens." *Jahrbuch des k. d. arch. Inst.*; Ergänzungsheft. vii. 17 *sqq.* (1907), for the archaeology of Syracuse; and also E. A. Freeman, *History of Sicily* (1891–94) *passim.*

(E. A. F.; T. A.)

SYRACUSE, a city of New York, U.S.A., the county seat of Onondaga county; midway between Albany and Buffalo, at the south end of Lake Onondaga, on Federal highways 11 and 20 and the State Barge canal. It has a municipal airport and is served by the Lackawanna, the New York Central, the West Shore and six inter-urban electric railways and by 34 motor-truck lines. Pop. (1920) 171,717 (19% foreign-born white); 1928 estimate 199,300.

Syracuse has a beautiful site of 25·31 sq.m., on high ground, in an amphitheatre of hills around the south end of the lake (5 m. long), surrounded by a rich agricultural region, within a short drive of the Finger Lake region and less than 100 m. from the Adirondacks and the Thousand islands. Two creeks wind through the city to the lake. Wide boulevards have been constructed over the abandoned beds of the Erie canal (which crossed it from east to west) and the Oswego canal (which came in from the north-west and joined the Erie in the heart of the city). There are six large parks covering over 400 ac. and many small parks and playgrounds; 320 m. of streets (154 m. paved); 106 churches, 3,341 retail business houses, large modern hotels and beautiful residential streets, many of them arched with interlacing elms. Salina street is the main business thoroughfare. Around St. Mary's circle are grouped the county court-house, the public library, the Cathedral of the Immaculate Conception and the unique building of the First Baptist church, which houses a hotel, built around and above the church, in a beautiful structure of ecclesiastical architecture. Syracuse university occupies 100 acres in the south-eastern part of the city, and on the western border are the State fair grounds (with extensive exhibition halls and a coliseum seating 7,500) where the State fair has been held annually since 1890. Six miles south is the Onondaga Indian reservation.

The city operates under a mayor-and-council form of government. The water-supply, brought from Skaneateles lake (20 m. S.W.) by a gravity system, is ample for a much larger population. Hydro-electric current is available from Niagara Falls and the Salmon river. The public educational system comprises 40 elementary, 5 junior high and 3 senior high schools, a normal, a night and a continuation school, and there are 17 parochial and several other private schools. The city's assessed valuation for 1927 was $302,326,444.

The Syracuse region, when first visited by Europeans, was the home of the Onondaga Nation and the capital of the Five (later Six) Nations of the Iroquois. It was visited by Champlain in 1615, by Radisson (while a captive of the Mohawks) in 1651, and in 1654 by Simon le Moyne, a Jesuit missionary, who found that the spring of which the Indians would not drink (because they believed a demon lived in it and gave the water an evil smell) was a fountain of salt brine. A mission was founded in 1655 by Chaumonot and Dablon near the present village of Liverpool (5 m. N.W. of Syracuse) and the next year the mission and a military post were formally established with pomp and ceremony. Both were abandoned because of the hostility of the Mohawks in 1658, but the mission was resumed in 1668 and continued through the century. The Onondaga village (south of the lake) was visited by many important representatives of the French and the English between 1670 and 1760 in their rivalry for the friendship of the Five Nations; and the raid from Ft. Schuyler (April 21, 1779) which determined the Onondagas to side with the British in the Revolution, took place within the present limits of Syracuse. The first white settler on the site of the city was Ephraim Webster, who established a trading post near the mouth of Onondaga creek in 1786. In 1788 Asa Danforth came from Mayfield (New York) with his wife and son. He built a saw-mill and a grist-mill, organized the militia, and is called "the father of Onondaga county." In 1788 the State undertook, by treaty with the Onondagas, to manage the salt springs, and in 1795 it acquired title to them and 10 sq.m. of surrounding land, in return for $1,000 in cash and promise of an annual rental of $700 and 150 bushels of salt. In 1797 the State began leasing the salt lands, on a royalty basis. Three villages soon sprang up around the southern end of the lake: Webster's Landing and Salina in 1797 and Geddes (founded by James Geddes, the first manufacturer of salt on a pretentious scale) in 1803. "The Landing" was known by several names in succession until 1820, when a post-office was established and the name of Syracuse was adopted, after the ancient Greek city in Sicily. It was incorporated as a village in 1825, became the county seat in 1827, and in 1847 Syracuse and Salina were consolidated and chartered as a city. The population in 1850 was 22,271. From time to time various annexations of contiguous territory have been made, including the village of Geddes in 1886. The salt industry was the foundation of the city's development. Until about 1870 it was the dominating industry and Syracuse was the principal source of supply for the United States. Not only was this industry the basis of most of the early individual fortunes in Syracuse, but pressure from the men interested in salt-making crystallized the demand for the Erie canal, the first section of which, passing through Syracuse from Rome to the Seneca river, was opened in 1820. As the salt industry declined, a variety of new and diversified manufactures sprang up. In the 1890's Syracuse made thousands of bicycles, and by 1900 it was one of the principal centres for the manufacture of typewriters.

SYR-DARYA (Gr. and Lat. *Jaxartes;* Arab. *Shash* or *Sihun*), (1) a river of Asiatic Russia, flowing into the Sea of Aral, and having a length of 1,500 m. and a drainage area of about 320,000 sq. miles. Its headstream is the Naryn, rising in the Tianshan south of Lake Issyk-kul, on the south slope (12,000 ft.) of the Terskei Ala-tau. After union with the Barskaun, it flows W.S.W. at 11,000 to 10,000 ft. above the sea, in a barren longitudinal valley between the Terskei Ala-tau and the foothills of the Kokshal-tau. As the Naryn it flows through a wild gorge in the south-west continuation of the Terskei Ala-tau, falling 4,000 feet. Fort Narynsk, 20 m. below the confluence of the Great and the Little Naryn, is only 6,800 ft. above the sea. Here the river enters a broad valley—formerly the bottom of an alpine lake—and flows past the ruins of Fort Kurtka, for 90 m. westward, as a stream some 50 yd. wide and from 3 to 11 ft. deep, used by the Kirghiz for irrigating their cornfields. The At-bash, a large mountain stream, joins the Naryn at the head of this valley and the Alabuga or Arpa at its lower end, both from the left. Before reaching the lowlands the Naryn cuts its way through three ridges which separate the valley of Kurtka from that of Ferghana, and does so by a series of wild gorges and open valleys (170 m.), representing the bottoms of old lakes; the valleys of the Toguztorau, 2,000 ft. lower than Kurtka, and the Ketmen-tube are both cultivated by the Kirghiz. Sweeping north, the river enters Ferghana—also the bottom of an immense lake—where, after receiving the Kara-darya (Black River) near Namangan, it assumes the name of Syr-darya. The Kara-darya is a large stream rising on the northern spurs of the Alai mountains. As it deflects the Naryn towards the west, the natives look upon it as the chief branch of the Syr-darya, but its volume is less. At the confluence the Syr is 1,440 ft. above sea-level.

On issuing from this gorge the Syr enters the Aral depression, and flows for 850 m. in a north-westerly and northerly direction before reaching the Sea of Aral. On this section it is navigated by steamers. Between the Irjar rapids and Baildyr-turgai (where it bends north) the river flows along the base of the subsidiary ranges which flank the Chotkal mountains on the north-west, and receives from the longitudinal valleys of these alpine tracts a series of tributaries (the Angren, the Chirchik, the Keles).

Some 50 m. below Chinaz (770 ft. above sea-level) the Syr bends northwards, but resumes its north-westerly course 150 m. farther down, following with remarkable persistency the edge of the loess. Its low banks, overgrown with reeds and rendered uninhabitable in summer by clouds of mosquitoes, are inundated for 20 m. on both sides when the snows begin to melt. These inundations prevent the moving sands of the Kyzyl-kum desert from approaching the Syr; below Perovsk (Kzyl-Orda, or Ak Mechet) the steppe conquers. Down to Perovsk the river rolls its muddy yellow waters, at the rate of 3 to 5 m. an hour, in a channel 300 to 600 yd. wide and 3 to 5 fathoms deep; at Perovsk its vertical section is 8,220 sq.ft., and 312,500 cu.ft. of water are discharged per second. The Arys and the Bugun are the only tributaries worthy of notice along this part of its course; the other streams which descend from the Kara-tau fail to reach the river. The Kirghiz rear numerous herds of cattle and sheep in the valley of the Arys, while lower down, as far as Julek, the Iginchis carry on agriculture. All this applies of course only to the right bank; on the left the moisture is absorbed by the hot winds which cross the Kyzyl-kum sands towards the river. The dryness of the atmosphere has a marked effect upon the Syr when it gets below Julek, the Kara-kum sands being then on its right. Ten miles below Perovsk the river traverses a marshy depression (the bottom of a lake not yet fully dried up), where it divides into two branches—the Jaman-darya and the Kara-uzyak. The latter spreads out into marshes and ponds, from which it again issues to join the former at Karamakchi, after a course of 80 miles. The main arm, owing to its shallowness and sinuosity, is very difficult to navigate, and the difficulty is increased by the rapidity of the current and the want of fuel. Between Kazalinsk and the Sea of Aral (158 ft.) navigation becomes somewhat easier, except for the last 10 m., where the river divides into three shallow branches before entering the "Blue sea." All three have at their mouths sandy bars with only 3 ft. of water.

Two former right-hand tributaries of the Syr—the Chu and the Sary-su—now disappear in the sands some 60 m. before reaching it. The Chu, which is 600 m. in length, rises in the Tian-shan south-west of Lake Issyk-kul, and as the Kashkar flows towards Lake Issyk-kul, but a few miles before reaching that lake turns suddenly to the north-west, enters under the name of Chu the narrow gorge of Buam, and, piercing the snow-clad Kunghei Ala-tau, emerges on its northern slope, having descended from 5,500 ft. to less than 2,000 in a distance of not more than 50 miles. In this part of its course it receives from the right the Kebin, whose high valley equals in size that of the upper Rhone. It then flows north-westwards through the valley of Pishpek, and, avoiding the Muyun-kum sands, describes a wide curve to the north before finally taking a western direction. Numberless streams flow towards it from the snow-clad Alexander mountains, but they are for the most part lost in the sands before reaching it. The Talas, 170 m. long, formerly an affluent of the Chu, which rises in the highest parts of that range, pierces the Cha-archa mountains, and, flowing past Aulie-ata on the south border of the Muyun-kum, enters the salt lake of Kara-kul 60 m. from the Chu. The Chu terminates in the Saumal-kul group of lakes, 60 m. from the Syr. Another elongated group of lakes—the Uzun-kul—near the above, receives the Sary-su, which has a length of nearly 570 m. and flows rapidly in a narrow channel along the western edge of the northern Famine Steppe (Bekpak-dala).

The delta of the Syr begins at Perovsk, whence it sends a branch to the south-west, the Jany-darya (New River), which formerly reached the south-eastern corner of the Sea of Aral, very near to the mouth of the Amu-darya. The Kirghiz affirm that a canal dug for irrigation by the Kara-kalpaks gave origin to this river. It had, however, but a temporary existence. A dam erected by the people of Khokand at Ak-mechet (Perovsk) caused its disappearance, and the Russians found nothing but a dry bed in 1820. When the dam was removed the Jany-darya again reappeared, but it failed to reach the Sea of Aral; in 1853 it terminated in Lake Kuchka-denghiz, after a course of 250 m.; all traces of its bed were then lost in the sand. Five centuries ago, in the time of Timur, the Mongol prince of Samarkand, the Jany-darya brought the waters of the Syr to the Daukara lakes, close by the present mouth of the Amu. The series of old river-beds in the Kyzyl-kum, which are still seen above Perovsk, indicate that the Syr had a constant tendency to seek a channel to the south-west, and that its present delta is but a vestige of what it was once. At a still more remote period this delta probably comprised all the space between the Kara-tau and the Nura-tau in Samarkand; and the series of elongated lakes at the base of the Nura-tau—the Tuz-kaneh and Bogdan-ata lakes—represent an old branch of the delta of the Syr which probably joined the Zarafshan before reaching the Amu. The cause of this immense change is simply the rapid desiccation of all northern and central Asia. The extension of the Caspian sea as far as the Sary-kamysh lakes during the post-Pliocene period and the extension of the Sea of Aral at least 100 m. to the east of its present position are both proved by the existence of post-Pliocene marine deposits.

(P. A. K.; J. T. Be.)

See W. R. Rickmers, *The Duab of Turkestan* (1913); A. Boutquin, *L'Asie Centrale, la Question du dessèchement du globe* (1910).

(2) A former province of Asiatic Russia, now included in the Kazakstan A.S.S.R. and Uzbek A.S.S.R. (*qq.v.*)

SYRIA, an independent State of south-west Asia placed under the mandate of France (1920). The region is bounded west by the Mediterranean, south by Palestine, east by Mesopotamia and north by Turkey. The area of Syria under the French mandate is estimated at 60,000 sq.m. and the population at under 3,000,000. Syria has been used as a name to include various expanses of country in south-western Asia. Some early Muslim geographers included all the Hamād in Syria, making its boundaries a blunt-headed triangle with a base some 700 m. long resting on the North Arabian Nefud. But Strabo, Pliny and Ptolemy, as well as Muslim geographers, drew the eastern frontier obliquely from the Gulf of Aqaba to Rakka (Raqqa) on the Euphrates and thus placed the Hamād in Arabia.

The name *Syria* is not found in the original Hebrew of the Scriptures; but it was used by the Septuagint to translate Aram. Homer knows only Ἄριμοι, but Herodotus speaks of "Syrians" as identical with Assyrians, the latter being, he thinks, a "barbarian" form, and he applies the name very widely to include, *e.g.*, north Cappadocians ("White Syrians" of Pteria). Syria, however, is probably the Babylonian *Suri*, used of a north Euphratean district, and a word distinct from Assyria. Generally the ethnic term, Syrian, came to mean in antiquity the Semitic peoples outside the Mesopotamian and Arabian areas; but neither in pre-Greek nor in Greek times had the word Syria any precise geographical significance, the various lands retaining their distinctive status, *e.g.*, Commagene (Kummukh), Cyrrhestica, Phoenicia, Palestine, etc. It is only under the Graeco-Roman administration that we find a definite district known as Syria and that was at first restricted to the Orontes basin. All that was understood until 1914 by Syria came to be so known officially to the Romans and Byzantines; but the only province called simply Syria, without qualification, remained in the Orontes valley.

Syria, under the French mandate, is a section of the great ancient block of which Arabia, Sinai and Africa also form part. This old block rises steeply from the Mediterranean to about 10,000 ft. and then falls in a series of long steps eastward to the basin of the Upper Euphrates, which flows in a great structural depression between the ancient block and the newer and loftier fold mountains of Kurdistan beyond. In the extreme north of French mandated Syria a section of these fold mountains forms part of the orography.

A marked feature of the old block section is that it is deeply gored by fracture lines, which run mainly in a north to south direction. The 34° N. parallel, which passes near Baalbek, marks a watershed from which may be traced the Orontes (Nahr el 'Āsi) flowing northward among the fracture lines and the north Lītāni, in its upper course, flowing southward. The Jordan valley continues the great north to south fault into Palestine whence it may be followed southwards via the Dead sea and the gulf of Aqaba into East Africa. The Orontes, after flowing northwards past the 36° N. parallel, turns abruptly westward and occupies the depression between Jebel Akra and the Amanus mountains. In this valley is Antioch. The southward-flowing Lītāni repeats this on the south when it turns abruptly westward through the upper Cretaceous of Lebanon and becomes known in its lower course as the Kasimiya. Numerous smaller streams flow westward into the Mediterranean from the mountains of Lebanon (*q.v.*) and Jebel Nuseiriye. The latter is a high chain of Jurassic limestone with basaltic intrusions, whose peaks rise to 10,000 ft. and whose passes do not fall under 6,000 ft. To the east of the Orontes-Lītāni-Jordan fracture is the triple chain of Jebel al Ala in the north defining the Orontes valley on the east. Like its western parallel it springs up to the south into a lofty chain known as Jebel esh Sharqi (Anti-Lebanon) (*see* Lebanon), which culminates on the south in the outstanding peak of Hermōn (8,000 ft.). Thereafter the mountain ranges lose much of their distinctive character.

To the east of the mountains lie the desert and steppe lands. Oases in a series are fed by local streams. Of these the most important are the Saltpan of Jebeil in the north fed by the North al-Dahab; the oases of Kinnesrin and Aleppo, fed by the North Kuwaik and that of Sham or Damascus fed by streams from Hermōn, of which the Barada (Abana) and the Acwaj (Pharpar) are the chief. Marine Pliocene beds have been found at El Forklus in the Palmyra desert. To the west of the mountain ridges lies the coastal plain. It is very narrow in the south from Tyre (Es Sur) to Tripoli, but widens out in the north especially near the river mouths. The coast (with the exception of the delta sections) shows marked north to south lines. These seem related structurally to the great north to south faults among the mountains. The few indentations of the coastline limit the natural harbours, but where local circumstances have been favourable (*e.g.*, a small island off Tyre and a small promontory near Beirūt) some of the great harbours of the ancient world grew up. On this coast, it was said, the east and west met. Thus behind the mountains were the great bazaars—Damascus, Antioch, Awa and Aleppo—and on the coast the great ports, Tyre, Sidon, Acre, Beirūt, Tripoli, Latakia and Alexandretta.

Climate.—The coastal strip of Syria has the best climate, because it is exposed to the moderating influences of the Mediterranean. The westerly rain-bearing cyclonic storms bring rain in winter to this part which has the heaviest fall in the south (Beirūt 21·66 in. mean annual rainfall). Among the mountains of Lebanon the rainfall often exceeds 40 inches. The coast lands are also less affected by intense heat, owing to the sea influences, the mean annual temperature at Beirūt being 68°. Where the cooling sea winds are shut off by the mountains, as at Aleppo and Damascus, the heat is intense. In winter the dense, cold, dry anticyclonic influences of central Asia spread over the plateau regions of Syria, giving frost and snow among the mountains; but this is never experienced along the coast. The interior steppe gives great contrasts of temperature both seasonal and diurnal, although the rainfall is always slight. In early summer a hot, dry wind, often bringing large quantities of sand, blows out from the desert and often damages the vegetation of the coastal regions. These general climatic conditions mean that Syria, except the narrow littoral strip, which was the ancient Phoenicia, and the small deltas, such as that of Latakia (Laodicea), is not highly productive without irrigation. The larger rivers (*e.g.*, the Orontes) flow in deep beds and are thus of little use for irrigation purposes. Mid-Syria, except for the lacustrine oases, is a region mainly occupied by pastures and yielding only thin cereal crops. The plains south and south-east of Aleppo have a little spring rain giving a good spring pasture which has attracted the nomads from farther south. Below the latitude of Raqqa-Homs thin steppe begins, and quickly degenerates into desert broken only by a chain of poor oases, south of a low ridge running from Anti-Lebanon to Euphrates. Of these the principal are Karietein and Tadmor (Palmyra), through which passes the trade from Damascus to the east.

Flora and Fauna.—Two distinct floral regions meet in Syria, that of the Mediterranean and that of the west Asiatic steppe-land. The first, to be seen on the coast and the western slopes of the highlands, is characterized by evergreen shrubs, and by quickly-flowering spring plants. On the lowest levels the southern forms, the *Ficus sycomorus* and the date-palm, appear, and increase in the direction of Egypt. (*See* Lebanon and Palestine.) The steppe region, whose flora appears east of the western ridge, is distinguished by the variety of its species, the dry and thorny character of its shrubs, and great poverty in trees. Among cultivated trees, the olive is at home throughout Syria, except on the steppe: the mulberry is planted extensively in the lower Lebanon; and all sorts of fruit-trees flourish in irrigated gardens, especially on the Phoenician coast, in the oases of Damascus, and in the Buka'a. The lower western slopes of the coast range are largely devoted to tobacco growing. In the northern inland hill-country liquorice grows wild. The mammals of Syria include the isabelline bear, badger, pole-cat, ermine, roe and fallow deer, wild ass, Syrian squirrel, pouched marmoset, gerbill and leopard.

Population and Religion.—The population (1922) of the major divisions of Syria was as follows:—Syria 1,198,829, Lebanon 628,863, 'Alawis 261,062 and Jebel ed Drūz 50,328. Phoenicia and the Lebanon districts in the south coastal region have the densest population, while the oases of Damascus and Aleppo, the Orontes valley and parts of the extreme north-west are well-peopled. The bulk of the population shows Semitic features. The Aramaean element is fundamental though it has a large admixture of immigrant Arabian blood which is constantly being reinforced. In the extreme north the highlands are almost entirely held by Kurds who entered from beyond Euphrates in comparatively recent times. Kurds live upon the Commagenian plains, as also in the northern trans-Euphratean plains. Among them in the Taurus and Amanus, and outnumbering them on the plains, formerly lived Armenian communities, many of whom have become refugees in mandated Syria. These are found as far south as the plain of Antioch and the basin of the Sajur. To the north of Aleppo and Antioch live remnants of pre-Aramaean stocks, mixed with many half-settled and settled Turkomans (Yuruks, Avshars, etc.), who came in before the Mohammedan era, and here and there colonies of imported Circassians. Mid-Syria shows a medley of populations, in large part alien, for which *see* DRUSES; MARONITES; and LEBANON. In the Phoenician coast towns are many Greeks. In the steppe-land are numbers of true Arabs, mostly belonging to the great Anazeh family, which has been coming northwards from Nejd in detachments since the 13th century. Turks and various Europeans complete the medley.

The bulk of the population is Mohammedan. Besides orthodox Muslim there are also Shī'ite sects, as well as followers of old religions modified by Islam such as the Ismailites (Assassins), *q.v.*, Metawali, Nosairis, Ansarieh, and especially the Druses (*q.v.*). The Jews are found mainly in the larger centres of population. The Christians are an important element and have had churches in Syria since the earliest times. There are three uniate patriarchs and one orthodox patriarch of Antioch. Arabic is the prevailing language though it has many local dialects. Survivals of Aramaic are in the remote villages of Anti-Lebanon. From the upper Sajur northwards Turkish prevails, but many Kurdish communities retain their own tongue.

Education.—The American university of Beirūt was founded in 1866. There were 934 students in 1923–24. There is also a Jesuit university in Beirūt founded in 1875. The French have about 500 schools with 50,000 pupils, while the Greek Catholics have a seminary at Ain Traz near Beirūt, and a patriarchal college in the city. The Maronites, Roman Catholics and British missionary societies have educational institutions. There are high grade schools at Aleppo, Damascus and Brummāna and a training college at Beirūt.

Government.—Until 1914 Syria was a province of Turkey-in-Asia. By decision of the Supreme council of the Allied powers after the World War of 1914–18 Syria was recognized in 1920 as an independent State to be placed under the mandate of France. This was confirmed by the League of Nations in 1922. The country was originally divided into five regions (*états*) but since 1925 the *états* of Damascus and Aleppo have been united to form the territory of Syria (Sanjaqs of Hamā, Homs, Damascus, Haurān, Aleppo, Alexandretta and Deir ez Zor). The other regions are 'Alawis (Sanjaks of Latakia and Tartūs), Great Lebanon, and Jebel ed Drūz. The Great Lebanon (*q.v.*) was proclaimed a State in 1920 with Beirūt as the seat of government. Syria is administered by a high commissioner.

Communications.—There has been a great improvement in the roads during the 20th century. In 1924 Syria had 4,021 m. of roadway of which 1,384 m. were fit for motor traffic. Railway communication is also good; lines run from Beirūt to Homs, Hamā, Aleppo (Haleb) and Damascus. The latter is connected via Der'ā in the extreme south with Haifa and northern Palestine generally. The following sections of railway were opened in 1925, Beirūt to Damascus; Riyāq Mameltein to Aleppo, Homs to Tripoli; Beirūt to Damascus to El Hammé.

Commerce and Trade.—The great caravan trade with the east that made Syria and the Levant so important in the middle ages and long before, has now almost entirely ceased. Syria is mainly an agricultural country with large areas given over to cattle and sheep rearing. About 10% of the area of mandated Syria, including the Haurān, raises crops, of which wheat, barley, and millet are the most important. Over a million tons (estimate) of wheat were raised in 1925. Sesame, from which oil is produced, is a valuable but uncertain crop. About 4,700 ac. in Latakia, Aleppo, Beirūt and Damascus produce about three million pounds of tobacco. A marked feature of recent developments in Syria (1920–28) is the extended cultivation of cotton. In 1922 5,000 tons were produced; two years later this had reached 30,000 tons. Sugar cane and hemp are also important. The white mulberry is grown in the north to feed silk-worms. Oranges, lemons and bananas are important among the exports. (E. G. Bow.)

ANCIENT HISTORY

Rude stone monuments (circles and dolmens) and other prehistoric remains are an indication that Syria must have been inhabited from an extremely early period. Within historic times a great number of different nationalities have fought and settled within its borders, the majority belonging to the Semitic stock. This last circumstance has rendered possible a considerable degree of fidelity in the tradition of the oldest local names. After the Aramaeans had absorbed what remained of the earlier population, they themselves were very powerfully influenced by Graeco-Roman civilization, but as a people they still retained their Aramaean speech. Of the political relations of Syria in the most ancient times we know but little. Each town with its surrounding district seems to have constituted a small separate State; the conduct of affairs devolved upon the noble families. In the latter part of the 16th century B.C. all north Syria fell under the Cappadocian Hatti domination. The south part of Syria was known to Sargon of Akkad (*Agade*) as Ammon and was visited by his armies. This is known as the Canaanite period, succeeded about 1000 B.C. by the Aramaean. As early probably as the 16th century B.C. Syria became the meeting-place of Egyptian and Babylonian elements; a type of western Asiatic culture resulted which through the commerce of the Phoenicians was carried to the western lands of the Mediterranean basin. Industry especially attained a high state of development; rich garments were embroidered, and glass, pastes, faience, etc. were manufactured. The influence exercised on Syrian art by the powerful neighbouring states is confirmed by recent finds which show the action of the Aegean culture on Phoenicia and Palestine. The Syrians were more original in what related to religion; every place, every tribe, had its "lord" (Ba'al) and its "lady" (Ba'alat); the latter is generally called 'Ashtar or 'Ashtaret (*i.e.*, Ishtar, Astarte). Besides the local Ba'al there were "the god of heaven" (El) and other deities; human sacrifices not uncommon.

Something about the ancient political and geographical relations of Syria can be gleaned from Egyptian sources, especially in connection with the campaigns of Tuthmosis (Thothmes) III. (*see* EGYPT, *History*), in western Asia and the administration of Amenophis (Amenhotep) IV. (the Tell el-Amarna Letters). The Egyptians designated their eastern neighbours collectively as 'Amu. Syria up to and beyond the Euphrates is called more precisely Sahi and is regarded as consisting of the following parts: (1) Rutenu, practically the same as Palestine (occasionally Palestine with Coelesyria is called Upper Rutenu, as distinguished from Lower Rutenu extending to the Euphrates); (2) the land of the Kheta (sometimes reckoned as belonging to Rutenu with Kadesh on the Orontes as its capital in the Ramesside period); (3) Naharina, the land on both sides of the Euphrates (extending, strictly speaking, beyond the Syrian limits). The Canaanites in general are called Kharu. From these lands the Egyptian kings often derived rich booty, so that in those days Syria must have been civilized and prosperous. Moreover, we possess enumerations of towns which can be readily identified, such as Aleppo, Kadesh, Sidon, as well as many in Palestine. The Tell el-Amarna

Letters (15th century B.C.) show Syria held in part by Egyptian viceroys, who are much preoccupied with southward movements due to pressure of Amorite peoples, and of the Mitanni and the Kheta, whose non-Semitic blood was mingled with that of the Aramaeans even in Palestine. On the latter in Syria, *see* HITTITES. It need only be said here that this people bulked most largely in the relations of Egypt with Syria from the 16th to the 14th centuries. During the reign of Rameses II. it was centred on the upper Orontes (Kadesh). Later we find Kheta focused farther north, on the middle Euphrates (Carchemish), and more or less cut off from Egypt by the Hebrew State. They remained, however, the most powerful of the Syrian elements until the westward extension of Assyria about 1050 B.C., under Tiglath-Pileser I. Late in the 8th century Sargon III. took Carchemish and ended Hittite power.

With the fall of the Kheta the Aramaeans were the people who held the most important towns of Syria, gradually advancing until at last they occupied the whole country. Of the Aramaean stocks named in Gen. x. 23, xxii. 21 *et seq.* very little is known. A great part was played in the history of Israel by the State of Aram Dammesek: *i.e.,* the territory of the ancient city of Damascus; it was brought into subjection for a short time under David. The main object of the century-long dispute between the two kingdoms was the possession of the land to the east of the Jordan (Hauran, and especially Gilead). Hamath in the valley of the Orontes was from an early period one of the most important places in Syria; according to the Bible, its original inhabitants were Canaanites. In 733 B.C. Tiglath-Pileser II. compassed the overthrow of the kingdom of Damascus; he also took Arpad (Tel Arfad), an important place three hours to the north of Aleppo. Hamath was taken by Sargon in 720. Henceforward the States of Syria were subject to one or other of the great world-empires, and were still in dispute between Babylonia and Egypt as late as Necho. Thereafter the Mesopotamian powers prevailed, even if in some cases a certain degree of independence was preserved; *e.g.,* by the Phoenician cities. These, however, in spite of more than one revolt, continued to supply fleets to the Persians down to the time of the Macedonian invasion (332 B.C.).

The foundation of numerous Greek cities after Alexander's time was of great importance for Syria (see *e.g.,* ANTIOCH). The Graeco-Syrian civilization extended far to the south down both sides of Jordan, and, but for the Maccabaean revival, would have absorbed the Jews. The Seleucidae had severe struggles with the Ptolemies for the possession of the southern part of Syria (*see* MACEDONIAN EMPIRE).

After having been reckoned from 83 to 69 B.C. among the dominions of Tigranes, king of Armenia, the country was conquered for the Romans by Pompey (64–63 B.C.). It is of special interest to note that the kingdom of the Arab Nabataeans was able to keep its hold for a considerable period on the north as far as Damascus. The country soon became one of the most important provinces of the Roman Empire; its proconsulship was from the first regarded as desirable, and this eminence became still more marked afterwards. Antioch, adorned with many sumptuous buildings, as the chief town of the provinces of Asia, became in point of size the third city of the empire. The high degree of civilization then prevailing in the country is proved by its architectural remains.

The administrative divisions of Syria during the Roman period varied greatly at different times. Hadrian made three provinces of it, Syria, Syria Phoenice and Syria Palestina. At the beginning of the 5th century we find the following: (1) Syria Euphratensis, which had for its capital Hierapolis (*q.v.*). (2) Syria I., or Coelesyria, having Antioch as its capital. The name Coelesyria (*ἡ κοιλὴ Συρία*), no doubt, was applied originally to the valley ("hollow") between Lebanon and Anti-Lebanon, but was afterwards extended to the district stretching eastwards from the latter range. (3) Syria II., or Syria Salutaris, with Apameia as capital. (4) Phoenice Maritima; capital, Tyre. (5) Phoenice ad Libanum; capital, Emesa (Hoṃs). To this division Damascus and Palmyra belonged. (6, 7, 8) Palestina I., II. and III. (9) Arabia (capital, Bostra), which embraced all the region from the Hauran to the Arnon, and skirted the Jordan valley, stretching southwards to Petrae. Through the kingdom of the Nabataeans Roman influence penetrated from Syria far into northern Arabia.

In A.D. 616 Syria was subjugated for a brief period by the Persian Chosroes II.; from 622 until 628 it was again Byzantine; 636 and the immediately following years saw its conquest by the Mohammedans (*see* CALIPHATE). During the struggles of the Mohammedan dynasties for the possession of Syria the country still enjoyed a considerable degree of prosperity.

In the period of the crusades the kingdom of Jerusalem, whose rulers were never able to establish a foothold to the east of the Jordan, extended northwards to Beirut; next to it lay the countship of Tripoli on the coast; and beyond that in north Syria was the principality of Antioch. Syria suffered severely from the Mongol invasions (1260), and it never recovered its former prosperity. In 1516 the Ottomans took it from the Egyptian Mamelukes (*see* TURKEY: *History*). Its mediaeval importance as an intermediary of trade between Europe and the East was impaired by the opening of the Red sea route, and abolished by the Suez Canal. For the archaeology of Syria *see* ASIA MINOR: *Archaeology.* (D. G. H.; X.)

MODERN HISTORY

Syrian Nationalism.—One result of the Turkish revolution of 1908 was to give an impetus to the Nationalist movement which had begun, some years before, to gain ground in the Arabic-speaking provinces of the Turkish empire, and especially in Syria.

It was not until 1912, when Turkey was reeling under the shock of the Balkan wars, that it was thought that something should be done to conciliate the Arabs. Kiamil Pasha, who became grand vizier towards the close of the year, allowed a national assembly to be convened at Beirut for the purpose of formulating the Syrian demands. The assembly met in Jan. 1913, but its proceedings were annulled by Mohammed Shevket Pasha, who succeeded Kiamil a few weeks later. In June 1913 a so-called Arab congress was held in Paris. The members were drawn mainly from what may be called the French sphere of influence in the Lebanon and Beirut. The congress adopted a comparatively moderate programme, including the usual demand for decentralization, and resolved that it should be communicated, not only to the Turkish Government, but to foreign Powers in friendly relations with Turkey.

The Turkish Government was sufficiently impressed to invite three Muslim members of the congress to visit Constantinople. Another conciliatory gesture was the recall of the Vali of Beirut, an uncompromising opponent of concessions to the Arabs, and the appointment of a more liberal-minded successor. A little later a number of Arabs, including some of the militant reformers, were given seats in the Turkish Senate or lucrative appointments in the civil service. By these means the Turks succeeded in buying off some of their opponents, but on the main points at issue they continued to temporize, and the Syrian demands received no substantial satisfaction. The situation in Syria was watched with special vigilance in Paris. On Dec. 21, 1912, the prime minister, M. Poincaré, declared in the Senate that "we have traditional interests in the Lebanon and Syria, which we intend to have respected." On the eve of the World War France was busily engaged in strengthening her position in the Levant against German competition, and was negotiating for the acknowledgment, on a *do ut des* basis, of her prior claim to concessions in Syria and Palestine.

When Turkey entered the war, in Oct. 1914, France promptly asserted her claims in the Levant, and so far as Syria was concerned, as distinct from Palestine, they were never questioned. As between Great Britain, France and Russia the matter was disposed of in the spring of 1916 by a tripartite agreement, which was elaborated as between Great Britain and France by the so-called Sykes-Picot agreement. This agreement, which was concluded on May 16, 1916, gave France virtually a free hand on the Syrian coast, with a veiled protectorate over the interior.

War Conditions.—In Syria itself it looked at first as though the outbreak of war had given the Nationalists their opportunity. But the tide soon turned against them. Among the French consular archives which were seized in Syria the Turks claimed to have discovered evidence of treasonable dealings with France on the part of a number of the Nationalist leaders. This was the signal for a series of executions and deportations, which began in the summer of 1915 and continued for the next 12 months. For the time being, at least, the Nationalist agitation was completely cowed. Syria had, indeed, little chance of giving trouble. Except for an occasional raid on the coast, it did not become a theatre of war until the eve of the Armistice and had no opportunity—even if it had the desire—to co-operate with the Allies. In the autumn of 1918 Gen. Allenby, at the head of the British forces in Palestine, having expelled the Turks from Palestine, swept on after them through Syria, and the Armistice which came into force on Oct. 31, 1918, left the whole of Syria in the hands of the Allies.

Post-war Settlements 1918–24.—On Nov. 7, 1918, the British and French Governments issued a joint declaration, in which they announced their intention of establishing, both in Syria and Mesopotamia, "national governments drawing their authority from the initiative and free choice of the native populations." Meanwhile the Syrian sea-board, including Beirut, was placed in charge of the French, while the interior was handed over to an Arab Government which was set up at Damascus under the emir Feisal, both areas remaining as occupied enemy territory under the general supervision of Lord Allenby as commander-in-chief. On Sept. 15, 1919, Great Britain and France signed a convention by which the Syrian seaboard came under the direct and exclusive control of France. The interior remained under the administration of the emir Feisal, but it was now brought within the French sphere of influence, and ceased to be under the general control of the British commander-in-chief. The anti-French agitation conducted by the Arab Nationalists came to a head in March 1920, when an Arab congress met at Damascus and declared "the complete independence of Syria, without any form of foreign interference." At the same time, Feisal was proclaimed king of Syria. Great Britain and France united in refusing to recognize the Syrian kingdom, but the Damascus Nationalists remained defiant. The end came in July 1920, when a French ultimatum to the Arab Government was followed by an advance into the interior, the flight of the emir Feisal, and the entry of French troops into Damascus.

Meanwhile, Syria had been under discussion at the Peace Conference in Paris, where it was the subject of a complicated, and at times acrimonious, exchange of views between Great Britain and France. It was eventually agreed in principle that the situation in Syria should be examined on the spot by an international commission of enquiry, but all that actually happened was that two American delegates, Dr. King and Mr. Crane, spent a few weeks in Syria in the summer of 1919. They reported that a French mandate would be wholly unacceptable and recommended that the Mandatory Power should be the United States, with Great Britain as a second-best. The King-Crane report, however, had no influence on the course of events, and on April 25, 1920, the Supreme Council of the Allies formally agreed at San Remo that the mandate for Syria should be allotted to France. The terms of the mandate were approved by the Council of the League of Nations on July 24, 1922, but further delays intervened, and the mandate did not become fully effective until Sept. 29, 1923. The situation was finally regularized by the formal detachment of Syria from the Ottoman empire under the Treaty of Lausanne, which came into force in Aug. 1924.

French Administration.—It was, however, the French occupation of the interior in the summer of 1920 which marked the opening of the new régime by bringing the whole country under direct French control. The Lebanon, which the French had occupied at the Armistice, was recognized in Sept. 1920, by the League of Nations as a separate "State," with an area considerably larger than the pre-war province. The Lebanon was predominantly Christian, and its administration involved the absorption of a large number of unwilling Muslims. Inner Syria was broken up into the "States" of Damascus and Aleppo, together with the "Territory of the Alawiyin," with its capital at Latakia. In July 1922 the three divisions of Syria proper, as distinct from the Lebanon, were given an opportunity of co-operating in matters of common concern through the medium of a federal council. By a decree dated Dec. 5, 1924, the federation was dissolved, the States of Damascus and Aleppo were amalgamated into the State of Syria, and the State of the Alawiyin became a separate unit.

The Druse Rebellion.—Syria contains many turbulent elements, and the French had repeatedly to deal with unrest in various parts of the mandated territory. In 1919–20 they met with determined resistance in the Djebel Ansariyeh, the northern neighbour of the Lebanon. There was serious rioting at Damascus in 1922 and again in 1925. In the Alexandretta district, in the extreme north of Syria, the French were constantly harassed by Turkish raids across the border, while they also had some trouble with the tribesmen of the desert frontier on the east. In the Druse country in the Hauran there was scarcely a quiet year until 1923, and it was here that the signal was given for the widespread rising which closely followed the arrival of Gen. Sarrail as high commissioner, in succession to Gen. Weygand, at the beginning of 1925. The Druses rose in open rebellion in July. Their initial successes brought to the surface the latent discontent which existed in other parts of Syria, and it looked for the moment as though the French would be faced with a general rising. A serious situation developed at Damascus, and on Oct. 18–20 the French took the extreme measure of subjecting the city to a 48-hour bombardment. By the end of 1925 the weak French garrison in Syria had been considerably strengthened, and the insurrection had been checked, though by no means completely suppressed. In Dec. 1925 Gen. Sarrail was superseded as high commissioner by Henri de Jouvenel, whose declared policy was one of conciliation. De Jouvenel was not, however, conspicuously successful. Nationalist opposition defeated his attempt to form a provisional Syrian Government under the sheikh Taju'd-Din, while in some parts of the country, notably at Damascus, the population boycotted the elections which he ordered to be held as a first step towards a *modus vivendi.* By the middle of 1926 the back of the rebellion had been broken, though the country remained restless.

The circumstances of the rising were closely investigated, on behalf of the League of Nations, by the permanent Mandates Commission at a special session held in Rome in Feb. and March 1926. The commission, in its report to the League Council, convicted the French of serious errors of policy and severely censured the conduct of Gen. Sarrail, though at the same time it recognized the difficulties of the mandatory power.

In June 1926 de Jouvenel appeared in person before the Mandates Commission to report progress. The gist of his statement was that France looked forward to an eventual settlement on the lines successfully followed by Great Britain in 'Iraq, but that the real difficulty was that Syria was a medley of warring sects and races which it would take time to weld into a nation. Article I. of the mandate required France to provide Syria with a permanent Constitution in the shape of an organic law within three years of the date on which the mandate came into force. The time-limit expired on Sept. 29, 1926, but on Sept. 20 the Council of the League agreed to a six months' extension. The Mandates Commission took note of this decision at its meeting in Nov. 1926, but it returned to the subject in reporting to the Council on the situation in Syria in July 1927, when it drew attention to the fact that the organic law had not yet been promulgated. At the end of 1927 the linked problems of Syrian constitution and of the relations between Syria and France still awaited a final solution.

Though in this respect the situation remained anomalous, the pacification of Syria had made considerable progress since the Druse rebellion began to flicker out in the spring of 1926. The embers of the rising still smouldered, but the crisis was over, and in the end the Druse leaders either fled the country or made their peace with the victors. In May 1926 de Jouvenel succeeded in setting up a Syrian Government under Ahmed Nami Bey, though it was a Government which derived its authority from the high commissioner and not from any representative assembly. In the State of the Alawiyin the representative council resumed its sittings in Oct. 1926, but Syria as a whole remained without constitutional machinery through which it could negotiate a permanent settlement with the Mandatory Powers. On the other hand, an increased measure of autonomy was granted to the Lebanon, which was formally proclaimed a republic on May 23, 1926, while in the Alexandretta district the situation was eased by the signature on May 30, 1926, of a Franco-Turkish treaty defining the frontier between Syria and Turkey and guaranteeing Syria against Turkish raids.

In Aug. 1926 de Jouvenel was succeeded as high commissioner by Henri Ponsot, who arrived in Syria in October, was recalled to Paris for consultation with the Home Government a few months later and returned to his post in June 1927. By this time, though there was still much latent unrest, Syria could no longer be said to be out of hand. On July 27, 1927, M. Ponsot made his eagerly awaited statement of policy. Its key-note was *festina lente*. France undertook to encourage the political evolution of the various Syrian States and to promote co-operation between them in matters of common concern, but she was non-committal on the subject of Syrian unity and independence. M. Ponsot's first important step after the publication of this statement was one which caused much dissatisfaction in the Lebanon. He insisted on a drastic modification of the Lebanon Constitution of 1926. The senate was to be abolished, and half the members of the chamber, instead of being popularly elected, were to be nominees of the Lebanese Government. To these unpopular proposals the Lebanese parliament eventually agreed, under protest, on Oct. 12, 1927.

On the French side public opinion was moving in the same direction, and on Dec. 14, 1927, the foreign affairs committee of the senate passed a resolution urging that definite proposals with regard to the future administration of Syria should be put forward without delay. In Feb., 1928, M. Ponsot announced that elections would shortly be held for a constituent assembly. The immediate sequel was the resignation of Ahmed Nami Bey as president of the Syrian State in favour of Sheikh Taju'd-Din who had been M. de Jouvenel's original choice for the same appointment. M. Ponsot next proceeded to issue a series of decrees abolishing the censorship of the Press, terminating the state of siege, declaring an amnesty (with certain exceptions) for political offenders, and giving the franchise to all citizens who had attained the age of 21. Polling took place in April, 1928, and resulted in the election of a constituent Assembly of a predominantly Nationalist complexion.

The assembly met at Damascus on June 9, and proceeded to frame an elaborate constitution, of which the outstanding feature was that Syria was declared to be an independent republic with Damascus as its capital. It was further declared that Syria was one and indivisible, and that the post-war territorial charges (including the enlargement of the Lebanon and its recognition as a political unit distinct from Syria) were null and void. M. Ponsot pointed out that the proposed constitution ignored the existence of the mandate, and would make it impossible for France to discharge her obligations as the Mandatory Power. His remonstrances, however, were ineffectual. The assembly was obdurate, and in August, a deadlock having been reached, M. Ponsot suspended the sittings of the assembly for three months. Thus, in the autumn of 1928 the gulf between the Mandatory Power and the people of the mandated territory was still unbridged, and although Syria was outwardly quiet, the Syrian problem seemed as far as ever from a solution. (*See* also DRUSES, LEBANON.)

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SYRIAC LANGUAGE. Syriac is the name given to the language used by Christian writers in the region east of Antioch, including the Christian subjects of the Persian empire. It seems to have been originally the local Aramaic dialect of Edessa (*q.v.*), which became a centre of Christianity as early as the last third of the 2nd century. Edessa was till 216 the seat of a native monarchy, consequently the new religion took a vernacular form there, whereas inside the Roman empire no languages except the imperial Greek and Latin were used by Christians for literature or public worship until the 4th century. But the Bible and the forms of Christian liturgy having been translated into the Edessene dialect and publicly used, this dialect was accepted all over the East by native Christians as a classical literary language.

Since the 5th century A.D. owing to theological differences Syriac-using Christians have been divided into Nestorians or East Syrians and Jacobites (Monophysites) or West Syrians, and these groups are now linguistically distinguished by certain differences of pronunciation, chiefly in the vowels. The East Syrians in most cases have kept the more primitive pronunciation, *e.g.*, the old Semitic *ā* with them remained *ā*, but with the Jacobites passed into *ō*. The name *Jesus* is by the East Syrians pronounced *Ishoʿ*, by the Jacobites *Yeshūʿ*. The language of the Maronites, a religious body now in communion with Rome and chiefly living in the Lebanon region, is in all respects the same as that of the Jacobites or West Syrians. Classical Syriac is now nowhere a spoken language. A variety of the Western Syriac survived till about 50 years ago in some villages near Damascus, and the Nestorians of the Tigris valley speak a modern dialect akin to the old East Syriac though differing considerably from it.

Writing.—Syriac has the same 22 letters as Hebrew. Their forms are ultimately derived from the Old Hebrew and Phoenician alphabets. The oldest mss., of the 4th and 5th centuries, are written in a very beautiful current hand known as *Estrangĕla*, the lapidary form of which is still preserved in some old inscriptions at Edessa. This gave place to other scripts from about the 9th century, the Jacobite form being less graceful and further removed from the *Estrangĕla* than the Nestorian. Speaking generally, this writing only indicates the consonants, the vowel *u* (short or long without distinction), long *i*, and final *a*. The other vowels, so long as Syriac remained a living language, were not indicated at all, or only partially indicated by a dot above or below the whole word. But about the time when Syriac began to be supplanted by Arabic two systems of vowel-signs were invented, one by West Syrians, who borrowed the forms of Greek vowels, and the other more elaborate by East Syrians, who used combinations of dots. These signs are written above and below the consonantal letters. Neither system completely distinguishes long from short vowels; the Nestorian system is more satisfactory, though more cumbrous.

Consonantal Permutations.—Syriac is a dialect of Aramaic (*see* SEMITIC LANGUAGES), and uses the same alphabet as Hebrew as remarked above. As in Hebrew the six letters *b g d k p t* are aspirated (β γ δ χ φ θ) when immediately preceded by any vowel sound. Thus "he wrote" is in Arabic *kataba*, in Hebrew kāθaβ in Syriac *kθaβ*. We may note that the unwritten light vowel after *k* (light as *e* in "belong") aspirates the following consonant, but the second member of a diphthong is reckoned as a consonant, so that we get *baytā* ("house"), not *bayθā*.

The peculiar dentals and sibilants of early Semitic, preserved almost in their original diversity in classical Arabic came to be pronounced differently in Hebrew and Syriac. So we get

Arab. *thālāthā*	Heb. *shlōshā*	Syr. *tlāθā*	("three")
" *dhahab*	" *zāhāβ*	" *dahβā*	("gold")
" *'arḍ*	" *'arcṣ*	" *'ar'ā*	("earth")
" *ẓuhr*	" *ṣohŏraim*	" *ṭahrā*	("midday")

In the Arabic *s* and *sh* sounds Syriac generally agrees with Hebrew against Arabic, but the details are too complicated to be given here.

Parts of Speech. (1) **Pronouns.**—As in Hebrew the personal pronouns exist in two forms: the longer is used as a nominative and is a separate word, the shorter is attached to verbs as an accusative and (in a slightly different form) to nouns as a possessive. These suffixes give rise to less change in the vowels of the words to which they are attached than in Hebrew. The relative pronoun is *d* (i.e., *d* followed by the shortest kind of vowel), which is prefixed to words.

(2) **Nouns.**—There are two numbers, sing. and pl., and two genders, masc. and fem. Syriac, like all Aramaic dialects, has no definite article, but the noun has three "states"—absolute, construct, emphatic, e.g., *rēsh*, "head," "a head"; *rēsh* (*malkā*), "the-head-of (the-king)"; *rēshā*, "the-head." But in Syriac the emphatic state (*rēshā*) has almost superseded the simple "absolute," which is hardly used except for adjectival or participial predicates and in certain stock phrases. The construct, which, as in Hebrew, must be immediately followed by a genitive, is less used than in Hebrew, except as the form on which to hang the possessive suffixes. In its place the relative participle *d* is used; in place of *rēsh malkā* ("the-head-of the-king") we find *rēshā dmalkā, i.e.*, "the-head which-the-king (-has)," or *rēsheh dmalkā, i.e.*, "his head which (-is)-the king." Here the *d* is practically equivalent to our "of." This genitive (with prefixed *d*), does not require the governing noun to precede it immediately, as must be the case with the construct: in this and many respects Syriac has gained greater flexibility in syntax than Hebrew.

The fem. sing. ending is *-ā* (absolute), *-aθ* (construct), *-tā* or *θā* (emph.): thus the fem. sing. abs. is always identical in form with the masc. sing. emph. The plural endings are: masc. abs. *-īn*, const. *-ai*, emph. *-ē*; fem. abs. *-ān*, const. *āθ* emph. *-āθā*.

(3) **Verbs.**—The most notable peculiarity of Syriac as compared with other Aramaic dialects, and indeed other Semitic languages generally, is that the prefix to the imperfect is *n*, not *y*, *e.g.*, "he will write" is *neχtoβ*, not *yeχtoβ*: this is likely to have been originally a mere local peculiarity of the speech of Edessa. The Syriac verb has lost the original passive forms still surviving in Arabic, and in their place uses reflexive forms, with prefixed *eθ-* and a change in the last vowel. The simple active *kθaβ* makes its passive *eθkθeβ*; the intensive *katteβ* makes *eθkattaβ*; and the causative *aχteβ* makes *ettaχtaβ*. (Note the changes made in the *b g d k p t* letters caused by the presence or absence of a preceding vowel.)

In Syriac the verbs have become real tenses, partly with the help of the auxiliary (*h*)*wā*, a truncated form of *hwā* ("was"). Thus we get Pres. *kāθeβ*, "he writes," "he is writing"; Impf. *kāθeβ wā*, "he was writing"; Fut. *neχtoβ*, "he will write"; Subj. *dneχtoβ*, "that he may write"; Aor. or Perf. *kθaβ*, "he wrote," "he has written"; Plupf. *kθaβ wā*, "he had written"—sometimes also used for simple Aorist.

(4) **Particles and Syntax.**—Syriac uses a great many conjunctions, many of them adapted from Greek. Thus we have *gēr* from *γάρ*, *dēn* from *δέ* (or at least used like Greek *δέ*), even *man* from *μέν*. The order of words which is permissible is also very free, more so than in any other Semitic language, a fact which gives to Syriac great flexibility and also renders word-for-word translation into it easier.

In some Syriac translations from the Greek, notably the later Jacobite translations of the Bible and other Greek theological works, Greek idiom is very slavishly followed. This, however, is to be regarded rather as learned pedantry than as linguistic evolution. In other works, *e.g.*, the Syriac version of Pseudo-Callisthenes *Life of Alexander*, which was translated not from the original Greek but from a Pahlavi text, the influence of the Persian idiom is quite perceptible in the syntax.

Christian Palestinian Syriac is the name given to a literature written not in "classical Syriac," but in the vernacular dialect of Palestine. It is exclusively theological (Bible, Homilies, Cyril's *Catecheses*, etc.), and appears to date from the 5th or 6th centuries when certain emperors, notably Justinian, made belated efforts to evangelize the non-Greek-speaking populations of Palestine. The documents are written in a peculiar script. The language is very similar to the Jewish Targums and to some Aramaic parts of the Talmud: unfortunately the linguistic value of this literature is greatly diminished by the fact that it wholly consists of translations from the Greek and follows the Greek idioms with painful literalness.

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(F. C. B.)

SYRIAC LITERATURE. The use of Syriac by Christians as a literary medium had its original centre in Edessa (Syr. Ūrhāi, modern Urfa), where, in all probability, the chief Syriac versions of the Bible were made. The use of the same dialect appears in the earliest Christian literature connected with such Mesopotamian cities as Nisībis, Amid, Mardīn, Taghrīth and Seleucia-Ctesiphon, as well as west of the Euphrates at such centres as Mabbōgh (Hierapolis) and Aleppo, northwards at Malaṭiah and Maiperḳat and in the districts of Lake Van and Lake Urmia, and to the east and south-east of the Tigris in many places which from the 5th century onwards were centres of Nestorian Christianity within the Sassanian empire. In Palestine and western Syria, the home of pre-Christian Aramaic dialects, the vernacular Semitic speech had under Roman dominion been replaced by Greek for official and literary purposes. Apparently this state of things lasted till after the Mohammedan conquest, for Barhebraeus tells us that it was the caliph Walīd I. (A.D. 705–715) who, out of hatred to Christianity, replaced Greek by Arabic as the language of official documents at Damascus.

Syriac literature continued in life from the 3rd to the 14th century A.D., but after the Arab conquest it became an increasingly artificial product, for Arabic gradually killed its vernacular use.

Religious Literature.—In the literature as it survives many different branches of writing are represented—homilies in prose and verse, hymns, exposition and commentary, liturgy, apocryphal legends, historical romance, hagiography and martyrology, monastic history and biography, general history, dogmatics, philosophy and science, ecclesiastial law, etc. But the whole is dominated by the theological and ecclesiastical interest. When we put aside one or two exceptionally fine pieces, like the hymn of the soul in the apocryphal Acts of Thomas, the highest degree of excellence in style is perhaps attained in straightforward historical narrative—such as the account of the Perso-Roman War at the beginning of the 6th century by the author who passes under the name of Joshua the Stylite, or by romancers like him who wrote the romance of Julian; by biographers like some of those who have written lives of saints, martyrs and eminent divines; and by some early writers of homilies such as Philoxenus (in prose) and Isaac of Antioch (in verse).

For the general history of culture the work of Syriac writers as *translators* is, perhaps, as important as any of their original contributions to literature. Beginning with the earliest versions of the Bible, which seem to date from the 2nd century A.D., the series comprises a great mass of translations from Greek originals —theological, philosophical, legendary, historical and scientific. In a fair number of cases the Syriac version has preserved to us the substance of a lost original text. Often, moreover, the Syriac translation became in turn the parent of a later Arabic version. This was notably the case with some of the Aristotelian writings, so that in this field, as in some others, the Syriac writers handed on the torch of Greek thought to the Arabs, by whom it was in turn transmitted to mediaeval Europe. The early Syriac translations are in many cases so literal as to do violence to the idiom of their own language; but this makes them all the more valuable when we have to depend on them for reconstructing the original texts. The later translators use greater freedom. It was not from Greek only that translations were made into Syriac. Of translations from Pahlavī we have such examples as the version of pseudo-Callisthenes' *History of Alexander*, made in the 7th century from a Pahlavī version of the Greek original—that of *Kalilah and Dimnah* executed in the 6th century by the periodeutēs Bōdh—and that of *Sindbad*, which dates from the 8th century; and in the late period of Syriac literature, books were translated from Arabic into Syriac as well as vice versa.

The Cradle of Syriac Literature.—All our historical sources support the view taken above that Edessa, the capital of the kingdom which the Greeks and Romans called Osrhoene, was the earliest seat of Christianity in Mesopotamia and the cradle of Syriac literature. But as to the date and circumstances of its evangelization we have little reliable information. The well-known legend of the correspondence of Abgar Ukkāmā, king of Edessa, with Christ and the mission of Addai to Edessa immediately after the Ascension was accepted as true by the historian Eusebius (d. 340) on the faith of a Syriac document preserved in the official archives of the city. An amplified form of the same story is furnished by the *Doctrine of Addai*, an original Syriac work which survives complete in a St. Petersburg (Leningrad) ms. of the 6th century, and is also represented by fragments in other mss. of the 5th and 6th centuries. This work was probably written at Edessa about the end of the 4th century. But whether in its longer or its shorter form, the whole narrative must be pronounced unhistorical. In all probability the first king of Osrhoene to adopt Christianity was Abgar IX., son of Ma'nū, who reigned from A.D. 179 to 214 or 216, and the legend has confounded him with an earlier Abgar, also son of Ma'nū, who reigned first from B.C. 4 to A.D. 7 and again from A.D. 13 to 50. (*See* Lipsius, *Die edessenische Abgar-Saga*, 1880.) A contemporary of Abgar IX. at Edessa was the famous Bardaiṣān, himself a convert from heathenism, who was of noble birth and a *habitué* of the Edessene court. It was no doubt partly under his influence—also possibly in part through impressions received by Abgar during his visit to Rome about A.D. 202—that the king's conversion took place. But Christianity must have reached Edessa some 30 to 50 years earlier. Our oldest native historical document in Syriac—the account of a severe flood which visited Edessa in Nov. A.D. 201—mentions "the temple of the church of the Christians" as overthrown by the flood. The form of this notice shows, as von Gutschmid and others have remarked, that Christianity was not yet the religion of the State; but it must for some time have had a home in Edessa. By a skilful piecing together of the data furnished by the oldest Syriac versions of the Bible—such as the derivation of the Old Testament version from the Jews, and the almost exclusive use of Tatian's Diatessaron as the gospel of the Syriac Church down to the beginning of the 5th century—F. C. Burkitt has shown it to be probable that the preaching of Christianity at Edessa reaches back to the middle of the 2nd century or even to about the year 135 (*Early Eastern Christianity*, Lecture II.).

The Syriac versions of the Bible are treated elsewhere (*see* BIBLE) and may here be dismissed with a brief summary of facts and opinions. The received Syriac Bible or Vulgate (called the Peshitta or "simple" version from the 9th century onwards) contains all the canonical books of the Old Testament. In the New Testament, 2 Peter, 2 and 3 John, Jude and the Apocalypse were originally left out, but Syriac versions were made at a later time. The Peshitta version of the Old Testament must have been originally made mainly by Jews, of whom we know there were colonies in Mesopotamia in the 2nd century. The translation was executed entirely from the Hebrew, but underwent later revision which brought it more into conformity with the LXX.—this to a greater degree in some books than in others. The Peshitta New Testament—according to the convincing theory which at present holds the field—is not the oldest form of the Syriac version, at least as regards the Gospels. From the beginning of the 3rd to the beginning of the 5th century Tatian's Harmony or Diatessaron —whether originally compiled in Syriac, or compiled in Greek and translated into Syriac—was the current form of gospel in the Syriac Church. The text of the Gospels underlying it "represents the Greek text as read in Rome about A.D. 170." Slightly later was made the Old Syriac version of the separate Gospels, which survives in two mss.—the Curetonian and the Sinaitic—in two differing forms: but this never obtained much currency. Its text "represents, where it differs from the Diatessaron, the Greek text as read in Antioch about A.D. 200." Then at the beginning of the 5th century, by the efforts of the masterful Rabbūlā, who was bishop of Edessa from 411–412 to 435, a new version or recension of the Gospels was made and incorporated in the Peshitta or Vulgate, the use of the Diatessaron being henceforth proscribed. Rabbūlā's text of the Gospels "represents the Greek text as read in Antioch about A.D. 400." The history of the Peshitta rendering of the Acts and Epistles is less clear.

Apocryphal Books.—Of the large number of Apocryphal books existing in Syriac the majority have been translated from Greek, one or two (such as *Bar Sīrā* or *Ecclesiasticus*) from Hebrew, while some (like the *Doctrine of Addai* above referred to) are original Syriac documents. Special mention may be made here of the tale of Aḥīḳār—the wise and virtuous secretary of Sennacherib, king of Assyria—and of his wicked nephew Nādhān. This is the Syriac version of a narrative which has had an extraordinary vogue in the world's literature. It is now known to have existed in Aramaic as far back as the 5th century B.C., appearing in Jewish papyri which were lately discovered by the German mission to Elephantine. It appears to be traceable in its Greek dress in writings of the philosopher Democritus and the dramatist Menander; it was certainly known to the author of Tobit and perhaps to the author of Daniel; some would trace its influence in the New Testament, in the parable of the wicked servant and elsewhere; it was known to Mohammed and is referred to in the Koran; it has been included among the tales in the *Arabian Nights;* and it survives in a good many versions ancient and modern. The old Syriac version, which is to be found in a number of mss., was probably made from an early Aramaic version, if not from the original itself (which must surely have been Semitic). The Syriac has in turn become the parent of the Arabic, Armenian and Ethiopic—possibly also of the Greek and Slavonic-versions. (*See* F. Nau, *Histoire et sagesse d'Ahikar l'Assyrien*, 1909.)

Another deeply interesting Syriac Apocryphon is the *Acts of Judas Thomas* (*i.e.*, Judas the Twin), which is included in the collection of *Apocryphal Acts of the Apostles.* The *Acts of Thomas* is now generally recognized to be an original Syriac work (or "novel," as Burkitt calls it), although a Greek version also exists. It seems to have arisen in Gnostic circles, and its tendency is wholly in favour of asceticism and celibacy. Among its peculiarities is the fact that Judas Thomas is regarded as the twin brother of Christ. The author has incorporated in it the finest poem to be found in all Syriac literature, the famous Hymn of the Soul.

Lives of the Saints.—Lives of saints and martyrs form a large group among Syriac books. Among such documents connected with the early history of Edessa we have, besides the *Doctrine of Addai*, certain martyrdoms, those of Sharbēl and Barsamyā assigned to the reign of Trajan, and those of Guryā and Shāmōnā and of the Deacon Habbībh under Diocletian and Lincinius. All these documents, like *Addai*, belong probably to the 2nd half of the 4th century, and are unreliable in detail for the historian though they may throw some light on the conditions of life at Edessa under Roman government. There are also accounts of martyrdoms at Samosāta (Assemani, *Acta Mart.* ii. 123–147), including that of St. Azazail published by Macler (Paris, 1902). But the great bulk of the Syriac martyrdoms have their scene farther east, within the Persian dominions.

The life and writings of Bardaisān, "the last of the gnostics," and in some sense the father of Syriac literature and especially of Syriac poetry, have been treated in a separate article. *The Book of the Laws of the Countries*, which embodies his teaching, was re-edited in 1907 by F. Nau (this also in the 2nd volume of Graffin's *Patrologia*). Mention may here be made of the valuable edition and translation by the late C. W. Mitchell of *S. Ephraim's prose refutations of Mani, Marcion and Bardaisan. Transcribed from the palimpsest B. M. Add. 14628* (1912–21).

An early Syriac document, probably of the 2nd or 3rd century, is the *Letter of Mārā son of Serapion,* which was edited by Cureton in his *Spicilegium Syriacum.* It is almost the only exception to the rule that all surviving Syriac literature is Christian.

By the beginning of the 4th century much progress had been made with the organization of the Christian church not only within the Roman district of Mesopotamia, but also to the east and south-east within the Sassanian empire, round such centres as Seleucia-Ctesiphon on the Tigris (near Baghdad), Karkā dĕ-Bēth Sĕlōkh (modern Kerkuk) and Bēth Lāpāt or Gundēshābhōr (in the modern province of Luristan). The adoption of Christianity by Constantine as the official religion of the Roman empire had an unfortunate effect on the position of the Christians in Persia. They were naturally suspected of sympathizing with the Roman enemies rather than with their own Persian rulers. Accordingly when Sapor II. (310–379) declared war on Rome about 337, there ensued almost immediately a somewhat violent persecution of the Persian Christians, which continued in varying degrees for about 40 years. One result of this and later persecutions of the same kind has been to enrich Syriac literature with a long series of *Acts of Persian Martyrs,* which, although in their existing form intermixed with much legendary matter, nevertheless throw valuable light on the history and geography of western Persia under Sassanian rule.

4th and 5th Centuries.—The two most important 4th-century writers—Aphraates and Ephraim—are dealt with in separate articles. The importance of the former lies in the simple cast of his religious thought, his independence of theological formulas, his constant adherence to the letter of Scripture, his quaint exegesis, and the light he throws on the circumstances of his time, especially (1) the feeling between Jews and Christians, and (2) the position and sympathies of the Christian subjects of Sapor II. The position and character of Ephraim are very different. He is the typical exponent in Syriac of unbending Catholic orthodoxy.

Before leaving the 4th century we may mention two other writers who probably both lived on into the 5th—Balai and Cyrillōnā. The former was the author of a good many poems; the longest—which is however by some attributed to Ephraim—is the work in 12 books on the history of Joseph, of which a complete edition was published by Bedjan in 1901. Other poems of his were edited by Overbeck in *S. Ephraemi Syri,* etc., *opera selecta,* pp. 251–336; and these have since been supplemented by Zetterstéen's edition of a large number of his religious poems or metrical prayers (*Beiträge zur Kenntniss der religiösen Dichtung Balais,* Leipzig, 1902). His favourite metre was the pentasyllabic. Cyrillōnā composed a poem on the invasion of the Huns in 395.

The 5th century was a time of storm and conflict in the churches of Mesopotamia and Persia, as in other parts of the Christian world. The teaching of Apollinarius that in Christ the Divine Word took the place of the human rational soul, thus seeming to do away with his possession of a true humanity, had led to a reaction by Paul of Samosāta, Diodore of Tarsus, Theodore of Mopsuestia, and Nestorius of Constantinople. Though with some points of difference, they agreed in emphasizing the permanence of the two separate natures in Christ, united but not mingled or confused, and laid stress on the reality of our Lord's human experience. One question on which great contention arose was as to the propriety of applying to the Divine nature attributes which belonged to the human nature—*e.g.,* birth from a human mother—and vice versa. Hence the great dispute about the application to the Virgin Mary of the epithet *θεοτόκος.* It seems to have been the objection of Nestorius to the use of this expression which mainly led to his condemnation and deposition at the Council of Ephesus (431) under the influence of Cyril, although as patriarch of Constantinople (428–431) he had distinguished himself by his zeal for Nicene orthodoxy. New light on the theological position of Nestorius is to be obtained from the long-lost *Book of Heraclides,* a work of his own which has turned up in a Syriac version and was published by Bedjan in 1910.

At Edessa the result of the conflict between the Nestorians and their opponents was long doubtful. When Rabbūlā, the fierce anti-Nestorian and friend of Cyril, died in 435, he was succeeded in the bishopric by Ibas, who as head of the famous "Persian school" in the city had done much to inculcate on his pupils the doctrines of Theodore of Mopsuestia. But the feeling against the Nestorian party grew in strength, till on the death of Ibas in 457 the leading Nestorian teachers were driven out of Edessa. The Persian school continued to exist for another 32 years, but was finally closed and destroyed by order of the emperor Zeno in 489. The Nestorian teachers then started a great school at Nisībis (which had been under Persian rule since Jovian's humiliating treaty of 363). By the energetic efforts of Bārṣāumā, bishop of that city, practically the whole church of Persia was won over to the Nestorian creed.

Great Churchmen.—At the beginning of the 5th century one of the most able and influential men in the Syriac-speaking Church was Mārūthā, bishop of Maiperkaṭ or Martyropolis. Without entering on the details of his ecclesiastical activity, we may note that he was twice associated with embassies from the Roman emperor to Yazdegerd I. (399–420); that along with Isaac, patriarch of Seleucia (390–410), he obtained from the Persian monarch a concordat which secured a period of religious toleration; and that he arranged for and presided at the Council of Seleucia in 410, which adopted the full Nicene creed and organized the hierarchy of the Persian Church. As a writer he is chiefly known as the reputed author of a collection of martyrologies which cover the reigns of Sapor II., Yazdegerd I. and Bahram V. By his history of the Council of Nicaea he made a great contribution to the education of the Persian Church in the development of Christian doctrine.

The next bishop of Edessa, Ibas, who succeeded in 435 at the death of Rabbūlā, proved himself a follower of the Nestorian doctrine. (*See* above.) As a teacher in the Persian school of Edessa he had translated, probably with the help of his pupils, certain works of "the Interpreter," *i.e.,* Theodore of Mopsuestia. Among these may have been the commentary on St. John of which the complete Syriac version was published by Chabot in 1897. He may possibly have translated a work of Aristotle. To the Nestorian movement in Persia he rendered useful service by his letter to Mārī of Bēth Hardashēr, in which he maintained the tenets of Diodore and Theodore, while allowing that Nestorius had erred. On the ground of his writings he was condemned and deposed by the "robber synod" of Ephesus (449), but was restored by the Council of Chalcedon (451), after he had anathematized Nestorius. His death in 457 was followed by a strong anti-Nestorian reaction at Edessa, which led to the expulsion of many of the leading teachers.

On Isaac of Antioch, "one of the stars of Syriac literature," *see* the special article. In spite of his over-diffuseness, he is one of the most readable of Syriac authors.

A Nestorian contemporary of Isaac, Dādhīshōʿ, who was catholicus of Seleucia from 421 to 456, composed commentaries on Daniel, Kings and Ecclesiasticus. His chief importance in the history of the Persian Church lies in his having induced a synod of bishops to declare that church independent of the see of Antioch and of the "Western Fathers." (*See* J. Labourt, *Le Christianisme dans l'empire perse,* 1904, p. 122 *seq.*)

The most powerful missionary of Nestorianism during the 2nd half of the 5th century was Barṣāumā of Nisībis, whom his opponents called "the swimmer among the reeds," *i.e.,* the wild boar. Born probably between 415 and 420 he imbibed Nestorian doctrine from Ibas at the Persian school of Edessa, but was driven out in 457 on the death of his master, and went to be bishop of Nisībis. In a succession of missionary journeys he succeeded, partly by persuasion and partly (if his enemies are to be believed) by violence, in attaching to Nestorianism nearly all the Christian communities of Persia, with the exception of Taghrīth, which was always strongly Monophysite. He had many quarrels with his ecclesiastical superior the catholicus of Seleucia, but finally made peace with Acacius soon after the accession of the latter in 484. Among other severities towards the Monophysites, he persuaded the Persian king Pērōz (457–484) to banish many of them into the Roman dominions. One of his great aims was to secure for the Nestorian clergy freedom to marry, and this was finally sanctioned by a council at Seleucia in 486 (Labourt, *op. cit.*, chap. vi.). Barṣāumā must have been bishop of Nisībis for nearly 40 years, but was dead by 496. His writings seem to have been chiefly liturgical; he gave the first set of statutes to the school of Nisībis, which was founded during his bishopric.

His fellow-worker Narsai, whom the Jacobites called "the leper," but the Nestorians "the harp of the Holy Spirit," apparently accompanied Barṣāumā from Edessa to Nisībis, where according to Barhebraeus he lived for 50 years. Barṣāumā appointed him head of the new school, where he taught rigidly Nestorian doctrine. He was a copious writer, especially in verse. Many of his poems have now been published. (*See* Mingana, *Narsai, homiliae et carmina*, 2 vols. Mosul, 1905.) His theological position is clearly defined in a homily on the three doctors—Diodore, Theodore and Nestorius—published by the Abbé Martin in the *Journal asiatique* for July 1900.

To about the same period belongs *The book of Hierotheus* by the "pantheist" Stephen bar Sūdh-aite, which has recently been edited and translated by F. C. Marsh (1927).

Early Monophysites.—Among the early Monophysites were two of the best of Syriac writers—Jacob of Sĕrūgh and Philoxenus of Mabbōgh, who have been treated in special articles. The one wrote mainly in verse, the other in prose. *See* also JOSHUA THE STYLITE.

Another early Monophysite was Simeon of Bēth Arshām, who by a series of journeys and disputations within the Persian empire did all he could to prevent the triumph of Nestorianism among the Persian Christians. He had considerable success at the time, but the ground he had won was soon reconquered by his opponents, except at Taghrīth and the surrounding district. It was after a successful disputation in presence of the Nestorian catholicus Bābhai (497–502/3) that Simeon was made bishop of Bēth Arshām, a town near Seleucia. He made several journeys to Constantinople, where he enjoyed the favour of the empress Theodora. It was there he died; probably about 532–533. His biography was written by John of Asia in the collection of lives of eastern saints which has been edited by Land (*Anecd. syr.* vol. ii.). His literary productions consist only of a liturgy and two exceedingly interesting letters. The one has for its subject Barṣāumā and the other Nestorian leaders in Persia, and gives a highly malicious account of their proceedings. The other, which has been often edited, is an account of a severe persecution which the Himyarite Christians of Najrān in south-west Arabia underwent in 523, at the hands of the king of Yemen. (See *The book of the Himyarites*, a Syriac work edited and translated by A. Moberg, Lund, 1924.) As Simeon had repeatedly visited al-Ḥīrah and was in touch with the Arab kingdom which centred there, his letter is a document of first-rate historical importance.

Mention should be made of two other early Monophysite leaders who suffered persecution at the hands of the emperor Justin I. (518–527). The one, John of Tellā, author of 538 canons, answers to questions by the priest Sergius, a creed and an exposition of the Trisagion. His life was written by his disciple Elias, and also by John of Asia. The other, John bar Aphtōnyā, was the founder of the famous monastery of Kenneshrē, opposite Jerābīs on the Euphrates, and wrote a commentary of the Song of Songs, a number of hymns and a biography of Severus, the Monophysite patriarch of Antioch (512–519).

The life of the great missionary bishop Jacob Burdĕʽānā or Baradaeus, from whom the Monophysite Church took its name of Jacobite, belongs rather to ecclesiastical than to literary history. (*See* H. G. Kleyn, *Jacobus Baradaeus, de Stichter der Syrische monophysietische Kerk*, Leyden 1882.)

Translators from the Greek.—In Sergius of Rās'ain we find one of the best Greek scholars and ablest translators whom Syria has produced. Of his life little is known, and that little not wholly creditable. He wavered curiously in his ecclesiastical views, and ended by helping the persecutors of the Monophysite Church, to which he himself had belonged. He seems to have lived as a priest and physician at Rās'ain in Mesopotamia most of his life. About 535 he travelled on various ecclesiastical missions, and finally made a journey to Rome and thence to Constantinople (in this latter accompanied by the pope Agapetus). The result was to bring about the deposition and banishment of the Monophysites from the latter city. Sergius died almost immediately afterwards, in 536. Among the works which he translated into Syriac and of which his versions survive are treatises of Aristotle, Porphyry and Galen, the *Ars grammatica* of Dionysius Thrax, the works of Dionysius the Areopagite, and possibly two or three treatises of Plutarch. His own original works are less important, but include a "treatise on logic, addressed to Theodore (of Merv), which is unfortunately imperfect, a tract on negation and affirmation; a treatise, likewise addressed to Theodore, *On the Causes of the Universe, according to the Views of Aristotle, showing how it is a Circle*; a tract *On Genus, Species and Individuality*; and a third tract addressed to Theodore, *On the Action and Influence of the Moon, explanatory and illustrative of Galen's* Περὶ κρισίμων ἡμερῶν, bk. iii., with a short appendix 'On the Motion of the Sun' " (Wright). According to the historical compilation which passes under the name of Zacharias Rhetor, he also wrote a treatise on the faith. Some of his translations were revised at a later time by Honain ibn Isḥāḳ (d. 873).

Another translator from Greek was Paul, Monophysite bishop of Callinīcus or ar-Raḳḳah, who, being expelled from his diocese in 519, retired to Edessa and there occupied himself in translating into Syriac the works of Severus, the Monophysite champion who was patriarch of Antioch from 512 to 519. This version appears to be quite distinct from that used by the compiler of the chronicle of Zacharias, and also from the version of "the 6th book of the select letters of Severus" which was made by Athanasius "presbyter of Nisībis" in 669, edited by E. W. Brooks (1902–04).

That important legal work, *The Laws of the Emperors Constantine, Theodosius and Leo*, which was composed in Greek about 475, and "which lies at the root of all subsequent Christian oriental legislation in ecclesiastical, judicial and private matters" (Wright), must have been repeatedly translated into Syriac. The oldest form is contained in a British Museum ms. which dates from the earlier part of the 6th century, and this was edited by Land (*Anecd. syr.* i. 30–64). A later (probably Nestorian) recension is contained in a Paris ms., which was used along with the other by Bruns and Sachau in their exhaustive edition (*Syrisch-römisches Rechtsbuch*, Leipzig, 1880). In *Notulae syriacae* (privately printed 1887) Wright edited the surviving fragment of a 3rd recension which is preserved in a 13th-century ms. at Cambridge. Finally Sachau has published three new redactions of the treatise from a ms. found at Rome in 1894 (*Syrische Rechtsbücher*, vol. i., Leipzig, 1907).

Anonymous Works.—We may here take note of three important anonymous works, of which the first probably and the other two certainly belong to the 6th century.

The Mĕʽarrath gazzē or *Cave of Treasures*, translated and edited by C. Bezold (Leipzig, 1883–88), is akin (as Duval remarks) to the *Book of Jubilees*. It is an imaginary history of the patriarchs and their descendants.

The tripartite narrative which is known as the *Romance of Julian* (the Apostate) has no claim to be regarded as an historical document. Its hero is Jovian, one of the feeblest of Roman emperors, and Julian is everywhere exhibited in flaming colours as the villain of the story.

A valuable historical source, though of small dimensions, is the *Chronicle of Edessa*, which gives a record of events from 132–131 B.C. to A.D. 540—at first exceedingly brief, but becoming somewhat fuller for the later years. It appears to be thoroughly reliable wherever it can be tested. It has been three times edited—first by Assemani in the *Bibliotheca orientalis* (i. 388–417), secondly by L. Hallier (Leipzig, 1892) with a translation, introduction and abundant notes, and thirdly by Guidi with a Latin version (in *Chronica minora,* Paris, 1903).

On John of Asia or Ephesus, the eminent Monophysite bishop and earliest Syriac church historian, *see* the separate article.

An historical work of somewhat similar character to John's is the compilation in 12 books which is generally known by the name of Zacharias Rhetor, because the anonymous Syriac compiler has incorporated the Syriac version or epitome of a lost Greek history written by that author. The Syriac work exists (not quite complete) in a British Museum ms. of about the beginning of the 7th century: this can be in part supplemented by an 8th-century ms. at the Vatican. From the latter Guidi published the interesting chapter (X. 16) which contains the description of Rome. The entire text of the London ms. was published by Land in the third volume of his *Anecdota syriaca;* and there is now an English translation by Hamilton and Brooks (1899), and a German one by Ahrens and Krüger (Leipzig, 1899).

Of the other 6th-century Jacobite writers we need mention only Moses of Aggēl (*fl. c.* 550–570) who translated into Syriac some of the writings of Cyril, and Peter of Callinīcus, Jacobite patriarch of Antioch 578–591, who wrote a huge controversial treatise in 4 books, each of 25 chapters, against Damian, patriarch of Alexandria, as well as other less important works.

The Nestorian writers of the 6th century were numerous, but as yet we know little of their works, beyond what ʽAbhdīshoʽ tells us in his *Catalogue.* It will be sufficient to mention one or two. Joseph Hūzāyā (*i.e.,* of al-Ahwāz or Khūzistan), who came third in succession to Narsai as head of the school of Nisībis, was the first Syriac grammarian and invented various signs of interpunction. Mārūthā, who was Nestorian catholicus of Seleucia from about 540 to 552 (*see* Labourt, *op. cit.,* pp. 163–191), and a man of exceptional energy, made the only known attempt, which was, however, unsuccessful, to provide the Nestorians with a Bible version of their own. He was the author of many commentaries, homilies, epistles, canons and hymns. Paul the Persian, a courtier of Khosrau Anōsharwān, dedicated to the king a treatise on logic which has been published from a London ms. by Land in the 4th volume of his *Anecdota.* Bōdh the periodeutes is credited with a philosophical work which has perished, but is best known as the author of the old Syriac version of the collection of Indian tales called *Kalīlah and Dimnah.* He made it doubtless from a Pahlavī version. His translation, which was edited by Bickell with an introduction by Benfey, must be distinguished from the much later Syriac translation made from the secondary Arabic version and edited by Wright in 1884, of this there is an English translation by Keith Falconer (1884). Ḥannānā of Ḥĕdhaiyabh, who nearly produced a disruption of the Nestorian Church by his attempt to bridge over the interval which separated the Nestorians from Catholic orthodoxy, was the author of commentaries.

Decay in the 7th Century.—"With the 7th century," as Wright remarks, "begins the slow decay of the native literature of the Syrians, to which the frightful sufferings of the people during the great war with the Persians in its first quarter largely contributed." The same process of decay was greatly promoted by the Arab conquest of Persia, achieved through the victory of Ḳādisīya in 636–637. The gradual replacement of Syriac by Arabic as the vernacular language of Mesopotamia by degrees transformed the Syriac from a living to a dead language. Apart from a few leading writers—such as Jacob of Edessa, the anonymous historian whose work has passed under the name of Dionysius of Tell-Maḥrē, Thomas of Margā, Dionysius bar Ṣalībī, and Barhebraeus (*qq.v.*)—there are few names of interest.

1. *Theology.*—Here we may first mention George, bishop of the Arabs (d. 724), who wrote commentaries on Scripture, and tracts and homilies on church sacraments, and finished the *Hexaēmeron* of Jacob of Edessa. Bābhai the Elder, a leading Nestorian in the beginning of the 7th century and a prolific author, wrote many commentaries and theological discourses. Īshōʽyabh III., Nestorian catholicus from 647 to 657/8, wrote controversial tracts, religious discourses and liturgical works. Elias of Merv, who belongs to the 2nd half of the 7th century, compiled a *Catena patrum* on the Gospels and wrote many commentaries. Timothy I., catholicus 779–823, wrote synodical epistles and other works bearing on church law. Moses bar Kēphā (d. 903), one of the most fertile of 9th-century authors, wrote commentaries, theological treatises and many liturgical works. Other important contributors to this sphere of literature were Īshōʽ bar Nōn (d. 827/8), John bar Zōʽbī (beginning of the 13th century), Jacob bar Shakkō (d. 1241), and the great Nestorian scholar ʽAbhdīshōʽ (d. 1318).

2. *History.*—Besides the important writers treated in separate articles, we need mention only four. Elias bar Shīnāyā, who in 1008 became Nestorian bishop of Nisībis, was the author of a valuable *Chronicle,* to which are prefixed numerous chronological tables, lists of popes, patriarchs, etc., and which covers by its narrative the period from A.D. 25 to 1018. Of this work, which exists in only one imperfect copy, the later portion was edited by Baethgen in 1884, and the earlier by Lamy in 1888. Another important *Chronicle* is that of Michael I., who was Jacobite patriarch from 1166 to 1199. Its range extends from the Creation to the author's own day, and it was largely used by Barhebraeus in compiling his own *Chronicle.* Till recently it was known only in an abridged Armenian version which was translated into French by V. Langlois (Venice, 1868): but the Syriac text was found in a ms. belonging to the library of the church at Edessa, and has been published by J. B. Chabot. A work rather legendary than historical is the *Book of the Bee,* by Solomon of al-Baṣrah, who lived early in the 13th century. Lastly, acknowledgment must be made of the great value of the Catalogue of Nestorian writers, by ʽAbhdīshōʽ of Nisībis, the latest important writer in Syriac. It was edited by Assemani in the 3rd part of his *Bibliotheca orientalis,* and has been translated into English by Badger.

3. *Biography, Monastic History, etc.*—Besides the important work by Thomas of Margā (*q.v.*) the following deserve special mention. Sāhdōnā, who was a monk in the Nestorian monastery of Bēth ʽĀbhē (the same to which Thomas of Margā belonged two centuries later) and afterwards a bishop early in the 7th century, wrote a biography of and a funeral sermon on his superior Mār Jacob who founded the monastery, and also a long treatise in two parts on the monastic life of which all that survives has been edited by P. Bedjan (Paris, 1902). Whilst accompanying the catholicus Īshōʽyabh II. (628–644) on a mission to Heraclius, Sāhdōnā was converted, apparently to Catholicism (*see* H. Goussen, *Martyrius-Sahdonas Leben und Werke,* Leipzig, 1897), and thereby caused much scandal in the East. The chief events in his life are narrated by Ishōʽdĕnaḥ. Another Nestorian who, a few years later, wrote ecclesiastical biographies and other theological works was Sabhrīshōʽ Rusṭam, who lived at Mount Īzlā and other monasteries. In the beginning of the 8th century David of Bēth Rabban, also a Nestorian monk, wrote, besides a geographical work, "a monastic history, called *The Little Paradise,* which is frequently cited by Thomas of Margā." A more important work is *The Book of Chastity,* by Ishōʽdĕnaḥ, who according to ʽAbhdīshōʽ was bishop of Ḳaṣrā—but read Baṣrā—about the end of the 8th century. This work is a collection of lives of holy men who founded monasteries in the East, and is a valuable historical source. The work itself, or an abridgment of it, was discovered and published for the first time by J. B. Chabot (Rome, 1896). As the last under this head we may mention a late anonymous biography, that of the catholicus Yabhalāhā III. (1281–1317), which throws much light on the relations of the early Mongol kings with the heads of the church in their dominions. Among other interesting features it contains information about the Nestorian Church of China in the 13th century.

4. *Philosophy and Science.*—Special mention may be made of ʽĀnānīshōʽ of Ḥĕdhaiyabh (middle of 7th century) well known as the author of a new recension of the *Paradise* of Palladius, and also the author of a volume on philosophical divisions and definitions; Romanus the physician (d. 896), who wrote a medical compilation, a commentary on the Book of Hierotheus, a collection of Pythagorean maxims and other works; Moses bar Kēphā, the voluminous writer above referred to; the famous physician Ḥonain ibn Isḥāḳ (d. 873), who wrote chiefly in Arabic, but deserves mention here by his services to Syriac grammar and lexicography, and still more by his translations of Greek philosoph-

ical and scientific works into Syriac and from Syriac into Arabic, becoming in a sense the founder of a school of translators; and Jacob bar Shakkō, whose work called the *Dialogues* treats of grammar, rhetoric, poetry, logic, philosophy and science.

5. *Grammar and Lexicography.*—Several of the authors in this department have already been mentioned. The more important, besides Jacob of Edessa and Barhebraeus, are ‘Anānīshō‘ of Ḥĕdhaiyabh, Ḥonain ibn Isḥāḳ, his pupil Bar ’Alī, Bar Sarōshwai (early 10th century), Bar Bahlūl (middle of 10th century), Elias of Ṭīrhān (d. 1049), Elias bar Shīnāyā (above), John bar Zō’bī (beginning of 13th century) and Jacob bar Shakkō.

Apart from the numerous editions of Syriac texts by Paul Bedjan, some of which have been cited above, nearly all the texts recently edited are included in one or other of three comprehensive series now running—viz., (1) *Patrologia syriaca* (Paris, 1894); (2) *Corpus scriptorum christianorum orientalium—scriptores syriaci* (Paris, 1907); (3) *Patrologia orientalis* (Paris, 1907). *See* W. Wright, *History of Syriac Literature* (1895); R. Duval, *La Littérature syriaque* (3rd ed. 1907); A. Baumstark, *Geschichte der syrischen Literatur* (1922). (N. McL.)

SYRINGA, the common name applied to several cultivated ornamental shrubs of the family Saxifragaceae (*q.v.*). The name arose from the fact that the original generic name of these shrubs was *Syringa,* which, however, properly belongs to the lilac (*q.v.*), the garden syringas being now known botanically as species of *Philadelphus.* They possess conspicuous, usually strongly scented flowers and in a wild state are natives of the north temperate zone. There are about 20 species.

The common garden syringa (*P. coronarius*) is a native of Europe. Noteworthy North American species are the scentless syringa (*P. inodorus*), the large-leaved syringa (*P. grandifolius*) of the south-eastern United States, and the western syringa (*P. Lewisii*), the State flower of Idaho, found from Montana to British Columbia and Oregon.

SYRINGE, a hydraulic instrument, based on the principle of the pump, for the drawing up and ejecting of liquids. The ordinary form is that of a glass or metal tube ending in a pointed nozzle and fitted with an airtight piston-rod and handle. The nozzle is inserted in the liquid, which enters the cylinder by atmospheric pressure when the piston-rod is drawn up. On pushing back the piston the fluid is ejected in a jet through the nozzle. In sizes varying from the needle-pointed hypodermic syringe to the abdominal syringe, it is a common surgical implement used for the injection of fluids into the body or for the washing of wounds and cavities. A larger syringe of metal with a flat perforated nozzle is used as a garden implement for watering plants.

SYRINX, the Greek name for the pan-pipes. The pipes composing it were stopped at one end, so that the sound waves had to travel twice the length of the pipe, giving out a note nearly an octave lower than that produced by an open pipe of equal length. It consisted of a varying number of reeds, having their open ends in a horizontal line and their stopped ends, formed by the knots in the reed, gradually decreasing in length from left to right. Each pipe gave out one note, but by overblowing, *i.e.* increased pressure of breath and tension of lips, harmonics could be obtained. The syrinx or pan-pipes owes its double name to ancient Greek tradition, ascribing its invention to Pan in connection with a well-known legend of the Arcadian water-nymph Syrinx.

Syrinx is also a term used in medicine and anatomy, meaning (1) the Eustachian tube; (2) a fistula; and (3) a kind of secondary larynx found in birds.

SYRYENIANS (also Sirianian, Syrjenian, Zyrenian, Ziriannian, Zyrian and Zirian), a tribe of the Permian division of the eastern Finns. Their headquarters are at Ust-Ishma, at the junction of the Ishma and Pechora. Formerly they spread farther to the west. They are of moderate stature, blond and grey-eyed, energetic and inclined to trade. They were converted to Christianity about 1350 and their language was reduced to writing. They call themselves Komi and are not sharply distinguished from the tribes known as Permian, the languages being mutually intelligible. The archaeological remains in the governments of Perm and Vyatka called Chudish by Russians are probably Syryenian. A grammar of the language was published by Castrén, and linguistic and other notices of the tribe are contained in the *Journal de la société finno-ougrienne,* especially for 1903.

SYZRAŇ, a town of Russia, in the Ulyanovsk province, in lat. 53° 10′ N., long. 48° 33′ E., near the right bank of the Volga. Pop. (1926) 48,458. It is on the Moscow-Kazan railway and has a branch going to Ryazan. There are flour mills, leather factories and saw-mills. Bricks and nails are manufactured and there is a brewery and a distillery. The town was originally a fort to protect settlers from Tatar and Circassian raids, but has developed, especially since the railway reached it, into a manufacturing centre, with river and rail trade in exported grain and imported timber and manufactured goods.

SYZYGY (sĭ′zĭ-jĭ), in astronomy, either of the points at which the moon is most nearly in a line with the earth and sun. The moon passes her syzygies, or is in a syzygy, at new and full moon.

SZÉCHENYI, ISTVAN, Count (1791–1860), Hungarian statesman, the son of Ferencz Széchenyi and the countess Juliana Festetics, was born at Vienna on Sept. 21, 1791. Entering the army in his 17th year, he fought with distinction at the battle of Raab (June 14, 1809), and on July 16 brought about the subsequent junction of the two Austrian armies by conveying a message across the Danube to General J. G. Chasteler at the risk of his life. Equally memorable was his famous ride, through the enemy's lines on the night of Oct. 16/17, 1813, to convey to Blücher and Bernadotte orders for the impending battle of Leipzig. In May 1815 he was transferred to Italy, and at the battle of Tolentino scattered Murat's bodyguard by a dashing cavalry charge. From Sept. 1815 to 1821 he travelled widely, studying the institutions of the countries through which he passed. A second—scientific—tour with his friend, Baron Miklos Wesselényi, taught him much about trade and industry. In 1825, when he went to France to attend the coronation of Charles X., the canal du Midi attracted his attention and suggested to him the idea of regulating the rivers Danube and Theiss. At the diet of 1825, when the motion for founding a Hungarian academy was made by Pál Nagy, who bitterly reproached the Magyar nobles for so long neglecting their mother-tongue, Széchenyi set the example by offering to contribute a whole year's income (60,000 florins) towards it. The formation (June 1833) of the Danube Navigation Company, which eventually opened up the Danube from Buda to the Black Sea was the fruit of Széchenyi's initiative and personal study. Széchenyi was also the first to start steamboats on the Theiss, the Danube and the lake of Balaton.

All this time Széchenyi had been following, with some anxiety, the political course of Kossuth, whose extravagances he feared would plunge Hungary back into the chaos out of which he had helped to raise her. The majority, indeed, sided with Kossuth, but neither this fact nor the gradual loss of his popularity restrained Széchenyi, both in the diet and at county meetings, from fulminating conscientiously against the extreme demands of Kossuth. His views at this period are expounded in the pamphlet *Politikai programm töredékek* ("Fragments of a Political Programme"). He held the portfolio of ways and communications in the first responsible Magyar administration (March 23, 1848) under Bátthyány, but his increasing apprehension of a revolution, with its inevitable corollaries of civil war and a rupture with the dynasty, finally affected his mind, and on Sept. 5 he was removed to an asylum. Here he remained for many years, but recovered sufficiently to correspond with his friends and even to meditate writing fresh books; but the sudden death of his old friend Baron Samuel Jósika and the once more darkening political horizon led him, in a moment of despair, to take his own life (April 8, 1860). He richly deserved the epithet "the greatest of the Magyars" bestowed upon him by his political antagonist Kossuth.

See Antál Zichy, *Biographical Sketch of Count Stephen Széchenyi* (Hung.; 2 vols., 1896–97).

SZECHUAN, the largest province of China Proper, area formerly nearly 220,000 sq.m., but since the institution of Kham (Chwanben) reduced to 160,000–185,000 sq.m., with a population only less dense than that of Shantung, recent estimates varying from 54,500,000 to about 61,500,000. The heart of Szechuan is the plateau known as the Red basin, a region that continued as a gulf of the sea for some time, in later Palaeozoic period, after the north Mongolian region became land, and changed to a freshwater lake during the Mesozoic, with deposition of the post-Rhaetic red sandstones, later wrinkled and converted into land. The province is bordered on the west by the immense eastern Tibetan fault-zone, which gives a rapid rise from the Min-ho (less than 1,500 ft. above sea-level) by broad terraces to great north-south mountain lines, the greater part of which is well over the 12,000 ft. level. Most of this western highland is now included in the province of Kham (Chwanben) save that the Liangshan and some other mountains involved in great river-bends remain in south-west Szechuan. There is much evidence of a long continuance of earth movement along this great fault line, and the river courses of the highland have adapted themselves to the changes involved, running southward between the ranges turning eastwards into south-west Szechuan and north Yunnan, eventually uniting in the north-eastward course of the Yangtze-Kiang. The mountain courses of the rivers are torrential; in the Red basin the rivers are generally navigable and afford the best means of communication. On the north-east, the Red basin grades up to the Tapaling or Tapashan, beyond which, to the north, is the great west-east range of the Tsinlingshan. The Tapaling (Tapashan) end in a great fault against the Hupeh basin, eastwards; and the latter is much lower than the Red basin. The Yangtze-Kiang makes its way from the one down to the other through the famous gorges of the north-east frontier of Szechuan to Ichangin Hupeh. Von Richtofen thought that the sinking of the Red basin, as compared with the Tibetan highland, has continued until recent times, whereas that of the Hupeh basin, as compared with the Tapaling and the Red basin, ended earlier. The result would be a tilt, lessening the slopes in the west of Szechuan, within the basin, but increasing them in the north-east; this furnishes at least a supplementary interpretation of the Yangtze-Kiang (*q.v.*) gorges, which are so notable a feature of China's physical geography, and have played such a part in isolating Szechuan from Hupeh. The Yangtze and its feeders within the basin in the west are less closely encased, so there are considerable alluvial plains, as around Cheng-tu, the capital, where irrigation is highly developed. Beyond the Yangtze-Kiang, to the south-east, stands the limestone horst of the province of Kweichow, with its border towards the Red basin, often at an altitude of 4,500 ft., drained by streams which reach the deep channel of the Yangtze by narrow valleys. The name Szechuan means four rivers, and the Yangtze-Kiang is made up of the Min, To, Fu and Kialing, flowing north to south into the Red basin, where they meet the Kin-Sha or Upper Yangtze, which has also been formed of north to south streams and has then rounded the Liangshan and flowed north along its eastern side, really entering the basin at Sui-fu (Su-chow-fu) where the Min, from Chengtu, joins it.

The climate of the Red basin may be studied from data for Chung-king, at the junction of the Kialing with the Yangtze. The monthly average temperatures vary from 49° F in December and January to 80°–82° F in July and August. The average minimum per month is not more than 2–2·5° below the average, so, in the Red basin, snow and frost are not often lasting. The rainfall, very low under the influence of the Central Asiatic anticyclone in December, January and February, but March has a rainfall of 2·8 in., April a rainfall of 4 in., and so the amount increases up to a maxima of about 11 in. in each of the months of June and August. The early onset of rain before the summer monsoon has begun is probably explained by the heating of the air in the deep basin and the consequent development of cyclones, which thus milden the climate of a region in the heart of a continent. The winter is not too cold for growth of cereals (wheat, barley, oats, millet) and the summer monsoon gives opportunities for almost tropical crops at low levels, and rice (especially on irrigated alluvium near Chengtu), sugar, hemp, sesamum, pulses, mulberry, oranges, maize and tobacco are thus grown. Wax trees are important around Kiating-fu. (*See* SUI-FU.)

Until the last millennium B.C. Szechuan was entirely non-Chinese, and was under Indian culture influence, the results of which persist in the cultivation of sugar-cane, the use of great water-wheels for irrigation, and the presence of the zebu and water-buffalo. The Tsin dynasty incorporated Szechuan within the empire, but its isolation has often made it a basis for separatist movements. The population within the basin has become definitely Chinese, though almost forming a separate nationality within the Chinese group. The western highlands have a sparse Tibetan population, while in the south-west are non-Chinese groups, Lolo, Sifan, Miautse, some probably of very long standing locally, others of relative late, if still pre-Chinese, entry.

The population reaches 550 per sq.m. in the east and centre, near Chungking (*q.v.*), the commercial focus (pop. 600,000), going up to 900 per sq.m. on the irrigated land near Chengtu (*q.v.*), the capital (pop. 400,000). Wanhsien, Sui-fu, Luchow, Shunking, Fowchow and Huchow all appear to have over 100,000 inhabitants each. In spite of the numerous large centres, 90% of the population is rural, living mostly in large villages.

The mineral resources of the province are little developed, owing to difficulties of extraction and transportation. Coal, mainly bituminous and associated with iron, is mined by adits along the Yangtze valley, and supplies the river steamers plying the 348 m. between Chungking and Ichang (Hupeh province). Other coal and iron producing centres are the Min and Kialing valleys. Copper is mined west of the Min river, where Ning-Yuan and Ya-Chow prefectures are the main producing districts. Salt extraction by brine pumping is also a widely prevalent activity. Gold, silver, lead and antimony are also mined, mainly west of the Min river.

Trade is severely handicapped by topography, and the easiest and most utilized routes are those of the river valleys. Overland transport is extremely slow and is largely performed by coolie labour. Small junks carry goods to the great emporium of western China, Chungking. This treaty port, opened in A.D. 1890, exports silk, tea, rice, cotton goods and tobacco from the Red basin, and hides, wool, timber, skins and medicines from the mountain area west of the Min river. The second category of goods generally comes down the Min river from Chengtu, the capital, a city at the edge of the mountain country, and so admirably placed to receive these commodities from such outpost towns as Tatsienlu and Ya-Chow. There are only two good overland roads, firstly, the Great North road from Peking via Sian (Shensi province) to Chengtu, and secondly, the Little North road from Wanhsien to Chengtu. Wanhsien, a small port on the Szechuanese side of the great Yangtze gorges, was opened to foreign trade in A.D. 1917, after 15 years' delay. The imports of Szechuan are mainly textiles, dyes, metals, soaps, kerosene, etc., whilst the exports, generally via Chungking and Hankow (Hupeh province) are silk and silk products, wax (from wax insects), tobacco, cotton goods and yarn, tea, wood oil, bristles, salt, sugar, musk and medicinal plants.

See F. von Richtofen, ***China***, vol. iii. (Berlin, 1912); L. Richard, *Geogr. de l'Empire de Chine* (Shanghai, 1905).

SZEGED, capital of the county of Csongrád in Hungary and the second town in the country. It lies just below the confluence of the Maros and the Tisa. Pop. (1920) 119,000. It is modern and well-built, the old town having been almost destroyed by flooding of the Tisa in 1879. In early times it was important because it lay on the salt and timber route from Transylvania to the Adriatic. To-day it is essentially a market centre lying at the meeting point of four contrasted regions, viz:—the drift-sand Danube-Tisa zone, the loess-covered Bačka, the garden region of the Körös-Maros interstream area and the cereal belt of the western Banat. It is the seat of a university.

SZÉKESFEHÉRVÁR, a town in Hungary, capital of the county of Fejér, lies in a marshy valley connecting the loess-covered plains of the Danube with the Upper Hungarian Plain (Kis-Alföld). It trades in wine, fruit and horses and has tanneries and shoe factories. The town was the coronation and burial place of the Hungarian kings from the 10th to the 16th century. The coronation church was built by St. Stephen, the first king of Hungary and in it were buried 15 kings. At the end of the Turkish occupation, 1543–1686, the church, its tombs and archives were destroyed. The town is a very old see of a Roman Catholic bishopric. Pop. (1920), 39,109.

SZEKLERS (Magyar Székelv), a people inhabiting the upper valleys of the Mureš and the Olt in eastern Transylvania. They number to-day about 450,000, but are no longer distinguishable from the Magyars, with whom they are closely akin. Their origin has been much debated. According to their own tradition, repeated in Procopius (*de bello Gothico,* iv. 18), they were descended from Attila's Huns, while others have seen in them Black Ugrians. It is, however, now generally accepted that they are true Magyars, transplanted here probably by St. Ladislaus to guard the frontier, their name meaning simply "frontier guards." For their history and bibliography, *see* TRANSYLVANIA.

SZÉLL, KOLOMAN (1845–1915), Hungarian statesman, was born on June 8, 1845. He studied at Budapest and Vienna, and in 1867 became deputy for the district of St. Gotthard. Széll was one of Déak's intimates, whose ward, the daughter of the Hungarian poet Vörösmarty, he had married. In 1875 he was finance minister in the Tisza cabinet, and began the task of restoring the shattered credit of Hungary. In 1878 he concluded with Austria the first economic *Ausgleich.* At that time the single Austrian bank was changed, in conformity with this arrangement, into the dualistic Austro-Hungarian bank, and Széll consolidated the Hungarian *rentes,* and nearly succeeded in balancing the State finances. As he feared that this balance would again be upset by the occupation of Bosnia and Herzegovina, he resigned from the cabinet, incurring thereby the displeasure of the Crown. At the beginning of the eighties Széll founded the Hungarian Mortgage Credit Bank, of which he was governor until the end of his life. He opened entirely new sources of credit for Hungarian agriculture. He declined repeated offers of the portfolio of finance. Széll became prime minister after the fall of Bánffy in February 1899. On the basis of the so-called Széll formula the new *Ausgleich* with Austria until the year 1907 was concluded after long negotiations. He was forced to resign on June 16, 1903. Széll was one of the Liberal seceders in 1904. Under the Coalition cabinet of Wekerle, he was chosen president of the Constitutional Party. He tried continually, but in vain, to bridge the opposition between Tisza and Andrassy. He died on Aug. 16, 1915.

SZILAGYI, DESIDER (1840–1901), Hungarian statesman and jurist, was born at Nagy-Várad (Grosswardein) on April 1, 1840. He studied law at Budapest, Vienna, and in Germany. As head of a section in the Hungarian ministry of justice he went to England to study the conditions of the administration of justice there, and took a conspicuous part in the codification work of the ministry of justice. Deputy in 1871, professor of public law and politics at Budapest university in 1874, he was in 1877 one of the leaders of the opposition, which, however, he left in 1886. In 1887 he was returned to parliament by Pozsony (Pressburg) as an independent member. He became minister of justice in 1889. From this time to 1894 he directed his efforts principally towards a radical reform of the whole administration of the courts. His name is connected with the changes in ecclesiastical legislation made in 1894, notably with article XXXI. of the law of civil marriage, and articles XXXII. and XXXIII. on the religion of the children and on State registration. Szilagyi was president of the house of deputies from 1895 to 1899. He died on July 3, 1901.

See *Szilagyi's Speeches* (4 vols., in Hungarian, ed. Fayer).

SZINYEI-MERSE, PAUL DE (1845–1920), Hungarian painter, was born at Szinyeujfalu and studied art at the Munich Academy. His pictures were characterised by gay and graceful colouring and a lyric view of nature. In 1873 he finished the masterpiece of his life "May Festival." He gave successful exhibitions at Munich (1909), Berlin (1910) and Rome (1911). In 1905 he was appointed director of the Hungarian National Academy of Arts. He died in 1920.

See Béla Lázár, *Paul von Szinyei-Merse* (1911); Alexius Petrovics, *Szinyei Pál* (Arts Lexicon, 1926).

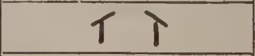
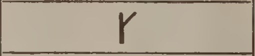
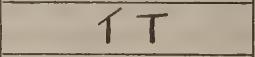
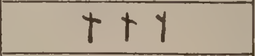
SZOMBATHELY, a town in western Hungary, that has lost, by the rearrangement of the frontier between Austria and Hungary in 1920, a large portion of the area it served as a market. It occupies the site of the Roman capital of Pannonia, *Sabaria Savaria* and many remains of the Roman period have been excavated; some of these are preserved in the museum at Budapest, the remainder in the municipal museum. The town lies in the centre of a rich wine-producing downland and is an important agricultural centre with steam flour and saw mills and factories producing agricultural machinery and textiles in addition to foundries and a state railway workshop. It has been the see of a Roman Catholic bishop since 1777 and possesses a beautiful cathedral and several other ecclesiastical buildings. Pop. (1920) 34,699. About 5 m. S. lies the village of Ják which has an 11th century Dominican convent whose church is reputed to be one of the finest examples of Romanesque architecture in the country.

SZYMANOWSKI, KAROL (1883–), Polish musician, was born at Timoshovka, Russia, of Polish parents, and studied under Sigismund Noskowski at Warsaw. He became one of the leaders in the revival of Polish national music, but his early works owe much to the German tradition. He has written songs, orchestral works and chamber music, but a large proportion of his compositions are for the pianoforte. He has also composed an opera "Hagith" written in 1912 and produced at Warsaw in 1922, which has won many admirers. In the works written after 1914 Szymanowski adopted new and ultra-modern methods.

FOUNDED A·D·1768

T This letter corresponds to Semitic *tau,* the form of which on the Moabite stone was **X**. In all Greek alphabets, as well as in the Lydian and the Latin, the form was T. Etruscan had a form ᛏ, from which probably were derived the Umbrian form ᛉ and the Faliscan † and Y.

Latin cursive gives a form that leans to the right ⌝. Carolingian ꞇ is based upon uncial ꞇ. Generally speaking, in mediaeval mss. the letter did not rise above the line and it is sometimes difficult to distinguish from a minuscule *c.* In modern handwriting and printing it is the custom to extend the vertical stroke above the horizontal.

NAME OF FORM	APPROXIMATE DATE	FORM OF LETTER
PHOENICIAN	B.C. 1.200	X
CRETAN	1.100-900	T
THERAEAN	700-600	T
ARCHAIC LATIN	700-500	T
ATTIC	600	T
CORINTHIAN	600	T
CHALCIDIAN	600	T
IONIC	403	T
ROMAN COLONIAL	PRE-CLASSICAL AND CLASSICAL TIMES	
URBAN ROMAN		T
FALISCAN		
OSCAN		
UMBRIAN		
CLASSICAL LATIN AND ONWARDS		T

THE DEVELOPMENT OF THE LETTER "T" FROM THE PHOENICIAN THROUGH THE CLASSICAL, DOWN TO THE PRESENT FORM

The sound represented by the letter throughout its history has been the unvoiced dental stop. In English this has become more alveolar than dental, that is to say, it is pronounced by the tongue pressing upon the gums rather than the teeth. Modern unvoiced stops are probably also to be distinguished from the corresponding sounds in ancient Greek by the addition of a slight puff of breath following the sound, thus bringing the sound near to being an aspirate. Greek would perhaps have transliterated the English unvoiced stops by the letters θ, ϕ and χ rather than τ, π and κ. This tendency towards aspiration is carried to much farther lengths in the Irish dialects of English. (B. F. C. A.)

TAAFFE, EDUARD FRANZ JOSEPH VON, COUNT [11th Viscount Taaffe and baron of Ballymote, in the peerage of Ireland] (1833–1895), Austrian statesman, was born at Vienna, Feb. 24, 1833, second son of Count Ludwig Patrick Taaffe (1791–1855), who was minister of justice in 1848 and president of the court of appeal. As a child Taaffe was one of the chosen companions of the young archduke, afterwards emperor, Francis Joseph. In 1852 he entered the public service; in 1867 he was Statthalter of Upper Austria, and minister of the interior in Beust's administration. In June he became vice-president of the ministry, and at the end of the year he entered the first ministry of the newly organized Austrian portion of the monarchy. For the next three years he took a very important part in the confused political changes, representing essentially the wishes of the emperor. From Sept. 1868 to Jan. 1870 he was president of the cabinet. In 1870 Taaffe, with the other members of the cabinet who advocated concessions to federalism, resigned. He returned to office in April, resigned once more, and became Statthalter of Tirol.

On the breakdown of the Liberal Government in 1879 he was again called to office, becoming minister-president in July, and held office until July 1893, when he was defeated on a proposal for the extension of the franchise and resigned, dying at Ellerschau, Bohemia, on Nov. 29, 1895. For the history of Taaffe's administration, *see* AUSTRIA. Essentially an opportunist, he maintained office for many years by an unprecedented employment of the principle *divide et impera.* Usually resting on the Slavs and clericals, he was accused by the German Liberals of ruining Austria; but he united a deep devotion to the emperor with a singular gift for managing men and at least prolonged the life of an impossible system.

By the death of his elder brother Charles (1823–1873), a colonel in the Austrian army, Taaffe succeeded to the Austrian and Irish titles. He married in 1862 Countess Irma Tsaky, by whom he left four daughters and one son, Henry.

See Wurzbach, *Biographisches Lexicon Oesterreichs. Memoirs of the Family of Taaffe* (Vienna, 1856), privately printed; and Taaffe's *Political Correspondence* issued after his death.

TA'AISHA: *see* BAKKARA.

TAAL, a municipality (with administration centre and 47 *barrios* or districts), of the province of Batangas, Luzon, Philippine Islands, on the Pansipit river, opposite Lemery, with which it is connected by a bridge. It is about 50 m. south of Manila and near to Lake Taal. Pop. (1918), 21,155. Extensive agricultural lands in the vicinity produce rice, corn, sugar and other products. The breeding of horses and cattle and fishing are also important industries. On an island in Lake Taal is the volcano of Taal which has had numerous violent eruptions—the last in Jan. 1911. Baskets, mats, harness, shoes and slippers, bolos and embroidery are made in considerable quantities. In 1918, Taal had 13 manufacturing establishments, 3 rice mills, 31 sugar mills and 941 household industry establishments. The language is Tagalog.

TABACO, a municipality (with administration centre and 45 *barrios* or districts) and port of entry of the province of Albay, Luzon, Philippine Islands, on Tabaco bay, a protected harbour about 20 m. north of Albay, the provincial capital, with which it is connected by the railway. Pop. (1918), 24,812. Abacá is the principal agricultural product. Cloths, baskets and mats are woven by the women. Tabaco has considerable commercial importance. In 1918, it had 16 manufacturing establishments and 664 household industry establishments. There were eight public schools. The language is Bikol.

ṬABARĪ [Abū Ja'far Mahommed ibn Jarīr ut-Ṭabarī] (838–923), Arabian historian and theologian, was born at Amol in Tabaristan and studied at Rei (Rai), Baghdad, and in Syria and Egypt. Cast upon his own resources after his father's death, he was appointed tutor to the son of the vizier 'Ubaidallāh ibn Yaḥyā. He journeyed to Egypt, but soon returned to Baghdad, where he remained as a teacher of tradition and law until his death. A Shāfi'ite in law, he claimed the right to criticize all schools, and ended by establishing a school of his own, in which he incurred the wrath of the Hanbalites.

Two of his works are very extensive. The one is the *Tārīkh ur-Rusul wal-Mulūk* (History of the Prophets and Kings), generally known as the *Annals*. (*Cf.* ARABIA, *Literature*, "History.") This is a history from the Creation to A.D. 915, and is renowned for its detail and accuracy. It has been published under the editorship of M. J. de Goeje (Leyden, 1879–1901). His second great work was the commentary on the Koran, which was marked by the same fullness of detail as the *Annals*. It has been published in thirty vols. (with extra index volume) at Cairo, 1902–1903.

TABASCO, a state of Mexico. Area 9,783 sq. miles. Pop. (1921) 210,437. The surface is generally low and flat, largely covered with lagoons, watercourses and swamps. In the south and south-east there is an area belonging to the rough higher formation of Chiapas. Dense forests cover the whole region, and there are valuable fine woods and dye-woods. There are several large lagoons on the coast, two of which are called Santa Ana and Tupilco bays. Two large rivers, the Grijalva and Usumacinta, traverse its territory. The Grijalva, also called Tabasco, the upper course of which is known as the Chiapas, is navigable for 93 miles. The Usumacinta forms the boundary between Guatemala and Chiapas until the frontier of Tabasco is reached, where its north-west course turns to the north and then north-west to a junction with the Grijalva—the two rivers having a common outlet. The Usumacinta, including its head streams, is about 500 m. long; excluding them about 330 m.; for about 270 m. it is navigable and for about 180 m. it is navigable by large steamers. There are no railways and few good roads, and these rivers and the navigable channels of the Cuxcuchopa, Soledad, Cocohital, Tular and Tortuguero are the principal practical thoroughfares in the State. The capital is Villahermosa (pop., 1921, 15,819), on the Grijalva river. The next most important town is Frontera, a port 3 m. within the mouth of the Grijalva.

TABERNACLE, the name given in the English Bible to the portable sanctuary, erected by Moses in the wilderness as the place of worship of the Hebrew tribes (Exod. xxv. *sqq.*). It stood within a rectangular court, measuring 100 cubits by 50, say 150 feet by 75, which formed the centre of the camp in the wilderness. Of the two equal squares into which the court may be divided, the more easterly was that in which the worshippers assembled. In the centre of this square stood the altar of burnt-offering, a hollow chest of acacia wood overlaid with bronze. In the western square stood the tabernacle itself. The essential part of the structure was that termed in the original the *mishkān*, *i.e.*, dwelling. It was formed of ten curtains, in two sets of five, of the finest linen with inwoven coloured figures of cherubim spread over a series of open frames of acacia wood overlaid with gold, each 10 cubits in height by 1½ in breadth. These frames, 48 in all, were so arranged as to form the southern, western and northern sides of a rectangular structure, 30 cubits in length and 10 in breadth and height, whose eastern end, forming the entrance, was closed by a special portière suspended from five pillars. The dwelling was divided into two parts by a second hanging, the "veil," 10 cubits from the western end. These two parts were termed respectively the holy place, and the most holy place or "holy of holies." Within the latter stood the ark of God, in which were deposited the two stone tables of the decalogue or "testimony." On the ark lay a solid slab of the finest gold, the propitiatory or mercy-seat, from which rose the figures of two golden cherubim, forming the innermost shrine of the wilderness sanctuary, the earthly throne of the God of heaven.

The furniture of the holy place consisted of the table of shew-bread, the altar of incense—both, like the ark, of acacia wood overlaid with gold—and the golden "candlestick," or seven-branched lamp-stand. As a protection the delicate and artistic curtains of the dwelling were covered by two similar sets of goats'-hair curtains; these, in their turn, were protected by a double covering, the one of rams' skins dyed red, the other made of the skins of a Red Sea mammal, probably the dugong (Exod. xxvi. 14).

The aim of the "priestly" writers, to whom we owe this conception of the tabernacle, was to provide a sanctuary and a ritual worthy of the higher conceptions of the Deity, which had grown up as the fruit of the discipline of the exile. The thought of the almost unapproachable holiness of the Deity underlies not only the gradation of the parts of the tabernacle—court, holy place and holy of holies, each marked by an ascending degree of sanctity—but also the careful gradation of the materials employed in its construction. The whole is to be regarded as the expression of a religious ideal. Building on the traditions of the simple Mosaic "tent of meeting," the priestly idealists followed the example of Ezekiel, and elaborated a sanctuary to serve as the model for the worship of the theocratic community of the future. "Let them make me a sanctuary, that I may dwell among them" (Exod. xxv. 8).

BIBLIOGRAPHY.—*See* "Tabernacle" by Kennedy in Hastings' *D.B.*, with which may be compared the corresponding articles in the *Ency. Bib.* by Benzinger, and in the *Jewish Encycl.* by König; also the commentaries on Exodus. (A. R. S. K.)

In architecture, the term loosely expresses a niche for a statue, with a canopy (*q.v.*) over it, especially in the mediaeval styles. When niches are arranged in vertical rows, with the canopy over one statue acting as the pedestal for the one above, the whole composition is often termed tabernacle work. The same term is also used for any richly decorated tabernacle or canopy-like forms, whether true tabernacles or not.

TABERNACLES, FEAST OF. A famous Jewish festival which commences on 15 Tishri (five days after the Day of Atonement), and lasts seven days. Of these the first two (Tishri 15 and 16) are full festival days, the last five (Tishri 17–21) half-holidays. The "eighth day" Festival (Shemini Aisereth), which like other festival days is doubled (Tishri 22 and 23; the second day in this case is called *Simchath Torah*), closes the celebration. The whole nine days bear one descriptive designation, "season of our rejoicing." The festival is one of venerable antiquity. Its observance is commanded in the Mosaic Law (Lev. xxiii. 34), and its purpose is there explained as to commemorate the way in which the Israelites dwelt in booths (*sukkoth*) in the wilderness.

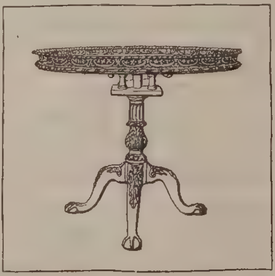
Every Jew who owns a court or garden is required to erect a booth or something more or less equivalent, and to dwell in it—or at least have meals in it—while the feast lasts. In order that the character of the original booth may as far as possible be retained, the modern counterpart is very lightly constructed. It "must not be covered with fixed boards and beams or with canvas, but with detached branches of trees, plants, flowers and leaves, in such a manner that the covering is not quite impenetrable to wind and rain or starlight" (Friedlander). The booths are required to be made during the days that intervene between the Day of Atonement and the Feast itself; they are adorned with garlands, flowers, and the like; often the text "Ye shall dwell in booths seven days" (Lev. xxiii. 42), is displayed in a prominent place within the booth. On the eve of the Feast the members of the household attend Synagogue, and on returning assemble in their booth and partake of a meal. On this evening (the first of the Feast) the meal (as in the case of the weekly Sabbath on Friday evening) is preceded by Qiddush or the solemn sanctification, first over a cup of wine which is then handed round, all drinking of it, and then over two wheaten loaves, specially baked and placed on the table covered with a cloth; these the head of the family then proceeds to cut into pieces, which are distributed to and eaten by all present. A special blessing—which is repeated before every meal during the seven days—follows ("Blessed art Thou, O Lord . . . Who hast commanded us to dwell in a booth"). At the conclusion of the meal, and on leaving the booth the following prayer is said by the head of the household:

> May it please Thee, O Lord my God, and God of my fathers, that in like manner as I have this time obeyed Thy command and have been sitting in the booth, so in the coming year I may be counted worthy to sit in the booth of Leviatham.

It should be observed that the Leviatham plays a prominent part in haggadic legend, especially in connection with the Messianic time. The monster is to be killed and the flesh is to furnish food for the righteous (at the Messianic banquet). From the hide tents will be made by God for the pious of the first rank. This last feature will explain the allusion in the text of the prayer.

On the occasion of the ceremony, the Synagogue is decorated with plants and fruits and certain ceremonies are carried out, viz., palm-branch processions culminating on the seventh day at the *Musaf* or additional service. For further details *see* Oesterley and G. H. Box, *Religion and Worship of the Synagogue* (2nd. ed. 1911). (G. H. B.)

TABLE (Lat. *tabula*), in furniture, a flat, oblong slab supported upon legs or pillars. Of the many kinds of tables according to their uses, the following are outstanding as pieces of furniture and in artistic possibilities: (1) artist's table, (2) billiard table (*q.v.*), (3) breakfast table, (4) card table, (5) china table, (6) console table, (7) dining table, (8) dressing table, (9) library table, (10) side table, (11) sofa table, (12) tea table, (13) wine table, (14) work table, (15) writing table. The table was known, in a small and rudimentary form, to the Egyptians, who used wood for its construction; the Assyrians certainly employed metal and possibly other materials in its manufacture. Grecian tables were also often of metal, with three or four legs and of considerable variety of form; they were small and low. By Roman times the table had apparently become somewhat more common. The favourite form was the tripod, but one and four legs were also used. (*See* Plate I., BRONZE, GREEK AND ROMAN.) Already the shape varied considerably, and in addition to wood, there were tables of marble, ivory, bronze and the precious metals. The more costly examples were carved, inlaid or otherwise ornamented; cedar and the finely marked or grained woods generally were much sought after. As in Greece the tables were low; they were intended for reclining, rather than sitting; their legs were those of wild beasts, or were formed of sphinxes, termini and other figures. Some of those which remain are of extreme grace and most delicate workmanship; to them the Empire style is enormously indebted. In antiquity tables of any kind can only have been the appanage of the rich. In the early middle ages, although there was variety of form—the circular, semi-circular, oval and oblong were all in use—tables appear, save in rare instances, to have been portable and supported upon trestles fixed or folding, which were cleared out of the way at the end of a meal. The custom of serving dinner at several small tables, which is often supposed to be a very modern refinement, was certainly followed in the French châteaux, and probably also in the English castles, as early as the 13th century. For persons of high degree, fixed tables were reserved. Even at a period when domestic furniture was of a very primitive character and few modern conveniences had been evolved, costly tables were by no means unknown—some dim traditions of Rome's refinements must necessarily have filtered through the centuries. Thus Charlemagne possessed three tables of silver and one of gold—no doubt they were of wood covered with plates of the precious metals. Before the 16th century the number of tables properly so called was small; hence very few of earlier date than the middle of that century have come down to us. In the chapter-house of Salisbury cathedral is a restored 13th century example which stands practically alone. In point of age it is most nearly approached by the famous pair of trestle tables in the great hall at Penshurst.



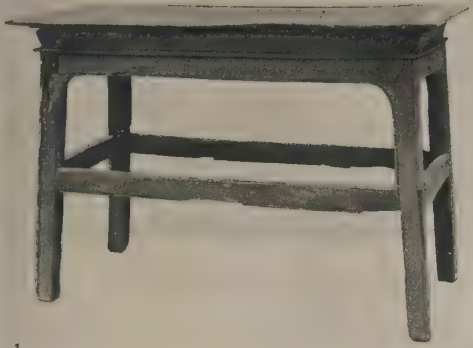
BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

ENGLISH CHIPPENDALE TRIPOD TABLE WITH TILT TOP, 1760–1770

When the table became a fixed and permanent piece of furniture the word "board," which had long connoted it, fell into disuse save in an allusive sense, and its place was taken by such phrases as "joyned table" and "framed table"—that is, jointed or framed together by a joiner; sometimes people spoke of a "standing" or "dormant" table. They were most frequently oblong, some 2 ft. or 2 ft. 6 in. wide, and the guests sat with their backs to the wall, the other side of the table being left free for service. Sometimes they were used as side-tables, or furnished with a cupboard beneath the board; they were supported on quadrangular legs or massive ends and feet, full of Gothic feeling, and were several inches higher than the dining-table of the 20th century. Heavy stretchers or foot-rails were fixed close to the floor—for the avoidance, no doubt, of draughts. Oak was the usual material, but elm, cherry and other woods were sometimes used. Soon the legs became bulbous, and were godrooned or otherwise ornamented, and the frame began to be carved. The introduction, before the 16th century closed, of the "drawing table" marked the rapidity with which this piece of furniture was developed. This was the forerunner of the "extending dining table." Of the three leaves of which these tables were composed two were below the other; they drew out and were supported by brackets, while the slab proper dropped to the same level. Somewhat later legs became excessively bulbous; this ugly form gave place soon after the middle of the 17th century to baluster-shaped legs. Hitherto tables had, generally speaking, been large and massive—little in the nature of what is now called the "occasional table" seems to have been provided until some years after the Restoration. About that time small tables of varying sizes and shapes, but still of substantial weight, began to be made; many of them were flap-tables, which took up little room when they were not in use. These, however, had been known at an earlier date. Charles II. had not long been on the throne when the idea of the flap-table was amplified in a peculiarly graceful fashion. Two flaps were provided instead of one, the result being the rather large oval table of the "gate-leg" variety that has remained in use ever since, in which the open "gate" supports the flap. (*See* INTERIOR DECORATION; *English Furniture,* Plate I.) Towards the end of the reign tables began to have the graceful twisted legs joined to the flat serpentine stretchers, which produced, almost for the first time in English furniture, a sense of lightness and gaiety. The walnut tables of the end of the Stuart period were often inlaid with marquetry of great excellence. The number and variety of the tables in well-to-do households were now increasing rapidly, and the console-table was imported from the Continent contemporaneously with the common use of the mahogany side-table.

As mahogany came into general use, about the beginning of the second quarter of the 18th century, an enormous number of card-tables were made with plain or cabriole legs and spade or claw and ball feet, often with lions' heads carved upon the knees; the top folded up to half its size when open. The Chippendale school introduced small tables with carved openwork "galleries" round the edges (to protect china and other small objects), and clustered legs; Gothic forms and Chinese frets were for a time fashionable. Later in this century, so prolific in new forms of furniture, tables were frequently made of rosewood and satinwood; side-tables, often highly elaborate, adorned with swags and festoons and other classical motives, supported by termini or richly carved legs, were gilded and topped with marble slabs or inlaid wood. (*See* INTERIOR DECORATION; *English Furniture,* Plate III.) The Pembroke table, of oblong form, with two semi-circular or oblong leaves, with edgings of marquetry, was a characteristic feature of late 18th century English furniture, and still retains its popularity. During the Empire period the taper was replaced by the round leg, rosewood grew commoner, and brass mountings became the rule. (For further illustrations *see* INTERIOR DECORATION; *European; Early American; Modern;* also, MODERN TENDENCIES IN APPLIED ARTS.)

TABLE MOUNTAIN (Dutch *Tafelberg*), a name frequently given in South Africa to flat-topped hills and mountains, which are a characteristic feature of the scenery. Occasionally such hills are called *plat, i.e.,* flat, *bergen.* Specifically Table Mountain is the mountain, which rises from the shores of Table bay, Cape Town lying at its seaward base and on its lower slopes. The mountain forms the northern end of a range of hills which terminates southward in the Cape of Good Hope. It is formed of gently inclined sandstones and quartzites of the Table Mountain Sandstone series, resting unconformably on granites, which are intruded into shales of the Malmesbury Series. The sandstones descend toward sea-level on the shores of False bay,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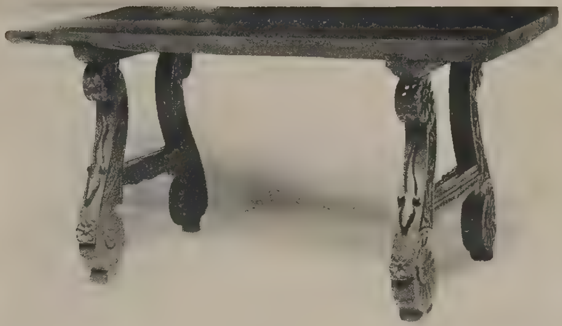
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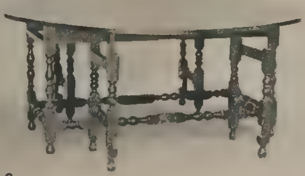
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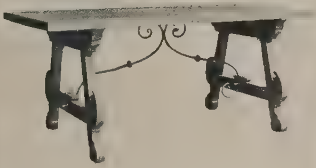
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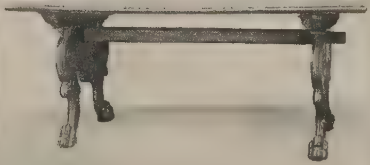
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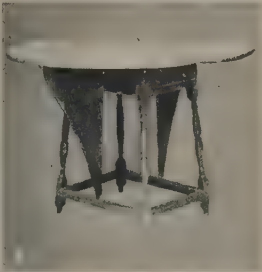

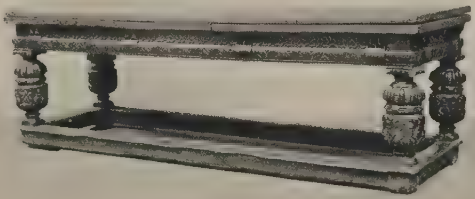
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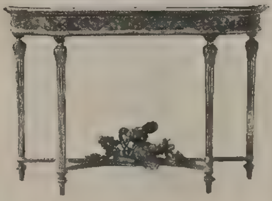
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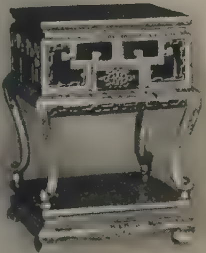
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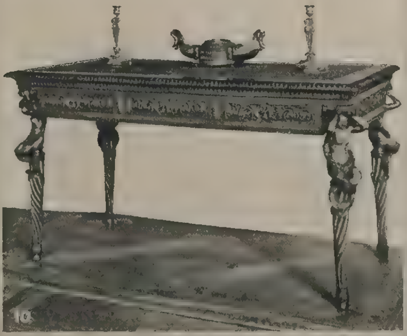
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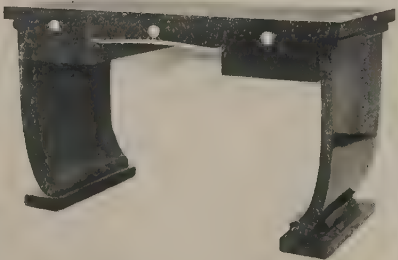
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BY COURTESY OF (1, 3, 5-8) THE METROPOLITAN MUSEUM OF ART, NEW YORK, (2) THE SPANISH ART GALLERY, LONDON, (4) THE HISPANIC SOCIETY OF AMERICA, (9) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM, (10) THE KEEPER OF THE WALLACE COLLECTION, (11) LORD AND TAYLOR

TYPES OF TABLES

1. Table of Egyptian wood, XVII.–XVIII. Dynasty, Drah abu'l nagga, Thebes*
2. Writing table of carved wood, English, late 16th century
3. Gate-leg table, American walnut, 1675–1700
4. Spanish table, 17th century
5. Carved Italian table of the 16th century
6. American oval butterfly table of walnut, 17th century
7. English draw table, closed, 16th century
8. Gilded wood French side table, Louis XVI. (18th cent.)
9. Lacquered Chinese table
10. Writing table with mounts of gilt bronze
11. Table in the modern mode

but are too high to be accessible as building stone for Cape Town. The northern face of the mountain, overlooking Table bay, extends like a great wall some two miles in length, and rises precipitously to a height of over 3,500 feet. The face is scored with ravines, a particularly deep cleft, known as The Gorge, affording the shortest means of access to the summit. East and west of the mountain and a little in advance of it are lesser hills, the Devil's Peak (3,300 ft.) being to the east and Lion's Head (2,100 ft.) to the west. Lion's Head ends seaward in Signal hill (1,100 ft.). The western side of Table Mountain faces the Atlantic, and forms an escarpment, with a broken sky line, known as The Twelve Apostles: to the south Hout's Bay Nek connects it with the remainder of the range; on the east the mountain overlooks the Cape Flats. On this side its slopes are less steep, and at its foot are Rondebosch, Newlands, Wynberg, and other residential suburbs of Cape Town. The ascent of the mountain from Wynberg by Hout's Bay Nek is practicable for horses. The surface of the summit is broken into small valleys and hills, and is covered with luxuriant vegetation, its flora including the superb orchid *Disa grandiflora* and the well-known silver tree. The Kasteel-Berg (Castle Mount), a northern buttress of the mountain, has its own peculiar flora.

The south-east winds which sweep over Table Mountain frequently cause the phenomenon known as "The Table-cloth." The summit of the mountain is then covered by a whitish-grey cloud, which is being constantly forced down the northern face towards Cape Town, but never reaches the lower slopes. The clouds (not always caused by the south-easter) form very suddenly, and the weather on the mountain is exceedingly changeable. The rainfall on the summit is heavy, 72·14 in. a year being the average of twelve years' observations. This compares with an average of 54·63 in. at Bishop's Court, Newlands, at the foot of the mountain on the east, and with 25·43 in. at Cape Town at the northern foot of the mountain. The relative luxuriance of the vegetation on the upper part of the mountain, compared with that of its lower slopes, is due not only to the rainfall, but to the moisture condensed from clouds. (*See* also CAPE TOWN.)

TABLES, MATHEMATICAL: *see* MATHEMATICAL TABLES.

TABLINUM, in architecture, one of the most important rooms of a Roman house, usually of large size, opening off the atrium (*q.v.*), in the centre of the side opposite the entrance. At its rear there was frequently a large window looking out on the peristyle (*q.v.*) or colonnaded inner court. It was frequently decorated with busts or pictures of the family ancestors, and took the place of the modern, formal drawing room.

TABOR, a small town in Bohemia, Czechoslovakia, on the Luznice, a tributary of the Vltava, is mainly of historical importance since it was founded in 1420 by the more advanced Hussites, who came to be known as Taborites. In site and build it indicates its original purpose. Standing on the summit of an isolated hill, separated from the surrounding country by the Luznice and protected by marshes, the market place in the centre of the town is approached by very narrow streets to render the approach difficult in time of war. In this market place stands a statue of Žižka, one of the most famous Hussite leaders. Here also are the early 16th century diaconal church and the town hall with its museum of Hussite memorials. The district around Tabor is not particularly fertile, producing mainly the hardier cereals and potatoes. Pop. (1921) 12,561.

TABORA, a town of East Africa, Tanganyika Territory, in the Unyamwezi country (known officially as the Tabora district). Pop. (1921) about 25,000, including 150 Europeans and 1,200 Asiatics. Tabora is on the railway (completed in 1914) from Dar-es-Salaam to Kigoma, on Lake Tanganyika, being 530 m. from the ocean and 212 m. from the lake port. Another railway, 238 m. long (completed in 1928) links Tabora to Mwanga, on Lake Victoria. Tabora has several fine buildings, including government offices, churches, hospitals and schools. A Government school for the sons of chiefs combines farm work with literary teaching. There are large railway workshops and an aerodrome (first used in 1920, when aeroplanes arrived from Cairo).

The modern town was founded by Zanzibari Arabs, about 1820, close by the *boma* of a chief of the Nyamwezi. Its central position and good water supply made it an important trading centre and a place of strategic importance. The Germans built a strong fort here. During the World War it was captured by the Belgian Congo troops (Sept. 1916), and later passed to British administration. (*See* UNYAMWEZI and TANGANYIKA TERRITORY.)

TABRIZ, chief town of the province of Azerbaijan and second largest city of Persia, lies in the valley of the Azi Chai (the Bitter river which flows into Lake Urmia) at an elevation of 4,400 ft., in 38° 4′ N., 46° 18′ E., and 320 m. N.W. of Tehran. Overlooking the valley on the south rises the volcanic cone of Sahand (12,000 feet). The city was reported in 1880 to contain 318 mosques, 100 public baths, 166 caravanserais and some 26,000 houses; but in reality there is little of striking character to be seen except the bazaars and the Qabud Masjid, or Blue Mosque, with its stately façade of blue faïence, close to the gate leading to the Tehran road. The Ark, or Castle, a lofty structure dating from the middle ages, is a ruin. Two gates are memorials from 1882, when the Kurds under Shaikh Ubaid Allah attacked Tabriz and conquered Urmia. For the rest, the city consists of an interminable collection of yellowish-grey, uniform houses intersected by a labyrinth of crooked and narrow lanes, but, since the new régime in Persia, some streets have been widened. On the outskirts are beautiful gardens and the more modern country houses of the wealthy classes. The maximum summer temperature is 100° in August, and the minimum 6°; rainfall about 9 in.

Tabriz figures prominently in the chronicles of almost every traveller of note in Persia, in ancient and mediaeval times, from Marco Polo to Chardin and Tavernier. It was for a long period the great emporium of European trade with Persia, situated as it was on the main route from Trebizond and Erzerum; but since the opening of the Suez Canal drew to itself the trade of the southern half of Persia, and the railway through the Caucasus gave greater transport facilities on the Caspian Sea diverting the trade to Astara and Pahlevi, it has lost some of its activity. The difficulty and insecurity of the Trebizond-Tabriz roads and the recent rehabilitation of the 'Iraq have still further diverted much commerce by way of Baghdad. It is nevertheless a principal trade centre and point of local distribution and collection for N.W. Persia. The railway from Tabriz to Julfa (80 m.), built by the Russians in 1916 and transferred to Persia in 1921, connects with the Caucasian system and though in 1928 this line was in bad repair and lacked rolling stock there were signs of improved traffic. A constructed road suitable for heavy motor traffic runs parallel to the railway and continues to Khoi. From Tabriz to Tehran, via Kazvin, and to Astara on the Caspian Sea, via Ardabil, are unmetalled roads, but passable for motors.

Tabriz is the centre of the dried fruit industry of Azerbaijan, as well as the headquarters of an important rug industry. A match factory was working in 1927. There is a branch of the Imperial Bank of Persia and a local telephone service. The total value of trade passing through Tabriz in 1925–26 was 111,480,413 krans (£ St.=45 krans), of which 38,476,072 krans represented exports, chiefly carpets (29,337,601 krans), fruits (3,781,512 krans) and hides and skins. The chief imports were textiles, sugar and tea.

Tabriz (ancient Tauris) was probably an old city when it became the capital of Tiridates III., king of Armenia, in A.D. 297. In 858, in the reign of the tenth Abbasid Caliph, it was almost destroyed by earthquake, and again in 1041. In 1392, Timur took and sacked the city and, later, it fell under the sway of certain Turkman princes, from whom, in 1500, Ismail, first of the Safavis, took it; but it remained under Persia only till 1522 and then fell under Turkish rule. In 1618 Shah Abbas I. won it back to Persia. In 1721 the town was again in great part destroyed by earthquake and again passed, after a sanguinary struggle, under the Turks who held it until 1730, when it was retaken by Nadir Shah. Tabriz remained under the Persians until it was taken by the Russians in 1827, to be restored to Persia in 1828. Since 1905 it has been the capital of the heir-apparent. In 1908, the revolution against the Shah started at Tabriz and the arrival of Russian troops in 1909—nominally to save Russian subjects from famine

—marked the commencement of a Russian occupation of this as well as other Persian towns. Tabriz became involved in the World War owing to Turko-Russian conflicts and was occupied by the Russians in 1915 and again by the Turks for a short period in 1918. These alternate occupations thoroughly disorganized the civil administration and economical conditions of the province of Azerbaijan from which, in 1928, it had scarcely recovered.

Bibliography.—G. N. Curzon, *Persia and the Persian Question* (1892); A. V. Williams Jackson, *Persia past and present* (1906); A. Sven Hedin, *Overland to India* (1910); A. C. Wratislaw, "Turbulent Tabriz," *Blackwood's Mag.*, Jan. 1923; *see* also *Urmia.* (P. Z. C.)

TABU. Tabu, one of the few savage words that have struck root in the English language, is of Polynesian origin and has dialectical forms (*tapu, kapu, tambu*) in Polynesia and Melanesia; but the form *tabu* (or *taboo*) is the one which has become popularized, because it was as *tabu* that Capt. Cook first discovered the notion and its associated customs at Tonga in 1771.

I. MEANING OF TABU

Literally an adjective, meaning "marked off" (perhaps from the Polynesian *ta*=mark, *pu*=exceedingly), tabu implies that certain persons or things are unsafe for casual contact or use in ordinary life, "not to be lightly approached" (Codrington, *The Melanesians*, p. 188) because of supernatural penalties which would thereby be incurred. There is always some occult, magico-religious significance present. Another Polynesian word, *mana* (*q.v.*), expresses conveniently its positive aspect. Mana implies the mysteriously-efficient, transferable force recognized in all remarkable, impressive, wonder-working things as well as in striking human personalities. "Negatively, the supernatural is *tabu*, not to be lightly approached because (positively) it is *mana*—instinct with a power above the ordinary." Thus, for the Ila-speaking peoples of northern Rhodesia, we are told, vaguely-defined forces pervade all things, neutral in themselves, but available for those who have "the secret of manipulation." These forces, however, "are dangerous things to interfere with. They are *tonda* (tabu). For an ordinary person, under ordinary circumstances, to interfere with them is forbidden; it is dangerous to himself and the community. By saying certain things, doing certain actions and eating certain foods, he may liberate these energies with fatal results to himself and his neighbours. Persons in certain conditions and things put to certain uses, come into intimate contact with these forces and are therefore *tonda.*" (Smith and Dale, *Ila-speaking Peoples of N. Rhodesia,* ii. 83.)

Tabu may be either (1) inherent or (2) imposed.

(1.) **Inherent Tabu.**—Some things or conditions are intrinsically tabu, and infringement of their character brings its own penalty without external aid. Such inherent tabus are those associated permanently with women, the sick, the dead, strangers or temporarily with women in childbirth or warriors on campaign. Here inherent energy is discharged on all who break the tabu.

(2.) **Imposed Tabu.**—A common thing may become tabu through the action of a god, priest, king or chief, and the sanction of the restriction is his own power for avenging its violation. Thus, when Cook wanted to set up an observatory in the Sandwich islands, the priests tabued the place for him by setting up wands. Persons and things, places and times could be tabued. The power of imposing a tabu was a characteristically Polynesian prerogative, bound up with the theocratic powers of a prince or noble, which probably attained the highest development in New Zealand. The noble or chief, partaking of the divine essence of which he was the incarnation, was able to communicate his contagious holiness so that the objects in question could not be appropriated by anyone but a superior in rank. He might stop traffic on a river or cause great inconvenience to his people by tabuing a forest. This was generally done by putting up a pole with a bunch of rags or leaves or by erecting some corresponding notice-board. On the other hand, just as the priest or chief could impose the tabu, he could also remove it. Thus, at Hawaii in 1819, King Rihoriho at one stroke abrogated the laws of tabu, though only to make way for *le tabu,* the British Sunday.

However, these two aspects of tabu are considerably involved, for religion makes common cause with law and government, resulting in a theocratic system of controls, spiritual injunction backed by temporal power.

(3.) **Derivative Tabus.**—A third class of tabus arises from the contagiousness of tabu. It is transmitted by contact and the person or thing thus tabued becomes a new source of infection. Sometimes the infection may be removed by ritual means, such as an ablution. Sometimes it is too deeply ingrained to be removed. To discriminate between "things tabu," the primary sources of such contagion and "things tabued," in which tabu infection is derivative, is not always easy, since tabus as primarily matters of custom form part of the social inheritance. Thus, the clothing and discarded food of the king derive the tabu quality from his person. Further, not only what he touches, but what he sees also becomes tabu.

The Ambivalence of Tabu.—Of extreme importance in the study of tabu is its ambivalent character. *Either* that which is tabu is holy and to be feared as the seat of mystic, supernatural power, and therefore to be avoided lest harm befall from contact with it, or lest it be defiled by human touch and its divine essence be affected, *or* the object is unclean and therefore tabu lest it infect man with its own evil nature. Thus from this single root sprang not only uncleanness but also holiness.

II. MAJOR TABUS

(a) **Tabus on Priests, Kings, Chiefs, etc.**—Sir James Frazer has collected in the *Golden Bough* evidence of the tabus with which the semi-divine potentates, chiefs and priest-kings of primitive communities are surrounded. Thus, at Shark Point, West Africa, the king lives alone in a wood. He may never leave his house; he may not touch a woman; on no account may he quit his royal chair, even to sleep, for in that case the wind would die down and all navigation would stop. The supreme ruler at Congo is regarded as a god on earth. No subject may taste of any crop until the first-fruits have been offered to his majesty. When he leaves his residence, to visit other parts of his territory, all married persons are under obligation to observe the strictest laws of continence, any violation of which would prove immediately fatal to him. Were he to die a natural death, the world would be annihilated. "Among the Todas of southern India, the holy milkman who acts as priest of the sacred dairy, is subject to a variety of burdensome restrictions during the whole time of his incumbency, which may last many years. Thus, he must live at the sacred dairy and may never visit his home or any ordinary village; he must be celibate; if he is married, he must leave his wife. On no account may an ordinary person touch the holy milkman or the holy dairy: such a touch would so defile his holiness that he would forfeit his office. . . . . Further, the holy milkman never cuts his hair or pares his nails so long as he holds office: he never crosses a river by a bridge, but wades through a ford and only certain fords."

The sacred person must be guarded from harm without, but others must be protected also from hurt from him as a centre of contagion. Thus in a higher civilization, should anyone wear the mikado's clothes without his knowledge, he would have swellings all over his body. The touch of the king may remove the tabu caused by his own contagion. The Tongans were subject to a form of scrofula, which they often attributed to having inadvertently touched the chief or his belongings, and the touch or pressure of the chief's foot was sought as a cure for the malady. The sick man "sat down before the chief, and taking the chief's foot pressed it against his own stomach, that the food in his belly might not injure him, and that he might not swell up and die." It is possible that scrofula may have obtained its name of "king's evil" in 17th century England from the belief that it was caused, as well as cured, by contact with the majesty of kings.

In short, "the chief has mana, and is therefore feared. Men do not dread contact with the king lest they become kingly, but lest they be blasted by the superman's supermanliness."

(b) **Tabus on Women.**—In the "classic, well nigh universal" major tabu of the "woman shunned," the ambivalent nature of the emotion underlying tabu is especially seen. Full of mystery, especially at certain periods of her life, she is now worshipped as a goddess, now dreaded as a witch. The power to bring forth children indicates the possession of mana: hence the almost universal avoidance of the pregnant woman. Of the aborigines of the Amazon, it was said: "They believe that if a woman during her pregnancy eats of the meat, any other animal partaking of it will suffer; if a domestic animal or tame bird, it will die; if a dog, it will be for the future incapable of hunting, and even a man will be unable to shoot that kind of game for the future." In Fiji, a pregnant wife may not wait upon her husband. Among the Australian aborigines, women are secluded at childbirth and menstruation and all vessels used by them during this seclusion are burnt. Their very glance is poison and in some places girls, when tabu, are made to wear broad-brimmed hats lest their glance should infect the sun. Violation of the tabu on women may result in "sure death" through fright, as in the case of the Australian black fellow who, when he discovered that his wife had lain on his blanket during her tabued period, wholly succumbed to terror and died within a fortnight.

(c) **Tabus Between Relations.**—The Kirghiz woman does not look upon the face of her husband's father or elder kinsman and must never utter their names, even if they contain names of common objects but must use paraphrases, and, in describing a wolf carrying off a lamb through the rushes, would say "Look yonder, the howling one is carrying off the bleating one's young through the rustling ones on the other side of the glistening one." There is no suggestion of hostility between the tabued relatives, the stress being entirely upon the mutual respect shown.

This avoidance between relatives of opposite sexes has been closely associated with the general tabu on women. No doubt a mutual shyness between the sexes underlies these avoidances which are strongly reinforced by an admixture of the fears involved in the woman-tabu. But the tabu applies to both sexes. Woman is not avoided *as woman.* Other sentiments, especially the horror of incest, are involved.

(d) **Tabu on Strangers.**—The almost universal tabu on strangers is evidence of the fear of the unknown. "To guard against the baneful influence exerted voluntarily or involuntarily by strangers," says Frazer, "is an elementary dictate of savage prudence," but they may be admitted after a purificatory ceremony, for nearly all tabus may be neutralized by some ceremonial device. Westermarck has shown how both the tabu on strangers and the widely-spread practice of hospitality can ultimately be traced to the same root. The stranger is dangerous; it is therefore necessary to secure his good will at once. For the blessing of the stranger within the gates has exceptional power; his blessing is sought as urgently as his curse is feared.

(e) **"Sympathetic" Tabus.**—Much of the attention of the savage is directed to the food he eats. The belief that the qualities of the eaten pass into the eater, is an explanation of the food tabus and prejudices of savage peoples. Thus the hunter will not eat the heart of the deer he has killed lest he become timid like that animal, while to eat the heart of a lion would be to gain all the fierce courage of that beast. Such examples, however, do not warrant the definition of tabu as "negative magic," failing to cover the characteristics of many well-known tabus. "Sympathetic tabus" many of them certainly are up to a point, as are also the tabus on knots at childbirth, which must be observed lest delivery be impeded. But if tabu were a form of magic, the penalty for its infraction would be definite and measurable; whereas the distinguishing characteristic of tabu everywhere is the "infinite *plus* of awfulness" always accompanying its violation. There may be certain definite results, such as prescribed punishment for violations or social "growlings" showing the opposition of public opinion, to which the savage is at least as keenly sensitive as civilized man. But the "infinite *plus,*" always attached to the violation of tabu puts it into the realm of mystical, immeasurable dread. The threat is the more dire, because left to the imagination. "Do not meddle, or, if you do . . . !"

III. TABU AS A FACTOR IN MORAL TRAINING

While excessive development of tabus in any given society forms an insuperable barrier to progress, the code of tabu has an obvious ethical value. It helps men to realize that they are under obligation to the community of which they are a part. Young people begin to learn this lesson of social life at the very beginning of puberty and incorporation into the life of the tribe. The tabus and prohibitions with which they are surrounded, touch every phase of social, family and individual life from childbirth to burial.

Some have held that tabu is the *origin* of all ethics and morality. It is true that tabu has legalized and strengthened morality and, when tabus come to be regarded as the will of the gods, a rational element is introduced and the fear element, which now contains wonder and humility, is ready for transmutation into the loving reverence of the higher religions.

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TABULARIUM, the technical name of the record office or national archives building of ancient Rome, which dominates the west end of the Forum. It is built along the side of the Capitoline hill and was bordered, on the side toward the Forum, by two storeys of long arcades, the lower decorated with engaged Doric columns, and the upper with engaged Ionic columns. Each bay of the arcade is covered by a square, cloistered or four-sided vault. The tabularium is ascribed to Quintus Lutatius Catulus (*c.* 78 B.C.). It thus offers one of the earliest Roman examples of the use of engaged columns in connection with an arcade.

TABULATING MACHINES are mechanisms controlled by perforated cards which are used as mechanical aids to business methods. The first modern device of this class was designed for the automatic tallying or tabulation of statistics; but with extensive development modern tabulating machines are capable of automatically figuring and printing a report based on the information given to it in the form of perforations in cards or tape. Soon after the introduction of the Jacquard loom, in which the hooks lifting the warp threads were controlled by cards perforated to the desired pattern, Charles Babbage applied the principle to a calculating mechanism. Between 1834–54 he designed and partly built an "analytic engine" in which both the amount to be operated upon and the nature of the operation were entered by perforated cards. His machine was never completed. Development of the modern tabulating machine was accomplished by H. Hollerith.

Hollerith's first contribution was a means of tallying census returns through electrical reading of the data punched on cards and accumulating the totals in separate registers. The system was successfully used in the U.S. Census of 1890. During the next decade notable improvements were made including automatic feeding of the cards under brushes for reading and a machine for sorting the cards rapidly into desired groupings. Consequently the 12th U.S. Census in 1900 furnished particularly outstanding evidence of the possibilities of the system. The population volume was ready one year and seven months from the start of enumeration; whereas it was estimated that hand tabulation of the three factors alone of sex, nativity and occupation would have required the services of 100 clerks for seven years and 11 months. Since 1901 its commercial utility has been greatly increased. Whenever a transaction involves a number of amounts which are subsequently to be used as units two or more times in compiling various totals, it has been found to be generally economical to "translate" it on to a perforated card. If, for instance, the data connected with the cost of production of a certain part are recorded on a card this can then be used in computing totals of individual wages, department costs, machine costs, productive hours, etc. The tabulating method is now to be found in general use throughout the world.

The card upon which the data are recorded in the form of perforations has a column for each number or symbol to be entered. The digits 0 to 9 are denoted by holes punched proportionate distances from the bottom edge of the card starting with the 9 position. Above the 0 position is space for two additional perforations which are used principally for actuating certain control operations of the machine. These additional positions may also be used for special classification numbers or, in combination with perforations in the regular digit position, to denote alphabetical characters. The card is divided vertically into "fields" each denoting a particular fact of the total information recorded. Certain information is descriptive while other is quantitative. The former class controls sorting and indicating, while the latter represents amounts to be totalled. Sorting and totalling are accomplished by different machines. Three separate mechanical devices are necessary to the system: a perforating machine or punch, a sorter and a tabulator. The ordinary form of perforating machine has a set of 12 punches under which the card is advanced a column at a time. By means of a skip bar or stops, certain fields can be skipped where no punching is to be done. There are also more complete types of perforating machines arranged to permit automatic duplication of information already on one card on to others, to "gang" punch any predetermined number of cards with identical data, to number cards consecutively as they are punched. The speed with which trained operators can perforate the cards depends on the nature of the information being recorded as well as its extent. An output of 350 punched cards per hour might be considered an average performance.

Sorting the cards into the desired groups for tabulation is done at the rate of about 300 cards per minute for each digit of the class number. One well known form of sorting machine has 13 pockets, one for each possible columnar perforation and one for "rejects." The tabulator, or accounting machine, which totals the amounts perforated in given fields is capable of several different applications. The simplest form of this device consists of a set of counters actuated through a reading mechanism. Two methods of reading the cards are in use: electrical and mechanical. In the former, brushes make electrical contact through the perforations thereby actuating magnets to trip the counters. The mechanical method employs a full set of pins which are brought down upon the card momentarily at rest and which penetrate the perforations to actuate the counters mechanically. Printing tabulators are arranged to either total the cards at high speed—about 150 per minute—and then print the total, or list each card individually at slower speed followed by a total for the group. By means of special control features the machines automatically take totals of several fields after each sorted group and also store the amounts for grand totals. A great deal of flexibility is attainable in the way the items and totals may be made to appear on the printed sheet. Mechanism has lately been incorporated accomplishing direct subtraction without the necessity of perforating the complements of the numbers as formerly required. This permits of reports showing total credit and debit amounts and net balance. By using combinations of two or more holes in a column it is possible to list alphabetical characters as well as numbers. With alphabetical printing, addition or subtraction automatically sensed by the machine and devices added to the printing section for handling report and bill forms, there are now means available for automatic accounting. (B. To.)

TACANAN, a small group of tribes of South American Indians, constituting an independent linguistic stock. The Tacanas, from whom the stock takes its name, and their related tribes, live in north-western Bolivia, in the region just east of Cuzco, on the upper Madre de Dios river and its tributaries, and extend eastwards, between 13° and 15° S. lat., as far as the Beni. They are an agricultural as well as hunting and fishing folk, of the sedentary type, showing, apparently, considerable differences in cultural development between the different tribes. In spite of their close proximity to Cuzco, no significant study of this group has ever been made.

See A. D'Orbigny, *L'Homme Americain* (Paris, 1839); N. Armentia, *Navigacion del Madre de Dios* (La Paz, 1887).

TACHEOMETRY, a system of rapid surveying by which the positions of points on the earth's surface—both horizontal and vertical—are determined without using a chain or tape, or a separate levelling instrument. The ordinary methods of surveying with a theodolite, chain and levelling instrument are fairly satisfactory when the ground is clear of obstructions and not too precipitous. When the ground is much covered with brush or broken by ravines, chain measurements are both slow and liable to considerable error; the levelling, too, is carried on much slower though without serious loss of accuracy.

These difficulties led to the introduction of tacheometry, in which, instead of the pole formerly employed to locate a point, a staff similar to a level staff is used, having heights marked from the foot and graduated according to the form of tacheometer in use. The asimuth angle is determined as formerly. The horizontal distance is determined by two methods (1) from the vertical angle between the well defined points on the staff and the known distance between them, or (2) fixed wires in the diaphragm of the telescope. The difference of height is computed from (1) the angle of depression or (2) elevation of a fixed point on a staff and the horizontal distance already obtained. Thus all measurements requisite to the location of a point, both vertically and horizontally with regard to the point where the tacheometer is centred, are determined by an observer at the telescope without any assistance other than that of a man to hold the staff. (*See* SURVEYING.)

TACHIEN-LU: *see* TATSIEN-LU.

TACHOMETER, an instrument for measuring the speed of rotation of shafts and machine elements. Most tachometers have a rotating part which must be connected with the element whose speed is to be measured. With the hand-type this driving relation is maintained only long enough to take a reading, while with the types that are mounted on a machine the instrument is permanently connected to the rotating part and indicates the speed as long as that part is in motion. The hand-operated type usually has a stem provided with a vulcanized rubber tip of conical form which can be pressed into the centre-hole of the rotating shaft. Permanently mounted tachometers are driven by belt or flexible shaft, or through a mechanical coupling.

There are quite a number of different principles upon which the design of a tachometer may be based. All of the principles used in speedometers (*q.v.*) lend themselves equally well to the design of tachometers. In fact, a speedometer is a tachometer placed in driving connection with a road wheel and graduated in miles per hour instead of in revolutions per minute. Thus, there are centrifugal, magnetic drag, clockwork and magneto-type tachometers. In addition there is the principle of vibrating reeds which seems to have been used for tachometers only. It is based on the fact that in most machines having large revolving parts, such as steam turbines and electric generators, vibration of the frame is synchronous with rotation of the revolving part.

The Frahm vibrating reed tachometer consists of a series of calibrated steel reeds of different lengths, having one of their ends mounted in a brass block and a short length at their other end turned at right angles and enamelled white. These enamelled ends are located side by side in a rectangular opening in the case. With the instrument mounted on the machine (or merely held against it by hand), and the machine in operation, one or more of the reeds will respond visibly to the vibration of the machine. The speed of rotation of the shaft can be gauged to a much closer limit than the difference between the speeds indicated by adjacent vibrating reeds, usually 50 revolutions per minute. Reed tachometers are made for speeds of from 800 to 12,000 revolutions per minute. Preferably the range of any particular instrument should not exceed an octave, as if it does, and the actual speed corresponds to a reed near the lower end of the scale, both the reed located there and a reed corresponding to twice this speed will vibrate.

TACHYLYTE or **TACHYLITE,** in petrology the glassy variety of basic igneous rock as basalt or dolerite. Tachylytes are black in colour, with a pitch-like or resinous lustre, and in the thinnest sections are typically brown and translucent, the glass being crowded with granules of magnetite. They are found only under conditions which imply rapid cooling, and are much less common than the corresponding acid volcanic glasses, principally on account of the greater fluidity and greater power of crystallization which basic lavas possess. The principal mode of occurrence of tachylyte is as a chilled edge or selvage to thin dikes or sills of basalt or dolerite. This edge may be only a fraction of an inch in thickness and merges inward into crystalline basalt. Tachylytes of this nature are common among the Tertiary igneous rocks of the Western Isles of Scotland (Skye and Mull).

Exceptionally, tachylyte constitutes almost entire lava flows, as in the Hawaiian islands. The rapid cooling of the highly fluid lavas of this region has inhibited crystallization, giving rise to vast floods of basaltic glass containing only minor amounts of crystalline material. Lastly, tachylytes occur as scoria or bombs thrown out by basaltic volcanoes. These are well known at Stromboli, Etna and in Iceland. Tachylytes readily undergo weathering and alteration, and are converted by oxidation and hydration into palagonite, a red, brown or yellow cryptocrystalline material. (C. E. T.)

TACITUS, CORNELIUS (*c.* 55–120), Roman historian, lived through the reigns of the emperors Nero, Galba, Otho, Vitellius, Vespasian, Titus, Domitian, Nerva, and Trajan. All we know of his personal history is from allusions to himself in his own works, and from 11 letters addressed to him by his very intimate friend, the younger Pliny. The exact year of his birth is a matter of inference, but it may be approximately fixed near the close of the reign of Claudius. Pliny indeed, though himself born in 61 or 62, speaks of Tacitus and himself as being "much of an age" (Pliny, *Epp.* vii.20), but he must have been some years junior to his friend, who began, he tells us, his official life under Vespasian (*Hist.* i,1), no doubt as quaestor, and presumably tribune or aedile under Titus (80 or 81), at which time he must have been 25 years of age at least. Of his family and birthplace we know nothing certain; we can infer nothing from his name Cornelius, which was then very widely extended; but the fact of his early promotion seems to point to respectable antecedents, and it may be that his father was one Cornelius Tacitus, who had been a procurator in one of the divisions of Gaul, to whom allusion is made by the elder Pliny in his *Natural History* (vii.76). But it is all matter of pure conjecture, as it also is whether his "praenomen" was Publius or Gaius. The most interesting facts about him to us are that he was an eminent pleader at the Roman bar, that he was an eye-witness of the "reign of terror" during the last three years of Domitian, and that he was the son-in-law of Julius Agricola. This honourable connection, which testifies to his high moral character, may very possibly have accelerated his promotion, which he says was begun by Vespasian, augmented by Titus, and still further advanced by Domitian, under whom we find him presiding as praetor at the celebration of the secular games in 88, and a member of one of the old priestly colleges, to which good family was an almost indispensable passport. Next year, it seems, he left Rome and was absent till 93 on some provincial business, and it is possible that in these four years he may have made the acquaintance of Germany and its peoples. His father-in-law died in the year of his return to Rome. In the concluding passage of his *Life of Agricola* he tells us plainly that he witnessed the judicial murders of many of Rome's best citizens from 93 to 96, and that being himself a senator he felt almost a guilty complicity in them. With the emperor Nerva's accession his life became bright and prosperous, and so it continued through the reign of Nerva's successor, Trajan, he himself, in the opening passage of his *Agricola,* describing this as a "singularly blessed time"; but the hideous reign of terror had stamped itself ineffaceably on his soul, and when he sat down to write his *History* he could see little but the darkest side of imperialism. He was an academic republican, like many of those who perished in that reign of terror. They were innocent in many cases of plotting against the emperor's life; and, no doubt, many of the plots were imaginary. But some had been real, and Domitian was determined to take no risks. Hence academic sympathizers with republican ideals fell under suspicion and were involved in the indiscriminate slaughter of those three years.

He was apparently convinced that Tiberius had been a ruler of the same type as Domitian; and that prejudiced him against the great, but grim, successor of Augustus. Moreover, some of the memoirs, contemporary with Tiberius' reign, were not likely to depict him in a favourable light, and on those Tacitus had largely drawn. (For the value of this evidence *see* Furneaux, Tac., Ann. vol. i. p. 20 *ad fin.* For Tacitus' judgment on Tiberius see *ibid.* Introduction ch. viii.) But, apart from personal prejudice, the Romans of the upper classes who lived in Rome or resorted thither tended to dislike imperial rule both socially and politically, and did, as a fact, see so much of the worst of it that they failed to appreciate the blessings it had conferred on the world outside. To his friend, the younger Pliny, we are indebted for the little we know about his later life. He was advanced to the consulship in 97, in succession to a highly distinguished man, Verginius Rufus, on whom he delivered in the senate a funeral eulogy. In 99 he was associated with Pliny in the prosecution of a great political offender, Marius Priscus, under whom the provincials of Africa had suffered grievous wrongs. The prosecution was successful, and both Tacitus and Pliny received a special vote of thanks from the senate for their conduct of the case. It would seem that Tacitus lived to the close of Trajan's reign, as he seems (*Ann.* ii.61; iv.4) to hint at that emperor's extension of the empire by his successful Eastern campaigns from 115 to 117. Whether he outlived Trajan is a matter of conjecture. It is worth noticing that the emperor Tacitus in the 3rd century claimed descent from him and directed that ten copies of his works should be made every year and deposited in the public libraries. He also had a tomb built to his memory, which was destroyed by order of Pope Pius V. in the latter part of the 16th century.

Pliny, as we see clearly from several passages in his letters, had the highest opinion of his friend's ability and worth. He consults him about a school which he thinks of establishing at Comum (Como), his birthplace, and asks him to look out for suitable teachers and professors. And he pays (*Epp.* vii.33.) him the high compliment, "I know that your *Histories* will be immortal, and this makes me the more anxious that my name should appear in them."

The following is a list of Tacitus' remaining works, arranged in their probable chronological order, which may be approximately inferred from internal evidence:—(1) the *Dialogue on Orators,* about 76 or 77; (2) the *Life of Agricola,* 97 or 98; (3) the *Germany,* 98, published probably in 99; (4) the *Histories* (*Historiae*), completed probably by 115 or 116, the last years of Trajan's reign (he must have been at work on them for many years); (5) the *Annals,* his latest work probably, written in part perhaps along with the *Histories,* and completed subsequently to Trajan's reign, which he may very well have outlived.

The *Dialogue on Orators* discusses, in the form of a conversation which Tacitus professes to have heard (as a young man) between some eminent men at the Roman bar, the causes of the decay of eloquence under the empire. There are some interesting remarks in it on the change for the worse that had taken place in the education of Roman lads. The style of the *Dialogue* is far more Ciceronian than that of Tacitus' later work, and critics have attributed it to Quintilian; but its genuineness is now generally accepted. It is noticeable that the mannerisms of Tacitus appear to develop through his lifetime, and are most strongly marked in his latest book, the *Annals.*

The *Life of Agricola,* short as it is, has always been considered an admirable specimen of biography. The great man, with all his grace and dignity, is brought vividly before us, and the sketch we have of the history of Britain under the Romans gives a special interest to this little work.

The *Germany,* the full title of which is "Concerning the geography, the manners and customs, and the tribes of Germany," describes with many suggestive hints the general character of the German peoples and dwells particularly on their fierce and independent spirit, which the author evidently felt to be a standing menace to the empire. The geography is its weak point; much of this was no doubt gathered from vague hearsay. Tacitus dwells on the contrast between barbarian freedom and simplicity on the one hand, and the servility and degeneracy of Roman life on the other.

The *Histories*, as originally composed in 12 books, brought the history of the empire from Galba in 69 down to the close of Domitian's reign in 97. The first four books and a small fragment of the fifth, giving us a very minute account of the eventful year of revolution, 69, and the brief reigns of Galba, Otho, and Vitellius, are all that remain to us. In the fragment of the fifth book we have a curious but entirely inaccurate account of the Jewish nation, of their character, customs and religion, from a cultivated Roman's point of view, which we see at once was a strongly prejudiced one.

The *Annals*—a title for which there is no ancient authority, and which there is no reason for supposing Tacitus gave distinctively to the work—record the history of the emperors of the Julian line from Tiberius to Nero, comprising thus a period from A.D. 14 to 68. Of these, nine books have come down to us entire; of books v., xi. and xvi. we have but fragments, and the whole of the reign of Gaius (Caligula), the first six years of Claudius, and the last three years of Nero are wanting. Out of a period of 54 years we thus have the history of 40 years.

The principal mss. of Tacitus are known as the "first" and "second" Medicean—both of the 10th or 11th centuries. The first six books of the *Annals* exist nowhere but in the "first Medicean" ms., and an attempt was made in 1878 to prove that the *Annals* are a forgery, by Poggio Bracciolini, an Italian scholar of the 15th century, but their genuineness is confirmed by their agreement (*see* Introduction to vol. i., of Furneaux's edition of the *Annals* of Tacitus, Clarendon Press series, 1884) in various minute details with coins and inscriptions discovered since that period. Moreover, Ruodolphus, a monk, writing in the 9th century, shows that he is acquainted with a ms. of Tacitus containing at least the first two books. Add to this the testimony of Jerome that Tacitus wrote in 30 books the lives of the Caesars and the evidence of style, and there can be no doubt that in the *Annals* we have a genuine work of Tacitus.

Much of the history of the period described by him, especially of the earlier Caesars, must have been obscure and locked up with the emperor's private papers and memoranda. As we should expect, there was a vast amount of floating gossip, which an historian would have to sift and utilize as best he might. Tacitus, as a man of good social position, no doubt had access to the best information and must have talked matters over with the most eminent men of the day. There were several writers and chroniclers, whom he occasionally cites but not very often; there were memoirs of distinguished persons—those, for example, of the younger Agrippina, of Thrasea, and Helvidius. There were several collections of letters, like those of the younger Pliny; a number, too, of funeral orations; and the "acta senatus" and the "acta populi" or "acta diurna," the first a record of proceedings in the senate, the latter a kind of gazette or journal. Thus there were the materials for history in considerable abundance, and Tacitus was certainly a man who knew how to turn them to good account. He has given us a striking, and on the whole doubtless a true, picture of the empire in the 1st century. The rhetorical tendency which characterizes the "silver age" of Roman literature gives perhaps exaggerated expression to his undoubtedly strong sense of the badness of individual emperors, but he assuredly wrote with a high aim, and we may accept his own account of it (*Ann.* iii., 65): "I regard it as history's highest function to rescue merit from oblivion, and to hold up as a terror to base words and actions the reprobation of posterity." He is convinced of the degeneracy of the age, though it be relieved by the existence of truly noble virtues; and he connects this degeneracy more or less directly with the imperial régime. But it is difficult to dogmatize as to Tacitus' political ideals. He is primarily concerned rather with ethics than with politics; though he may feel that the world is out of joint—with whatever sentimental sympathy he may regard the age of "liberty" and admire the heroic epoch of the republic—yet he appears to realize that the empire is a practical necessity, and to the provinces even a benefit. Like the Stoics, with whom otherwise he has little in common, he censures rather individual rulers than the imperial system. But "the key to the interpretation of Tacitus," it has been well said, (Dill, *Roman Society from Nero to Marcus Aurelius*, Bk.i.ch.1.) "is to regard him as a moralist rather than a politician." Perhaps the strongest work in the *Annals* and *Histories* is the delineation of character.

Tacitus gives us no certain clue to his religious belief. His expressions of opinion about the government of the universe are difficult to reconcile with each other. There seems to have been a strange tinge of superstition about him, and he could not divest himself of some belief (*Ann.* vi. 21,22.) in astrology and revelations of the future through omens and portents, though he held these were often misunderstood and misinterpreted by charlatans and impostors. On the whole he appears to have inclined to the philosophical theory of "necessitarianism," that every man's future is fixed from his birth; but we must not fasten on him any particular theory of the world or of the universe. Sometimes he speaks as a believer in a divine overruling Providence, and we may say confidently that with the Epicurean doctrine he had no sort of sympathy.

Tacitus' style is discussed in the article LATIN LANGUAGE. Whatever judgment may be passed on it, it is certainly that of a man of genius, and cannot fail to make a deep impression on the studious reader. Tacitean brevity has become proverbial, and with this are closely allied an occasional obscurity and a rhetorical affectation which his warmest admirers must admit. He has been compared to Carlyle; and both certainly affect singularity of expression. But they are alike only in the brevity of sentences; and the brevity of Carlyle is not that of an artist in epigram. Tacitus was probably never a popular author; to be understood and appreciated he must be read again and again, or the point of some of his acutest remarks will be quite missed.

Tacitus has been many times translated, in spite of the very great difficulty of the task; the number of the versions of the whole or part is stated as 393.

Murphy's translation (we should call it a paraphrase) was for long one of the best known; it was published early in the 19th century. On this was based the so-called Oxford translation, published by Bohn in a revised edition. Messrs. Church and Brodribb's translation and Professor Ramsay's (1904) (the latter of *Annals* i.–iv.) are much better. Of the many commentaries *see* Ritter's (1864); Nipperdey's (1879); Heräus's (*Histories*, 1885); Furneaux's (*Annals*, i. vi., 1884; xi.–xvi. 1891; *Germania*, 1894); Spooner's (*Histories*, 1891). The last two editors' introductions are particularly useful. By far the best edition of the *Agricola* in English is that of Furneaux as revised by Anderson (Clarendon Press, Oxford). Of works relating to Tacitean Latinity, Draeger's *Syntax und Stil des Tacitus* is the best.
(W. J. BR.; X.)

TACITUS, MARCUS CLAUDIUS, Roman emperor from Sept. 25, A.D. 275 to April 276, was a native of Interamna (Terni) in Umbria. In the course of his long life he held various civil offices, including that of consul in 273. Six months after the assassination of Aurelian he was chosen by the senate to succeed him, and accepted by the army. During his brief reign he set on foot some domestic reforms, and sought to revive the authority of the senate, but, after a victory over the Goths in Cilicia, he succumbed to hardship and fatigue (or was slain by his own soldiers) at Tyana in Cappadocia. Tacitus, besides being a man of immense wealth (which he bequeathed to the state), had considerable literary culture, and claimed descent from the historian.

See Life by Vopiscus in *Historiae Augustae Scriptores;* also Eutropius, ix. 10; Aurelius Victor, *Caesares*, 36; Zonaras xii. 28; H. Schiller, *Geschichte der römischen Kaiserzeit*, i. 1883.

TACK: *see* NAIL.

TACNA, a province of Chile, which by the terms of the 1929 settlement of the Tacna-Arica question (*q.v.*) will be transferred to Peru. It is bounded north by Peru, east by Bolivia, south by Tarapaca and west by the Pacific. Area, 9,251sq.m. Pop. (1895) 24,160; (1920) 36,912. It belongs to the desert region of the Pacific coast. There are a few fertile spots near the mountains, where mountain streams afford irrigation and drinking water, and support small populations. None of its streams crosses the entire width of the province; they are all lost in its desert sands. The climate is hot, and earthquakes are frequent and sometimes violent. One railway in the province runs from the city of Tacna to Arica (*q.v.*), and another, constructed by the Chilean government, from Arica to La Paz, Bolivia. The province consists of two departments, Tacna and Arica, which once formed part of the Peruvian department of Moquegua. Its capital is Tacna (pop. 1895, 9,418; 1920, 14,376), a small inland town 48m. by rail from Arica, in a fertile valley among the foothills of the Andes. Existence is made possible in this oasis by a small mountain stream, also called Tacna, which supports a scanty vegetation. The town is the residence of a number of foreign merchants. (*See* also TACNA-ARICA QUESTION.)

TACNA-ARICA QUESTION. The war between Chile and Peru, begun in 1879, was terminated by a treaty of peace on Oct. 20, 1883, known as the Treaty of Ancón. Article 3 provided that the Peruvian provinces of Tacna-Arica should be held by Chile for ten years, after which a plebiscite would determine the sovereignty of those provinces. The country winning the provinces would pay to the other 10,000,000 Chilean silver pesos or Peruvian soles; a special protocol would prescribe the manner in which the plebiscite would be carried out. In 1892 negotiations were entered into between Chile and Peru for carrying out the plebiscite, but these and subsequent ones were unsuccessful. In 1922, however, at the invitation of the United States, issued at the suggestion of Chile and Peru, both Governments sent representatives to Washington and a protocol of arbitration was drawn up on July 20, 1922, which set forth that the only outstanding questions between the two countries were those relating to the unfulfilled provisions of Article 3 of the Treaty of Ancón, which should be submitted to the United States for arbitration.

Plebiscite Ordered.—In considering whether or not a plebiscite should be held the arbitrator had to determine: (1) whether the parties had acted in good faith in not coming to an agreement regarding the special protocol determining the terms of the plebiscite; (2) whether Chile's administration of the provinces had been such that a free and fair election could be held. The arbitrator decided the first question in the affirmative; and respecting the second, although far from approving the course of Chilean administration or condoning the acts committed against Peruvians, found no reason to conclude from the evidence submitted that a fair plebiscite could not be held under proper conditions.

In order appropriately to supervise and have general control over the plebiscite, the award set up a plebiscitary commission acting by majority vote, consisting of three members, one each appointed by Chile and Peru and the third, who should be president, appointed by the U.S. President. Registration and election boards were also provided. The arbitrator also reserved the right to entertain an appeal from the acts of the plebiscitary commission, which was to assemble at Arica not later than six months after the rendition of the award, and proceed at once to formulate rules for its own procedure and regulations governing the plebiscite and to fix the time and places for voting. The arbitrator provided that the 10,000,000 pesos should be paid: 1,000,000 in 10 days after the arbitrator's proclamation of the result of the plebiscite, a second 1,000,000 within the following year and 2,000,000 at the end of each of the subsequent four years. The customs revenues of Arica were assigned as security. The arbitrator decided that the Peruvian provinces of Tacna-Arica as on Oct. 20, 1883, constituted exclusively the territory in dispute, and that no part of the Peruvian province of Tarata was included therein. Tarata was transferred by Chile to Peru on Sept. 1, 1925, the definite boundary being left for a boundary commission.

Objections of Peru.—On April 2, Peru objected to the finding of the arbitrator for a plebiscite, maintaining that the meaning of the Spanish text of the Treaty of Ancón was "upon," "at" or "immediately after" the expiration of the ten years. Peru also requested guarantees for the voting, including immediate evacuation of the territory by the Chilean civil and military authorities and their replacement by Americans. The arbitrator replied on April 9, pointing out the agreed finality of the award and that the translation complained of was the one submitted by Peru. The problem before him was one of substance, of construction rather than of translation, a problem which had been debated by the parties long before the arbitration gave rise to any question of English translation. As to Americans taking over control of the provinces, the arbitrator found that this request went beyond the scope of his authority.

Meeting of Commission.—The plebiscitary commission met at Arica on Aug. 4, 1925, and drew up its rules of procedure. On Dec. 16, Chile appealed to the arbitrator from a resolution of the commission making the date of the plebiscite, she thought, conditional upon Chile complying with certain regulations of the commission. Chile took the position that by these regulations the commission exceeded its power and infringed upon her administrative control of the provinces and that the commission's control over the plebiscite began only with the registration of voters. Chile later withdrew the appeal regarding dates, and the arbitrator, in a decision dated Jan. 15, 1926, permitted its withdrawal. He pointed out at the same time that the submission agreed that the arbitrator should determine conditions of the plebiscite; that he had established a plebiscitary commission whose requirements had the same binding effect as if prescribed by him; and that conditions for holding a fair plebiscite became the concern of the commission from its organization.

The arbitrator held that while the territory remained in Chile's possession and subject to Chilean laws and authority pending the plebiscite, the possession and administrative authority were subject to the provision for holding the plebiscite, the award having stated that the exercise by Chile of legislative, executive and judicial power should not go to the extent of frustrating the provision for a plebiscite. The execution of the requirements of the plebiscitary commission was, therefore, but the exercise by both parties of their jurisdiction respectively in accordance with their agreement, and was not in derogation of the administrative authority of Chile.

On Feb. 16, 1926, the American Government proffered its good offices to Chile and Peru in an endeavour to adjust the differences, on the understanding that pending such an adjustment the authority of the plebiscitary commission should be maintained unimpaired. The American offer was accepted by Chile on Feb. 19, with the proviso that the arbitral award must be submitted for approval to the respective constitutional bodies. Peru was unable to accept the offer, and on March 11, the American ambassador at Santiago submitted a further memorandum to the Chilean Government explaining his Government's interpretation of the term "good offices." Chile reiterated her acceptance of the offer, and Peru having accepted, the secretary of State, through the American ambassador, on March 25, suggested that the plebiscitary proceedings should be temporarily suspended.

Chile and Peru appointed plenipotentiaries who met with the secretary of State on April 6. The secretary made proposals for the division of the territory between Chile and Peru, for the neutralization of the provinces, for the transfer of the provinces to a third party and finally a proposal for a corridor to the sea for Bolivia, the territory to the north thereof to go to Peru, to the south thereof to Chile, equitable compensation being made for improvements, etc. None of these proposals was accepted by both parties. The last proposal was accepted by Peru, but Chile desired something more definite, namely, the defining of the boundaries of the corridor, and made a proposal setting forth the limits of the corridor. This last proposal was rejected by Peru.

In the meantime conditions in the provinces had not been improved and the plebiscitary commission, being pressed by the Chilean member to fix the date for the elections, voted a resolution on June 14 declaring that Chile having failed in its obligation to create and maintain conditions proper and necessary for the holding of a free and fair plebiscite, the commission found that this failure had frustrated the efforts of the commission to hold the plebiscite as contemplated by the award and had rendered its task impracticable of accomplishment. The commission therefore decided that a free and fair plebiscite as required by the award was impracticable of accomplishment and that the plebiscitary proceedings be terminated. The commission thereupon closed up its work.

Intimations received during the summer of 1926 from both Chile and Peru led the secretary of State to make a final proposal of settlement on Nov. 30, 1926. His suggestion that the territory in dispute be given to Bolivia was not accepted, however, and, all types of possible solutions having been proposed and rejected, no further suggestions for a settlement were made. However, relations between the two countries gradually became more satisfactory, especially after the Sixth International Conference of American States at Havana, in January and February 1928, and the secretary of State on July 9, 1928, suggested to both Governments the re-establishment of diplomatic relations as "a favourable means for facilitating the definite removal of all existing misunderstandings and hence lead to permanent readjustment of the relations between the two countries mutually satisfactory to both." This suggestion was received favourably by both Governments and diplomatic relations were re-established on Oct. 3, when the Chilean ambassador presented his letters of credence to the President of Peru. The Peruvian ambassador presented his letters of credence to the President of Chile two days later.

Negotiations for a settlement were entered into and continued until May 14 when the President of the United States, not as arbitrator but in the exercise of good offices at the request of the parties, submitted to the American ambassadors at Lima and Santiago a proposal as the final bases of a solution. This provided that the territory should be divided, Tacna to Peru, and Arica to Chile; the dividing line to start at a point on the sea coast to be called "Concordia," ten kilometres to the north of the bridge over the River Lluta and to continue parallel to the Arica-La Paz Railroad following the topographic features. The sulphur deposits of Tacora remain in Chilean territory and the Uchusuma and Mauri canals remain the property of Peru. In case of disagreement, a third person designated by the President of the United States shall render the final decision. Chile will construct for Peru at Chile's expense within the Bay of Arica a wharf, customhouse and station for the railway from Tacna to Arica, Peru to enjoy all the privileges of a free port. Chile is to deliver to Peru the sum of six million dollars and also to deliver, without cost to Peru, all public works already constructed and all Government owned real property in the Department of Tacna. Chile is to maintain in the Department of Arica the franchise granted by Peru in 1852 to the Arica-Tacna Railroad Company and to deliver the Department of Tacna thirty days after the exchange of ratifications. Private property legally acquired in the territory under their respective sovereignties is to be respected by both Governments. A monument commemorating the consolidation of their friendly relations will be erected by the two Governments on the Morro de Arica. The children of Peruvian nationals born in Arica will be considered Peruvians until the age of twenty-one years, at which time they may elect their definitive nationality; Chileans born in Tacna will enjoy the same right. Both Governments agree to release the other from any obligation or indebtedness between them whether derived from the Treaty of Ancón or not.

In presenting this proposal to the two Governments, the American ambassadors at Lima and Santiago stated that the proposal was not to be interpreted as indicating that either the President or Government of the United States expressed any opinion or made any suggestion whatever regarding any future disposition by either party of that portion of the territory in dispute which would be in its possession should the proposal be accepted by the two Governments. Chile accepted on May 15, 1929, and Peru on May 16, 1929. It came into effect on Aug. 28, 1929. (F. We.)

TACOMA, a city of Washington, U.S.A., on Commencement bay, one of the arms of Puget sound, 30 m. by water south of Seattle and 151 nautical miles from the Pacific ocean; a port of entry and the county seat of Pierce county. It is on Federal highway 99 and the Pacific coast air-mail route, and is served by the Chicago, Milwaukee, St. Paul and Pacific, the Great Northern, the Northern Pacific and the Union Pacific railways, by interurban trolley and motor-stage lines, and by over 60 steamship lines, with sailings to the Orient, South America, Australia and Europe, and to Atlantic and Pacific ports of the United States. The population was 96,965 in 1920 (113·7 males to 100 females), of whom 21,705 were foreign-born, including 1,067 Japanese; and was estimated locally at 125,000 in 1928.

The fine natural harbour is 4·5 m. wide at its entrance between Point Brown and Point Defiance and about 2·5 m. long. There is no bar or other natural obstruction at the entrance, and the waters are deep throughout the entire extent. The climate is equable, and the precipitation moderate, about ⅗ of the rain falling in the four months November to February. From the tidelands the city rises gradually to a plateau 300 ft. high. The area (including 8·33 sq.m. annexed in 1927) is 51·26 sq.m., of which 4·91 sq.m. is water. The Olympic Mts. are visible to the west, and Mount Rainier (or Tacoma; 14,408 ft. high), in Rainier National park, 56 m. S.E., seems to stand at the city's doorway. Near by are four freshwater lakes, surrounded by evergreen forests. The city's parks cover 1,114 ac., including 640 ac. on Point Defiance. In the heart of the city is an outdoor stadium seating 40,000 spectators, and commanding an unobstructed view of the bay. Near it is the State historical building and the Ferry museum, containing a collection of Indian relics. In the north end of the city is the 40 ac. campus of the College of Puget Sound (Methodist; 1903). A zoning ordinance has been in effect since 1919, and an active programme of city-planning was undertaken in 1920. The assessed valuation of property for 1927 was $65,726,619. The city's water-supply and distributing system represents an investment of $7,602,888, and it has invested $13,183,872 in power-generating and distributing equipment, including hydro-electric plants near the base of Mount Rainier and in the foot-hills of the Olympics. By 1928 nearly 100,000 h.p. was developed, and under municipal ownership and operation (entered upon in 1893) rates for power had been reduced until they were the lowest in the country. Two of the transcontinental railroads have extensive terminals on the waterfront, and other wharves have been constructed by industrial concerns. The physical development of the harbour by the public and the administration of facilities owned by the Port of Tacoma District (a municipal corporation conterminous with Pierce county) are under the jurisdiction of a port commission. The piers owned by the municipality cover 280 acres. A municipal belt-line railway connects the railroads and the industrial district with the port. The traffic of the port in 1927 amounted to 4,751,162 tons, valued at $153,557,348, of which $49,299,590 represented exports to foreign countries, $18,899,029 imports and $85,358,729 domestic commerce with Alaska, Hawaii, California, the Atlantic Coast and the Gulf and local ports.

Manufactures.—The 600 manufacturing establishments of the city in 1927 had an output valued at $114,342,978 and a working force equivalent to 15% of the total population. The Tacoma Smelter (established in 1889 as a lead smelter, but handling chiefly copper since the opening of the copper mines in Alaska) receives 36,000 tons of ore annually, including some consignments from Europe, and ships 9,000 tons of refined copper, 250,000 lb. of arsenic and 550,000 oz. of gold and silver. Two of the transcontinental railways have repair and construction shops here, employing over 3,000 men. The annual output of the flour and cereal mills is valued at $18,000,000. The largest group of industries is that which manufactures lumber and lumber products, its output amounting to over $36,000,000 in a year. The annual lumber cut of the Tacoma district is 1,500,000,000 ft., and the city makes more fir doors, fir veneers, panels and wooden columns than any other city in the country.

History.—Tacoma harbour was visited by Capt. George Vancouver in 1792, and 30 years later the Hudson Bay Company established a trading-post at Nisqually. Commencement bay was surveyed for the United States in 1841 by Lieut. Charles Wilkes. Settlement began in 1852, when Nicholas Delin, a Swede, took a claim on the south shore of the bay and set up a small saw-mill, from which in 1853 he shipped lumber to San Francisco. In 1855 the settlers were frightened away by the opening of the Indian war, taking refuge in Ft. Steilacoom (12 m. S.W.) which had been built in 1849; but in 1864 Job Carr and his two sons, from Indiana, took claims on the west shore of the bay. Development of a city dates from the arrival from Portland in 1868 of Gen. Morton Matthew McCarver. He induced settlers to come; persuaded two of them to erect a saw-mill; and planned a town site, confident that a transcontinental railway would soon reach Puget sound. The first name he chose for the town was Commencement City, but this was soon dropped for the Indian word meaning a snow-covered mountain. In 1873 the Northern Pacific established its terminal on Commencement bay and named it New Tacoma. A town was organized in 1874, becoming the county seat in 1880, and in 1883 the two settlements were consolidated and incorporated as the city of Tacoma. In 1880 the population was 1,098; in 1887, when the railroad was completed across the Cascades, it had grown to about 5,000. A boom immediately set in, attracting land speculators from all parts of the country, and three years later (1890) the population was 36,006. There was little increase in the next decade, but between 1900 and 1910 the population grew from 37,714 to 83,743, and the total increase of the 20 years 1900 to 1920 was 157%. In the first quarter of the 20th century the assessed valuation of property increased (roughly) threefold; postal receipts were multiplied by nearly 9; and the value of the foreign commerce by 5.

TACTICAL FORMATIONS. The line and the column are the two elementary tactical formations, their corollaries being the skirmishing line and the square. All other formations spring from these, and the smallest unit which can evolve them is one of four men and a leader. In practice, however, it has been found necessary to double the number of men so that they may work in pairs when an open square formation is required.

Line.—Organized warfare begins with the line, that is a row of men in shoulder to shoulder formation, cemented into a unit through mutual protection, co-ordinated movement and combined offensive power. The strength of a line of men depends on maintaining an unbroken front, consequently its power of resistance can be increased by deepening it by ranks, that is by placing line behind line so that should any of the front rank become casualties their places may be filled by the men in rear of them who, until called upon to fight, are in reserve. Whilst in ancient times the ranks were close together, because fighting was carried out with shock weapons, in modern times the distances between the ranks of the line have been greatly enlarged. The weak points in the line are its two flanks and particularly its rear. If held in front, the rear of a line can offer little resistance, and if the line is attacked in flank the number of fighters is so small when compared to the attackers that the front is generally rolled up.

Column.—The column is mainly a logistical formation, its simplest form being that of single, or Indian file. Its underlying idea is that of "follow my leader," for wherever the column leader goes all the men have to do is to follow him. A column is not an offensive formation but a mobile one, a reservoir of offensive power which only becomes dynamic when deployed into line. It is a misnomer to suppose that a charging column gains strength if its numbers are increased. This is not so, because its offensive power is concentrated in its front rank; but its depth gives it moral support, and above all provides reserves immediately at hand to take advantage of a break through. The Grecian phalanx was a formation of single file columns, eight deep, marshalled in close order, and it is interesting to note that a return to this formation was made by most armies during the World War of 1914–18, but with this difference, that the single files, each a section of 6 to 8 men, were spaced at considerable intervals, the whole front being covered by bullets in place of pikes.

Skirmishing Line.—A skirmishing line is a line in open order, and is generally formed by deploying men in pairs at fixed intervals between each pair. It is a more flexible formation than the line, and better suited to individual fighting and the development of missile fire; its power of resistance, save in broken country, is however slight. The skirmishing line is probably the oldest of all formations, it is also the most modern, because solid lines of men can no longer operate on the battlefield. The skirmishing line to-day is one composed of sections of men rather than of individuals, or pairs, which advance in single file and extend into skirmishing order.

Square.—The square is essentially a protective formation as it has four potential fronts, and so can guard itself on all sides. Solid squares of men were frequently used in classical warfare, and were the normal formation during the 16th century. Rallying squares formed by hastily grouping men together were mainly used to meet cavalry. In modern times the hollow square, such as used by the British in the Napoleonic wars and the Egyptian campaigns, was a common protective formation; and to-day a column secured by advanced, rear and flank guards is nothing more than an elastic, or open, square with a central reserve. The future of the square formation is likely to be considerable, seeing that in mechanized warfare fronts may be anywhere. *See* also TACTICS. (J. F. C. F.)

TACTICS. The art of war differs from the science of war as action differs from theory. The second discovers the principles upon which the art of waging war is founded, and the first applies these principles according to conditions by means of the instrument of war—the forces employed to impose the will of one antagonist upon the other, whether this will is the will of an organized Government, or of a single man. Of all instruments of war man himself is the archetype, he is his own general, his own intelligence service, and he possesses power to move, guard and hit. From these natural powers are developed five essential tactical functions, namely, command, reconnaissance, security, mobility and offensive action; or planning, finding, protecting, manoeuvring and actual fighting. It is by the last of these that a commander finally imposes his will on his enemy through fear of destruction. These functions when combined may be divided under the headings of strategy and tactics; but in practice these two parts cannot be so easily separated, since strategy is the art of protected movement from which tactics, the art of protected offensive action, is developed. Whilst the one places an army in the best position to overcome its enemy's resistance, the other has for its object the economical development of pressure, so that movement in the desired direction may be maintained. Consequently it will be seen that whilst strategy aims at developing tactics, in its turn the aim of tactics is the development, or completion, of a strategical movement. In brief, the primary tactical function of battle is to generate mobility (strategy) through protected offensive action (battle).

The Decisive Point.—At once the question arises: Is it possible to lay down definitely the direction in which movement should be made? That is, can a commander off-hand decide on the decisive point of attack, that point which if struck in force will lead to the most economical destruction of the enemy's fighting power? The answer is "yes," for logically and historically it may be proved that the back of a man, or the rear of an army, is the decisive point to attack; that is, the point at which an enemy if struck can develop the least resistance and pressure, that is, where he is least well protected and least able to hit out. The validity of this statement can be readily proved by examining the organization of an army.

A modern army consists of three main tactical forces, namely, a reconnaissance force (cavalry), a protecting force (artillery), and an attacking force (infantry), these three forming the fighting body. Behind this body is situated the brain and internal organs, namely, the command, and the services of supply, maintenance, repair and evacuation. The body has power to hit and to guard, but of itself it possesses no power to co-ordinate its movements, or to supply itself and simultaneously maintain its tactical organization. Consequently, if it is deprived of its command, it is paralysed, and if deprived of its supplies, starved into surrender, or compelled to disperse. As neither the command nor the services possess power of exerting pressure or resistance physically, they form the decisive point of attack and defence. It follows, therefore, that whatever system of attack is adopted, whether it be a frontal attack, a flank attack or a rear attack, the object of both sides is to destroy the power of command of the opposing side, either directly through an attack on this command, or indirectly by an attack on the body, or stomach, which it controls.

Offensive and Defensive Action.—To attack presupposes offensive action, and this in its turn introduces defensive action, either to protect the attack or resist it. When the art of war is of a high order, the offensive and the defensive are so interwoven as to be inseparable, but as this degree of perfection has throughout military history been the exception rather than the rule, these two modes of fighting may be considered separately. The passive defence, that is a defensive which does not include mobile offensive action, has been justly condemned, yet it must be remembered that when in the form of purely defensive bodies of troops, or of fortresses, or fortified positions, it has been combined with mobile forces, it has more often than not proved itself a necessary operation. The active defence, that is the occupation of a position with a view to persuade an enemy to attack it, and then, when he has exhausted himself, counter-attack from it, has played as important a part in war as the offensive itself. The adoption of such an attitude depends entirely on circumstances, and each case must be judged on its own merits. Generally speaking, the active defence carries with it advantages of time, place and terrain, but for the moment it resigns the initiative by seldom being able to restrict the strategic mobility of the attacker.

Anatomy of the Attack.—Turning now to the attack itself, in all such operations, and more particularly so in modern times, may be discovered a definite tactical anatomy. First there is the act of approach, culminating in contact, which links strategy to tactics. Next there is the attack proper, and lastly the pursuit, or act of annihilation, which is virtually a new attack, and which should when possible be carried out by a fresh body of troops. The attack may be divided into three acts, or stages. First it is necessary to deprive the enemy of freedom of action; this is effected by deceiving him and surprising him, an attack on the mind of his command. By distracting and frightening him, an attack on his *moral*. And, finally, by compelling him to alter his dispositions, improvise new distributions, and force him to assume a defensive attitude, in other words to protect himself rather than hit out. It is difficult to find a word which embraces the idea of all these actions; possibly "distraction" is the best, which literally means "to pull asunder," to perplex the enemy's mind, to harass his *moral*, and to confound his organization. This distraction, or the upsetting of the enemy's mental, moral and physical equilibrium creates an opportunity for a decisive thrust, a dislocation of the enemy's plan which throughout history has commonly been achieved by a manoeuvre against the enemy's rear, or, failing his rear, one, or both, of his flanks. The result of this dislocation is that the enemy is compelled to make a complete "change of front" in plan and in distribution, so complete that frequently being forced to fight in two directions simultaneously he is deprived of all power to concentrate his forces. Thus unhinged, and reduced to a state of mental bewilderment, moral paralysis and physical disorganization, he offers himself an easy target to the knock-out blow which entirely disrupts his army, reducing it to a mob to be annihilated by the pursuit. Thus the attack may be divided into three acts, namely, distraction, dislocation and disruption, the one paving the way for the next and melting into it until the enemy's destruction is complete.

Tactical Elements.—Throughout history two main types of weapons have been used in attack and defence, namely, missile weapons and shock weapons. Frequently the first have gained supremacy in defensive actions when used by foot soldiers, and in offensive actions when used by mounted men. The second throughout the greater part of military history have *par excellence* constituted the weapon of the attack. So much so has this been the case that until quite recently it may be said that the tactical object of missile weapons has been to assist, or restrict, the movement forward of the *arme blanche*. Similarly, there have been two types of protection, and two types of movement, namely, direct protection by body armour, earth-works or terrain, and indirect protection by formation, invisibility and fire-power. Movement has been of two degrees—by foot and by horse. There have been also two main attack formations, the column and the line. The second is essential for the full development of missile weapons, and the first for what conventionally is called shock tactics. By this it must not be understood that weight of numbers endows a column with breaking power. In war there never is any shock of this description, for, as Commandant Colin says: *"an impulse never comes from the rear."* What depth does endow a column with is manoeuvrability, moral superiority, and above all, reserves at hand once the enemy's front has been shot, or hacked, through. In fact the column is a concentrated line in movement.

The simplest form of attack is one line or column meeting another line or column head on, this is known as the parallel order of battle. Generally speaking, as military history clearly shows, this order, the frontal fight, does not lead to a solution unless one side preponderates numerically, when the frontal attack of the stronger side develops into an overlapping attack, that is an attack which meeting with little or no resistance outflanks its opponent's front. In this attack of mobile wings pivoted on a stable centre, which is holding the enemy, may be discovered the germ of all tactical development down to the present day. We will now trace the above theories throughout the recorded history of war.

THE ARCHAIC PERIOD

Leadership and the Phalanx.—The primitive tactics of the archaic period of war are not a thing of the past, for they may be witnessed daily in brawls, riots, individual contests and mob fighting. They are brutal and cowardly, yet they form the nursery of individual courage and cunning, and from the earliest days onwards these two human qualities have stood in direct antagonism. Even to-day the highest military rewards are given for bravery and not for intelligence, and still the introduction of any novel weapon which detracts from individual prowess is met by opposition. Mob-fighting, whether on horse or foot, goes back to pre-cultural times; yet even then the idea of a leader must have existed, and it may be said that true military operations only began to take form when once a leader attained over his followers sufficient authority to order them out to fight or witness a fight, in place of merely assuming leadership during a haphazard brawl. When this control was established, the true battle, as Homer often describes it, was waged between the leaders themselves, their followers frequently being mere audiences to cheer on their respective champions and villify those of their enemy. If the followers engaged, and the tribal weapons were the spear and shield, it must soon have been obvious that the side which could first form a wall of men normally won. This wall is the beginning of the phalanx as known throughout Greece and depicted on the monuments of ancient Assyria and Egypt. The phalangites constituted the village, or city, militia. Their drill consisted in the "fall in" in lines, or ranks, and their tactics in forward or backward movement accompanied by push of pikes. The phalanx possessed little or no power to attack the simplest defences, consequently if the enemy refused to abandon his city wall, or come out of his village, the only method whereby he could be brought to book was to attack him economically, that is to destroy his crops. This was the normal system of war in ancient Greece.

The Oriental Battle.—During this early period, strategy may be considered as purely one dimensional. There was little idea of manoeuvre. Armies set out with one thought, namely, to meet each other on some plain, or in some valley, and fight it out. There they extended into parallel lines, and the one with the greatest front normally won, because its wings meeting with no opposition were able to overlap its less extended adversary. As these wings had to move the furthest, when cavalry was employed, as in Persia, they were placed on the flanks of the infantry, and in front of this line frequently swarmed archers and slingers. The infantry were massed in solid squares from 30 to 100 ranks deep, and if chariots were used they were drawn up in front of the foot soldiers, or in the intervals between them. When once the line of battle was ready, the light infantry cleared the front, the chariots charged the enemy to demoralize him, the infantry following them up to gain a decision. Meanwhile the cavalry attempted to sweep round the enemy's flanks, not so much to attack its adversary's rear as to pillage his baggage wagons. Given equal discipline and armament, and remembering that the infantry battle line was rigid and could not manoeuvre, these tactics leave little to be desired. Military superiority was based on numbers; which side could wash round, rather than manoeuvre round, the flanks of the other, this was the tactical problem. To hold men in reserve was futile, because this would have meant a shortening of the front of attack, and to manoeuvre squares of some 10,000 men standing on a 200yd. frontage was not possible with the drill of this period.

THE CLASSICAL AGE

Marathon and Plataea.—Though Aristides names Palamedes as the inventor of tactics, Nestor appears to have been the only general during the Homeric period who possessed tactical insight. He grouped the Greek army according to families to inculcate a spirit of rivalry, and divided it into a right, centre and left, placing his bravest warriors in the rear rank. From the Trojan War (1193–1184 B.C.) on to the first Messenian War (743–723 B.C.) no further innovation seems to have taken place, but in this war we find Euphaës, the Messenian general, handsomely beating the Spartans by a well-executed rear attack carried out by his cavalry. In spite of this admirable manoeuvre, one long known in the East but seldom well executed, the Spartans learnt nothing, the tactics of Euphaës on the field of Amphaea (730 B.C.) remained a sealed book to them, and no further progress was made in tactics until Miltiades, either intentionally or accidentally, won the battle of Marathon (*q.v.*) in 490 B.C., by a double development. Resting his wings on two small streams which prevented the Persians outflanking him, he made his centre weak and his wings strong with the result that when his centre was driven back his wings clinched inwards and took the Persians in flank. At the battle of Plataea (*q.v.*), fought in 479 B.C., though the Persians under Mardonius were taught a costly lesson when their cavalry attempted to charge unbroken infantry on the slope of a hill, the Greeks were taught an equally severe one when they believed that they could meet cavalry on any ground. The result was that it was only after this third invasion of the Persians that the Greeks, little by little, began to realize the importance of the mounted arm.

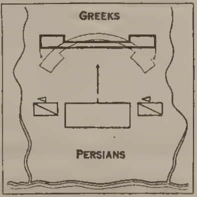


FIG. 1.—BATTLE OF MARATHON (490 B.C.), SHOWING TACTICS OF CONCENTRIC ATTACK

The Peloponnesian War.—The Peloponnesian War (431–404 B.C.) though it produced no general of the first order, shows a distinct advance in tactical knowledge. The sieges of Plataea (429 B.C.) and of Syracuse (415 B.C.) are a definite step forward in these operations. At the battle of Olpae in 426 B.C. Demosthenes, in command of the allies, defeated a superior Spartan army by a well-planned rear attack. Placing an ambush of 400 light troops behind the Spartan left wing he allowed his enemy to wash round both his flanks, whereupon the ambush fell upon the rear of the enemy's left wing, and put the whole army to flight. In his turn Brasidas, a Spartan, possessing none of the narrowness of his countrymen, by his rapid marches and sudden attacks, such as at Amphipolis (424 B.C.) showed that the value of mobility and surprise was fully realized by him. The main tactical lesson of this long war was the necessity for a well-trained light infantry for manoeuvre, seeing that cavalry were hard to come by in Greece. This, in the 4th century B.C. led to the reforms of Iphicrates. Hoplites were not only expensive to equip but immobile on any but unbroken ground, so Iphicrates lightened their equipment and produced a body of men known as peltasts, with whom he seriously injured the allies of the Lacedaemonians in the Corinthian War, and in 392 B.C. annihilated a Spartan Mora of 600 men.

The Development of the Oblique Order.—An interesting period in tactics is now entered, and one of rapid growth following on the footsteps of rapidly expanding culture. For centuries past there had been a tendency for the front of an attacking phalanx to drift towards its right, the reason being as Thucydides writes: "Because fear makes each man do his best to shelter his unarmed side with the shield of the man next on his right." This drift brought the right wings first in contact with their enemy, the left wings being somewhat refused; thus the parallel order tended towards an oblique order of attack. The tactical meaning of this drift seems to have been fully grasped by the Theban general Epameinondas. At the battle of Leuctra (*q.v.*) in 371 B.C. at the head of 6,000 to 8,000 men he met 11,000 Lacedaemonians under Cleombrotus. He changed the normal centre of gravity of the attack from right to left and so surprised his enemy and simultaneously reduced the chance of his right being defeated. He drew up his battle line, probably eight deep, and on its left marshalled a column of 1,500 men 48 deep. To secure the outer flank of this column he placed there the Theban Sacred Band, and in front of his left he drew up his cavalry squadrons. Ordering his right to move slowly and his left rapidly forward, he refused the Spartan left and destroyed the Spartan right; then he wheeled his column inwards, and took the whole of his enemy's army in enfilade, winning a battle of mind against some of the toughest muscle which ever took the field. Nine years later at Mantineia (*q.v.*) he repeated these tactics with signal success, but his death on the field robbed his victory of decisive results.

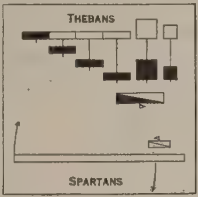


FIG. 2.—BATTLE OF LEUCTRA (371 B.C.), SHOWING TACTICS OF THE OBLIQUE ORDER

Philip of Macedon.—Let us briefly recapitulate the tactical possibilities thus far evolved, for we are about to enter a period when one man, Philip of Macedon, shook them together, creating perhaps the most perfect tactical instrument ever devised in the history of war. The following lessons had been learnt. The front of a phalanx of pikemen was inviolable on flat and unobstructed country, consequently the parallel order was obsolete. Its flanks were very vulnerable, consequently the oblique order of Epameinondas offered the best method of attacking heavy infantry with their like. For broken ground, mountain warfare and flank protection, light infantry were essential, and for rapidly outflanking an enemy and attacking him in rear cavalry were the decisive arm. The Persian Wars had taught the Greeks the danger of pitting heavy infantry against cavalry in cavalry country, and the danger of pitting cavalry against light infantry in light infantry country. Xenophon who was present at the battle of Cunaxa (*q.v.*) in 401 B.C. and in virtual command of the 10,000 during their famous retreat, produced in his Anabasis and his Cyropaedia the first great treatise on the art of war. All these things suddenly impinge on the fertile mind of Philip (382–336 B.C.). Out of them he constructed the perfect instrument—the army of Alexander.

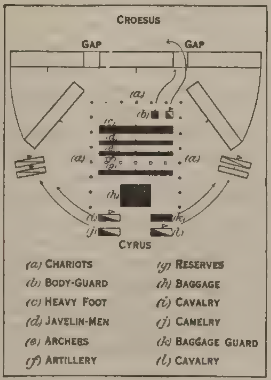


FIG. 3.—XENOPHON'S IDEA OF THE BATTLE OF THYMBRA (554 B.C.), SHOWING TACTICS OF EX-CENTRIC ATTACK

Whether consciously or not, it is not possible to say, he took as his tactical model the body of man and devised his organization accordingly. First he re-armed the phalanx with a longer pike, the Sarissa, and established it as the trunk or stable base of his army; it was in fact a mobile fortress the front of which defied attack. Having created this defensive base of operations he hinged on to it two arms, the left protective, to ward off blows, and the right offensive to deliver them. Both these arms were composed of cavalry, heavy and light, the right wing being in quality and quantity the stronger. To maintain the maximum flexibility he inserted between these cavalry wings and the phalanx two joints, or bodies, of light infantry, the Hypaspists on the right and the Thracian Javelin-men on the left. On the outer flank of the right wing cavalry he placed a strong body of light infantry and archers. Finally he organized a staff, a mobile artillery train, a body of engineers for siege work, and definitely established unity of command in the Macedonian army.

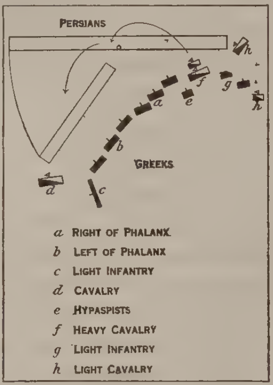


FIG. 4.—BATTLE OF GAUGAMELA, (331 B.C.), SHOWING TACTICS OF REAR ATTACK

Alexander the Great.—The perfection of this organization, probably the most efficient ever devised to meet the tactical conditions of its day, was fully proved in the campaigns of his son, Alexander the Great, who never lost a battle or a campaign, who invariably defeated his enemy on the plains, in the deserts and in the hills; who was never stopped by a mountain range or a river, and who reduced every fortress he laid siege to. In his four great battles against the Persians and Indians, namely, Granicus (*q.v.*) in 334 B.C., Issus (*q.v.*) in 333 B.C., Gaugamela (*q.v.*) in 331 B.C. and Hydaspes (*q.v.*) in 327 B.C., though his grand tactics vary, his minor tactics uniformly are based on the cavalry charge, and spring fully armed and armoured from Philip's superb organization, their one aim being to develop mobility through protected offensive action. They may be described as follows.

The tactical idea was to attack the enemy's command, the decisive point which, in the Persian army, was normally in the centre of the front rank. The method was an attack by cavalry which would roll up or penetrate the enemy's left wing, and so permit of the Persian command being attacked in rear. The pivot of the whole operation was the phalanx, which moved forward towards the enemy's left in echelon with its right leading, the cavalry wings doing likewise. The left being refused enticed the enemy, especially his cavalry, to attack it. The object of the left wing was to draw the enemy towards it; it was consequently only sufficiently strong to hold its own. Its right was protected by the impenetrable phalanx to which it was hinged by the Thracian light infantry. As the left wing swung back, the right wing, hinged to the phalanx by the Hypaspists, swung forward. The light cavalry fixed the enemy's left wing, and the heavy cavalry forming the apex of an arrow formation (the phalanx in echelon on its left, right leading, and the light infantry in echelon on its right, left leading) struck the enemy a terrific blow, pierced him, wheeled round, charged the enemy's command, and then took the enemy's right wing which was opposed to the Macedonian phalanx, or driving back Alexander's left wing, in reverse. Once destroyed an immediate pursuit followed. Such in brief were the tactics applied by Alexander.

The Decline of Greek Tactics.—The tactics employed by the Diadochi, his successors, were of a high order, for in spite of the fact that, during the last few years of Alexander's reign, the Macedonian army had become partially Orientalized, this though it detrimentally influenced its *morale* had actually enhanced its tactics by increasing its fire power. Archers were more extensively used, especially horse archers, and this brought siege and field artillery, in the shape of catapults and balistae more and more into use, especially under Demetrius Poliorcetes, the son of Antigonus.

In spite of inventions, tactical organization deteriorated and strategy advanced. Walled towns had now lost much of their defensive power, and the numerous combatants, all depending upon mercenary soldiers, made alliances and military combinations necessary. Command now took a more modern form, the commanders-in-chief—Antigonus, Seleucus, Ptolomy, etc., frequently planning the strategy of a campaign, and handing over tactical control to a hired subordinate. *Morale* steadily decreased as it must in ill-paid mercenary armies, and battles were frequently won by buying over the enemy's troops on the field itself. Though it is not possible to prove it, lack of trust in the cavalry and infantry compelled commanders more and more to rely on war elephants and artillery. Whatever was the cause, both came into general use, and by the time of Philopoemen battle fronts were sometimes covered by a veritable bombardment of bolts, arrows and balls, fired from catapults and balistae, as for instance at the third battle of Mantineia (*q.v.*) in 207 B.C. Yet the deterioration of tactics was progressive, and by the dates of the battles of Cynocephalae (*q.v.*) in 197 B.C. and Pydna (*q.v.*) in 168 B.C. they had so far retrogressed that the phalanx of Philip and that of Perseus had returned to the Spartan model, a wall of pikes with vulnerable flanks incapable of manoeuvring over broken ground. The exquisite combination and co-operation of arms which distinguished Philip of Macedon's army had been utterly forgotten.

The Early Legion.—The early Roman legion was very similar in organization to the Spartan phalanx. It was a city militia consisting originally of some 3,000 *milites*, or foot soldiers, and 300 *equites* who were not so much cavalry as well-to-do mounted infantry. To it were added a number of *velites*, or untrained light infantry. Its tactical formation was phalangial. Though this army was well suited to battles of push of pikes on the plains, it was ill suited to mountain warfare. The disaster suffered at the Caudine Forks (321 B.C.), and the long drawn out Samnite wars (343–290 B.C.) appear to have compelled the Romans to give up the purely linear formation of the phalanx, and substitute for it a more flexible one. The legion was divided into 30 maniples placed chequerwise in three lines—*hastati, principes* and *triarii*. The third line was composed of veteran troops held in reserve.

To compare the legion at its prime, that is after the 2nd Punic War, with the phalanx in its decadence, or even with the phalanx under Pyrrhus (280–275 B.C.), is absurd. Though Pyrrhus was an able general he depended more on the use of elephants than on organization. Philip of Macedon's model had by his day altogether deteriorated, and by the date of the 2nd and 3rd Macedonian Wars (200–194 and 176–168 B.C.), the Macedonian army had thrown back to the old Spartan model, yet it is interesting to note that both at Cynocephalae and Pydna it was a rear attack which decided the day in favour of the legion.

The 2nd Punic War.—When Hannibal invaded Italy in 218 B.C. the Roman legionaries were little more than a raw militia; yet, when he was defeated at Zama (*q.v.*) in 202 B.C., they were veterans ready to conquer the world. Sixteen years of incessant warfare had taught them, under such leaders as Claudius Nero, Marcus Livius and Scipio Africanus, how to wage war, but curiously enough it never taught them Hannibal's open secret (also Philip of Macedon's and Alexander's), namely, that cavalry is the decisive arm. It is true that Scipio Africanus realized this, and by launching Massinissa's Numidian horsemen on the rear of Hannibal's troops, won Zama, but throughout Roman history cavalry was seldom their decisive arm, they mainly depended on infantry, and increased the rapidity of their movements by a wonderful network of roads. This is clearly shown years later at Carrhae (*q.v.*) in 53 B.C. and Pharsalus (*q.v.*) in 48 B.C. In the last mentioned battle Pompey's cavalry were disgracefully led, and even Julius Caesar, one of the great captains, never handled cavalry as it was handled by Alexander or Hannibal.

As a tactician Hannibal excelled, and his tactics were more flexible than those of Alexander because the organization of his army was far more fluid. He was a master of stratagem and surprise, but in siege craft he fell a long way behind the great Macedonian, otherwise Rome would have been his. At the battle of the Trebia (*q.v.*) in 218 B.C. he made full use of fire power to disorganize the Roman attack. Sempronius pushed back his centre, exposed his own wings to envelopment, and was charged by Mago in rear. At Lake Trasimenus (*q.v.*) the following year Flaminius was surprised in a defile, he was deprived of front, rear and flanks, and his army was destroyed. The tactics Hannibal employed at the battle of Cannae (*q.v.*) in 216 B.C. have never ceased to be quoted; they were an improvement on those used at the Trebia, were somewhat similar to those of Miltiades at Marathon, and of Hindenburg at Tannenberg (*q.v.*) in 1914. Hannibal's grand tactical idea was that of the active defence. In place of forming a stable centre, as Alexander did, he formed a flexible one thrown forward in a half-moon formation so that when it was pushed back it would gain rigidity. Had it been a line, as was the case at Marathon, when forced to retire it might well have been broken. On the flanks of this central arch Hannibal hinged two flexible cavalry wings. The Romans forced back this living arch into a line, into a pocket, then Hasdrubal in command of the right cavalry wing wheeled round their left flank and charged them in rear. Their defeat was absolute. By 207 B.C. the Romans had learnt their lesson, and at the Metaurus (*q.v.*) it was Nero's attack on the rear of Hasdrubal's right flank which won him the day. Five years later at Zama Laelius and Massinissa fell on the rear of Hannibal's line and his defeat was total.

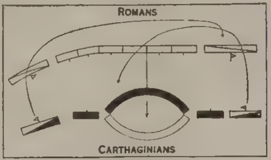


FIG. 5.—BATTLE OF CANNAE (216 B.C.), SHOWING TACTICS OF REAR ATTACK

Marius and Caesar.—After Zama the golden age of Roman tactics pales. There are many great battles, but mostly against ill-equipped barbarians. Technical rather than tactical perfection grows apace, and from an art war sinks into a trade. By the reforms of Marius (107 B.C.) the 30 maniples of the legion were converted into 10 cohorts, in all about 6,000 men. The distinction between *velites, hastati, principes* and *triarii* were abolished; the legionaries were all armed alike with a heavy javelin (*pilum*) and the short Spanish sword (*gladius*); the cavalry were removed from its organization, and the 3-line formation was replaced by a 2-line one, each of 5 cohorts at close distance. The veterans being in the first line. Such was the legion under Caesar, a cautious hard-headed tactician, a great administrator and a born diplomatist whose main contribution to tactics was his use of reserves. He solved the problem of how to sustain a frontal attack and simultaneously repulse an attack on flanks or rear. In his African war, on the open plain near Ruspina (46 B.C.), he was enveloped by the Numidian horse. Forming his troops into one line he ordered alternate cohorts to face about, burst through the Numidian ring with his flanking cohorts, and then charged the fragments. A similar manoeuvre was devised by Bouquet, about 1760, in his war with the red Indians in America. Caesar made great use of entrenched camps, converting them into movable fortresses to aid in victory, and to provide a rallying point in the event of defeat. As a strategist he fully grasped the value of an attack on his enemy's communications, and as a tactician he aimed at surprise, maintained an excellent system of scouting, but with the exception of his tactics at Ruspina he introduced no new formation of attack.

The Army of the Empire.—Under Augustus the changes which were taking form in the legion during the Civil Wars were brought to a head. The army of the republic was a burgess-militia; this had been largely replaced by professional soldiers and mercenaries. From this somewhat heterogeneous body of men Augustus created a standing army of 25 legions with cavalry attached. These were mainly quartered in permanent camps on the Rhine, Danube and Euphrates, and to them were frequently added large numbers of barbarian auxiliaries. For the protection of Italy Augustus raised ten praetorian cohorts of 1,000 men each. The total strength of the army under the early empire has been estimated at 300,000 men.

The main tendency of tactics now became defensive, the army by degrees approximating to a police force with two main duties, namely, internal security and frontier defence. The sword was largely discarded in preference for the spear, and so many missile weapons were added that hand-to-hand conflicts became the exception rather than the rule. The same forces were at work which modified the Hellenistic armies after the death of Alexander. Increase in wealth was followed by improvement in engineering and fortifications, with the result that artillery, both light and heavy, became the preponderating arm. At the siege of Massilia Caesar's soldiers had to protect themselves against projectiles with mantlets a foot thick. In A.D. 69, in a battle fought near Cremona between Vitellius and Vespasian, Tacitus tells us that the 15th Legion possessed a huge balista which would have destroyed the enemy's line had it not been damaged by two soldiers who risked their lives in the destruction of its mechanism. By the 4th century, according to Vegetius, each cohort was equipped with one catapult, and each century with one carro-balista which required 11 men to work it. Consequently the legion possessed an artillery train of ten "guns" and 60 "howitzers," that is approximately ten pieces to each 1,000 infantry, an exceedingly high proportion seeing that in Napoleon's time the number was generally three to 1,000, and even to-day it is seldom more than four or five to 1,000.

THE CHRISTIAN AGE

Glancing back over the history of war from the date of the Messenian War to the 4th century A.D., a period of 1,000 years, a similar tactical evolution can be traced in both the Grecian and Roman worlds. First we are confronted by an infantry period, the phalanx and early legion. Then contact with the Persian cavalry and Numidian horse points to the value of the rear attack. The art of war under Alexander, Hannibal and Scipio, all great cavalry and infantry leaders, suddenly advances by leaps and bounds, because they understand how to develop cavalry pressure from infantry resistance. Almost immediately after their death the art sinks to a low level, since this balance between the stable and mobile elements in tactics is not maintained. When the industrial epoch is entered, in the 3rd century B.C. in the case of the Hellenistic world, and in the 1st century B.C. in that of the Roman, artillery came to the fore, and though under able generals it is used offensively to develop the attack, more often than not it is used defensively to beat back an attacker. The will to clinch with an enemy is lost, and the result is that though military organization, especially in the Eastern empire, is of a high order, the loss in the spirit of the offensive deprives tactics of its soul, and the art of war enters its decadence.

Though it is obviously not possible to date the initiation, or close, of any tactical period throughout the Christian age, that is from about the close of the 4th century to present times, three great tactical cycles can be traced. The first is the cavalry cycle, which may be said to open with the battle of Adrianople (*q.v.*) in 378 B.C. and close with that of Agincourt (*q.v.*) in 1415. The second, the infantry cycle, though its origins are more indeterminable, next follows, reaches its apex under Frederick and Napoleon, and then steadily loses ground during the 19th century. In the World War of 1914–1918, it is definitely replaced by an artillery cycle, the origins of which reach back to the 16th century, and become plainly manifest during the Seven Years' War and the Napoleonic Wars. These three cycles will now be examined with the ultimate aim of forecasting the tactical tendencies of the age in which we live, and those of its immediate future.

THE CAVALRY CYCLE

The Late Roman and Early Gothic Cavalry.—Cavalry is pre-eminently the offensive arm, not because it can charge an infantry line, but because it can circumvent it, and either attack it in rear, or starve it into surrender by capturing its baggage train. Infantry can normally withstand the cavalry charge, consequently, when supported by cavalry, they, if efficiently armed, are invaluable as a "mobile fortress"—a pivot for cavalry manoeuvre, and if they in their turn are protected by artillery, which cannot protect itself, tactics flourish as a high art. After the battles of Carrhae (53 B.C.) and Pharsalus (48 B.C.) though there was a steady increase in Roman cavalry, there was also a steady deterioration in Roman infantry. Under Diocletian (245–313) cavalry rose from one-tenth to one-third of the infantry and numbered some 160,000; but this great mass of horse was withdrawn from the infantry, and by being formed into a frontier guard lost its offensive spirit, and generally speaking was no match for the barbarian horsemen who in the 3rd century invaded the empire.

The decline in the value of the Roman infantry which was due to social reasons as well as military, left the defensive Roman cavalry without a base to meet the offensive Gothic horsemen whose first irruption took place in A.D. 248. Thirty years later, the emperor Valens met the Goths under Fritigern at Adrianople; his cavalry were routed and his legionaries surrounded and destroyed. In this battle the Romans are reputed to have lost 40,000 men. Though at times such as the battle of Taginae (*q.v.*) in 552, which resembles Crecy (*q.v.*) in 1346, and the battle of the Sarno (554), which resembles Cannae, such eminent generals as Narses succeed in wonderful combinations of infantry and cavalry, and of fire and shock tactics, the use of cavalry becomes more and more general. In 535, Belisarius in Africa won the decisive victory of Tricameron (*q.v.*) over the Vandals purely by cavalry, and a few years later we find that he has so little use for his infantry that he mounted them to serve as dragoons.

Armoured Cavalry.—In the Byzantine empire war continued to flourish as an art, but in the West all art disappeared, and as cavalry took to armour, which they did at the beginning of the 6th century, battles were replaced by skirmishes and campaigns by forays. Infantry now took little or no part in battles fought on ground over which armoured cavalry could move. In 814 a chronicler writes of Charlemagne and his host: "Then appeared the iron king, crowned with his iron helm . . . and round him and before him and behind him rode all his men armed as nearly like him as they could fashion themselves; so iron filled the fields and the ways, and the sun's rays were in every quarter reflected from iron. 'Iron, iron everywhere,' cried in their dismay the terrified citizens of Pavia."

The Cavalry Cycle was now reaching its zenith. At Hastings (*q.v.*) in 1066 and at Dyrrhachium (1081) the English axemen were powerless against armoured horsemen, and again this is proved at Bouvines (*q.v.*) in 1214. All that infantry can do is to remain behind entrenchments and use missile weapons. To the knight of the middle ages stability is no longer afforded by the infantry mass, but by the armour he wears, his mobility being provided by his horse. As long as he is not met by equally well mounted and armoured antagonists, this combination of mobility and stability proves irresistible in the melée, the one and only end of mediaeval tactics.

This self-contained stability of cavalry is most noticeable during the Crusades, for the Christian casualties are remarkably small. At the battle of Hazarth (1125) Baldwin's losses are only 24 men, whilst the Turks lose 2,000, at Jaffa (1191) 2 Crusaders are killed on the one side and 700 Turks on the other. The Crusaders' mobility is, however, restricted since the Turkish cavalry is for the most part unarmoured, and consequently extremely mobile. In order to overcome this difficulty, it was found necessary to dismount many knights and form them up on foot; in other words to establish a phalanx which not only offered the Turkish horsemen a target to hit at, but also a base of operations and harbour of refuge for the mounted knights. This change in tactical organization, which is fundamental, enabled the Crusaders to develop mobility from a protective base, not a static entrenched camp, but a movable body of men who could occupy and hold the positions won by the charge. Here we find the germs of a new infantry, for this procedure was copied in western Europe.

With the advent of plate armour in the 13th century mobility is sacrificed to protection; for though it is still possible to dismount the knight, so heavy has his armour become that when once dismounted he is unable to move over muddy or broken country. At the battle of Tagliacozzo (*q.v.*) in 1268, Conradin's Ghibelline knights are so heavily armoured that Charles of Anjou's cavalry, after exhausting them by repeated charges, roll them out of their saddles by seizing them by the shoulders. As armour increases in weight natural obstacles play a more and more important part in the battlefield. At Bannockburn (*q.v.*) in 1314 Bruce takes up his position behind a stream, and Edward II.'s knights are bogged just as in Flanders tanks are ditched 603 years later.

The Influence of the Bow.—A definite change in tactics now sets in. At Dupplin Muir (*q.v.*) in 1332 Baliol and Beaumont did not beat the earl of Mar by reckless charges, but by skilful weapon co-operation. The majority of their knights were dismounted and formed into a phalanx, the flanks of which were protected by archers, whilst only 40 mounted knights were kept in reserve for the decision. The earl of Mar charged the phalanx, which remained stable; his knights were immobilized by the archers on the flanks, and annihilated by Baliol's squadron. This battle is the birthday of a new era in tactics—the tactics of the bow, pike and lance combined. It forms the mould in which all the English operations of the Hundred Years War (*q.v.*) (1337–1453) were cast, a war which proved disastrous to the gallant but insubordinate chivalry of France, as Crécy (*q.v.*), Poitiers (*q.v.*) and Agincourt (*q.v.*) testify. From the battle of Poitiers onwards cavalry falls into a rapid decline, the French knights learn nothing, and as the bow and pike destroy them a new weapon arises in the crude bombards of the 14th century, which are about to revolutionize the whole art of war and introduce the infantry cycle.

THE INFANTRY CYCLE

The Influence of Gunpowder.—The rise of infantry was due as much to social as to military reasons. Feudalism which restricted their use was attacked by trade as well as by gunpowder. The increasing wealth of the 14th century had brought the cities into conflict with the Barons, and the result was not only a widespread series of Burgher wars but a steady increase in the infantry arm which was, however, powerless to attack the feudal strongholds until artillery came to its assistance. During the second half of the Hundred Years War this difficulty was overcome, for it was due to the artillery of Charles VII. more than to the visions of Joan of Arc that the English were ultimately driven out of France. This monarch provided himself with a train of artillery against which mediaeval fortifications proved a poor protection, and next we find cannon used in the open field, as happened at Formigny (*q.v.*) in 1450. To all intents and purposes this battle closed the Hundred Years War.

Meanwhile the hand gun, or Couleuvrine, was being turned to advantage by Ziska, in the Hussite Wars. For long it had been the custom to laager the baggage wagons in rear of the battles of knights. Ziska now turned this laager into a mobile fortress which he garrisoned with archers, cross-bowmen and hand gunners. Once the knights had shattered themselves against it, he would issue out with his cavalry and destroy them. Thus he won the battles of Deutschbrod (1422), Aussig (1426) and Taus (1431).

The Influence of Artillery.—Whilst the Swiss maintained their pikes and their phalangial formations which had proved so effective since the battle of Sempach (1386), during the second half of the 15th century such extraordinary progress was made in artillery that the wagon fortress (wagenberg) proved useless. The dismounted English and French knights once again took to horse, and as ordnance began to accompany infantry, more and more could foot soldiers work independently of cavalry and wagon forts. The close of the 15th century and the opening of the 16th saw the three arms we know to-day, namely, cavalry, artillery and infantry assuming tangible form. In France the infantry are poor on account of the strength of the feudal system. In Switzerland they become decadent as they refuse to change their shock tactics. In Spain they become highly efficient, a result of their struggle with the Moors, and under Gonzalo, who armed his foot with sword and buckler; against the Swiss and the German Landsknechts, in 1502, near Barletta, he repeated the Roman tactics of Pydna; for as Machiavelli says: "By the help of their bucklers and the agility of their bodies, having got under their pikes, and so near that they could come at them with their swords, the Spanish had the day with the slaughter of most of the Swisses."

The Development of the Musket.—As artillery forged ahead, and at the battle of Ravenna (*q.v.*) in 1512 broke away from the close support of infantry, and by taking the enemy in flank played a decisive part in winning victory for the French under Gaston de Foix, a rapid evolution in the handgun set in. In 1520 the Spanish adopted the portable arquebus fork which stood them in good stead at Pavia in 1525. In this battle fought between the French under Francis I. and the Imperialists under Lannoy, we find a remarkable tactician, namely, the marquis de Pescaire drawing up a skirmishing line of 1,500 Basque arquibusiers who, according to Brantôme, "most wonderfully, though cruelly and villainously, discounted with much ease the power of the French cavalry."

In the wars between Charles V. and Francis I. the bow and cross-bow disappear. Artillery, owing to the development of fire-arms, is neglected, and seldom do we find more than one gun to 1,000 men. Fighting in extended order is developed, the musketeers rapidly growing in number. The French adopt the line as their tactical formation, the Spanish and Austrians maintain squares, normally of 3,000 men, 25 ranks deep. These squares possess a central corps of pikes, with bastions of musketeers at their corners. Later on, these solid squares are replaced by hollow ones, and at times their four sides manoeuvre as separate bodies. This is the beginning of the linear formation which definitely took form during the Thirty Years War.

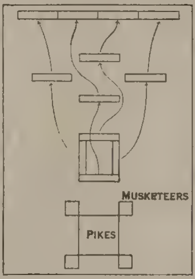
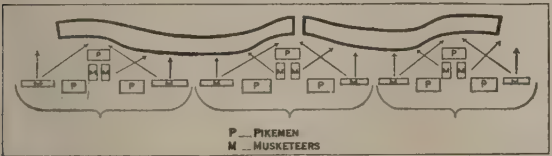


FIG. 6.—EVOLUTION OF THE SQUARE INTO THE LINE

Maurice of Nassau.—The 15th and 16th centuries were a period of transition from shock to fire tactics, or, broadly speaking, from the cavalry to the infantry cycles of war. The progress was remarkable in spite of opposition, for the new arms had as always to struggle for their existence. The elements of the new order had now been born, and two men, Maurice of Nassau and Gustavus Adolphus, shook them into form as Philip of Macedon had done nearly 2,000 years before their day. Maurice opened out the hollow square and placed its sides in "echequier." These sides he formed into regiments of two battalions each consisting of 500 men in ten ranks. The pikes were placed in the centre and the musketeers on the flanks; by a successive use of small bodies he wore his opponents down, and yet kept a reserve in hand. Having reorganized his infantry, he reduced the numerous calibres of the field guns to 24-, 12- and 6-pounders, and substituted iron balls for the hail shot hitherto used. He divided his artillery into two bodies, the heavy guns to introduce the battle, and the light to accompany the infantry and closely support them.

Gustavus Adolphus and the Thirty Years War.—Under Gustavus the evolution towards the line was rapid. He reduced the ranks of the musketeers to six, organized his army into brigades, each consisting of two regiments of two battalions each 1,000 strong. Each battalion was divided into eight companies each of which had 72 musketeers and 53 pikemen. He gave up the "echequier" formation and drew up his order of battle in line, the infantry in the centre and the cavalry on the flanks. In the Thirty Years War (*q.v.*) he used his artillery to break up the Imperialist squares by an overwhelming fire from a distance, and then charged home. Such tactics, combined with the flexibility of his troops in manoeuvre, won him his two great battles, namely, Breitenfeld (*q.v.*) in 1631, and Lützen (*q.v.*) in 1632. He never mastered, as Frederick the Great did, the tactics of artillery against an enemy who had taken up a strong defensive position such as that held by Wallenstein at Nuremberg in 1632. To do so a powerful howitzer was necessary, and failing this a mobile force of cavalry who could outflank the obstacle and attack the enemy, or his supply columns, in rear. After Gustavus's death we find this frequently taking place. Armour is discarded and the lance is laid aside, cavalry being armed with pistol and sword. Rocroi (*q.v.*) in 1643 was won by the French cavalry under Condé, and in England it was the cavalry of Cromwell which proved the decisive arm, since the infantry line found great difficulty in manoeuvring, and if its flanking cavalry were beaten it could be readily attacked in rear. The increased use of cavalry from Rocroi to the end of the 17th century marks the tactics of this period as one of manoeuvre; to fall upon the flank, or rear, of an enemy, is the controlling idea. Turenne was a master of these tactics, and for the first time since the opening of the infantry cycle the attack equipoised the defence. To assist cavalry mobility frontal fire is necessary, consequently skirmishers vanish and a rigid line is formed. The principal idea of Montecuccoli's order of battle is resistance, for as he says: "The secret of success is to have a solid body so firm and impenetrable that wherever it is, or wherever it may go, it shall bring the enemy to a stand like a mobile bastion, and shall be self-defensive." If once the enemy can be brought to a standstill, that is fixed by fire, the cavalry can manoeuvre. Marshal Luxemburg is a worthy disciple of Turenne. The battle of Fleurus (*q.v.*) in 1690 is a masterpiece in the art of manoeuvring, and so is that of Neerwinden (*q.v.*) in 1693.



FROM CAPT. HART, "GREAT CAPTAINS UNVEILED" (BLACKWOOD)

FIG. 7.—FORMATION ADOPTED BY GUSTAVUS ADOLPHUS, WITH BATTALIONS DIVIDED INTO COMPANIES OF MUSKETEERS AND PIKEMEN

The Solidification of Infantry.—The steady improvement in fire-arms, and the introduction of the socket bayonet by Vauban in 1687, reduced infantry to one type. The distinction between pikemen, musketeers, fusiliers and grenadiers was given up, and during the war of the Spanish Succession (1701–14) all foot were armed with the flintlock and the bayonet. Mobility was now reduced to a minimum, and battles are decided by order and cohesion followed by the cavalry charge. In this war Marlborough won most of his victories by cavalry, and when infantry played a prominent part, as at Malplaquet (*q.v.*) in 1709, the losses were appalling. The pike had vanished and had been replaced by the bullet, so that volleys of bullets in place of push of pikes now governed tactics.

Folard and Marshal Saxe.—It is a curious fact, yet one which cannot be disputed, that throughout the history of tactics when genius and leadership are wanting there has been a general tendency for military organization to return to its simplest form—the phalanx. This is what happened during the opening years of the 18th century, for though pikes had vanished, the phalangial idea is solidity, and as the English and German excel in this peculiarity the French suffered reverse after reverse. The crudeness of the phalangial order was clearly grasped by the chevalier de Folard who, in 1727–30, published a translation of Polybius fully sprinkled with his own ideas. Of this book Frederick the Great said: "Folard has buried diamonds in a rubbish-heap." This criticism is just, since the chevalier's ideas, though very confused, started a tactical argument of column versus line which only reached its solution in 1791. Folard attempted to establish a connection between fighting in line, column and in skirmishing order. He was supported by Maréchal de Saxe, who had not time, however, to put Folard's ideas into practice; in place he re-introduced fighting behind defensive posts, and made use of artillery to an extent unequalled since the days of Gustavus Adolphus. The result was that the Germans, Dutch and English suffered one defeat after another, since a phalangial army is incapable of maintaining its cohesion over obstructed ground.

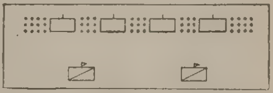


FIG. 8.—MARSHAL SAXE'S COMBINATION OF INFANTRY, LIGHT INFANTRY AND CAVALRY

Frederick the Great.—Frederick the Great now entered the tactical arena, and turned his attention to manoeuvre with a view to outflanking the phalanx. He divided his infantry into companies, established a definite drill, and formed his line of battle in three ranks. His cavalry were deprived of their fire-arms, and were taught to charge boot to boot and to rely on the *arme blanche*. So successful was he in their instruction, that there can be no question that the cavalry of Zieten and Seydlitz were the most efficient since the days of Alexander. Though completely successful in his Silesian Wars (1740–42 and 1744–45), it is not until the Seven Years War (*q.v.*) (1756–63) that his genius was fully manifested. In the early battles of this war, the Austrians dispersed their guns along their entire front, and made all efforts on the part of the Prussians of no avail. At Lowositz (1756) Frederick's cavalry were repulsed by gun fire, and so also were his infantry at Prague (*q.v.*) in 1757 and Kolin (*q.v.*) in 1757. Frederick now saw that artillery was the superior arm, and proved it at Rossbach (*q.v.*) and at Leuthen (*q.v.*) in 1757. In these two battles the demoralization of the enemy was handed over from the infantry to the gunner. Not only did Frederick realize that artillery should prepare the infantry attack, but that it should search out the enemy where the terrain concealed him, consequently he increased his howitzers to one-third of his total guns, and massing them brought them against the defender's flank.

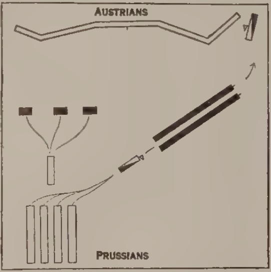


FIG. 9.—BATTLE OF LEUTHEN (1757), SHOWING TACTICS OF FLANK ATTACK

Leuthen is probably the finest example of the Frederician tactics. The Austrians, less well drilled, deployed, but he marched straight forward deploying his advanced guard only. Then wheeling the main body to the right he placed it at right angles to the enemy's left and deployed it in echelon in oblique order. The Austrians were fixed, since they were unable to manoeuvre. On their left flank, now in confusion through attempting to form a new front, Frederick converged the fire of *all* his guns. Under this fire his infantry advanced to the assault, and his cavalry manoeuvred on the rear of the enemy. At Torgau (*q.v.*) in 1760, one of his most daring battles, he separated his army, and whilst Zieten and his cavalry held the enemy's front, the bulk of his army took the Austrians completely in reverse.

Such were his battles, classical actions drawn from the study of classical history, for Leuthen was modelled on Leuctra (*q.v.*). In brief, his system is expressed in his favourite maxim—"To bring one's own strength against the enemy's weakness." Like Alexander he refused one wing and assaulted with the other, the refused wing acting as a reserve to that part of the line not used for the shock. The assaulting wing consisted of an advanced guard, an artillery mass, an infantry mass and a cavalry mass. When the enemy stood in the open his guns smote them, and when he sought shelter by ground his howitzers pounded him to pieces.

Rise of Light Infantry.—As a gunner Frederick stands supreme, and further, he knew well the value of the cavalry charge and the infantry assault, but he never seems to have grasped the value of a well-trained light infantry for protective duties, and for preparing the act of distraction, for only towards the end of his reign did he raise a few battalions of fusiliers. In spite of this neglect, the times demanded a change towards infantry flexibility. Folard had advocated it, Saxe had proved it at Lauffeld (1747), Henry Lloyd wrote about it in his "History of the Seven Years War," and so had Guibert, the most far-sighted tactician of his day in his "General Essay on Tactics" (1751). In 1702 the French had raised several "Compagnies Franches" under the duc de Bellisle, and in 1725 the English raised the Black Watch, a form of irregular police "for the protection of the country against robbers." It was, however, during the Seven Years War that the new infantry order took form. In Europe Moratz, Trenk, Nadasty and Frankini raised bands of Croats, Pandours and other ruffians who fought as independent riflemen, and in America, Bouquet, Rogers, Howe and Montgomery demonstrated their extreme value when well led and trained against the red Indians. After this war, all these lessons were lost sight of. The glamour of Frederick's great battles blinded the military eye; soldiers sought his secret in his drill and not in his ideas, and prepared for themselves a rude awakening in the wars of the American Rebellion and the French Revolution.

Whilst backwoodsmen and redskins were picking off the British red-coats, and whilst Simcoe, Tarleton and Ferguson were striving their utmost to counter them by raising light infantry, the maréchal de Broglie, in 1778, at the camp of Vaussieux carried out experiments in line and column, showing that the evolutions of the first were heavy and difficult, and of the second flexible and speedy. Mesnil Durand advocated massive columns, Guibert battalion columns. Then came the French Revolution, all tactical shibboleths were cast to the winds; cohesion disappeared, and man took to natural fighting, that is skirmishing, and though the Revolutionary armies, utterly lacking in discipline were frequently beaten, in 1794 an A.D.C. of the duke of York was compelled to acknowledge that "No mobbed fox was ever more put to it to make his escape than we were." Though in their first campaigns the French looked upon columns solely as reservoirs for skirmishers, it soon became apparent that skirmishers should be used for the act of distraction, and that columns should be used for the act of decision, artillery being employed to co-operate with the skirmishers. Thus was re-established the tactics of the successive employment of arms.

Napoleon.—Whilst in Austria and Prussia the art of drill was mistaken for the art of war, the greatest military genius of modern time, but certainly not the greatest tactician, emerged out of the chaos of the Revolution to astonish the world. As a grand tactician and a strategist Napoleon stands supreme, and it may be due to this that as a minor tactician he left much to be desired. Sometimes he broke his enemy's centre, as was the case at Rivoli (1797), Marengo (1800), Friedland (1807) and at Ligny (1815), but normally he preferred a flank, or, if possible, a rear attack, for he understood clearly that the rear was the decisive point. His grand tactics consisted in engaging as few troops as possible, using them up completely without reinforcing them, and meanwhile holding in hand his main body for the decisive blow, which when once delivered was normally followed by an annihilating cavalry pursuit. "It is by turning the enemy, by attacking his flank, that battles are won." So said Napoleon, and he always when possible attempted it, as at Castiglione (*q.v.*) in 1796, Ulm and Austerlitz (*q.v.*) in 1805, Jena (*q.v.*) in 1806, Eylau (*q.v.*) in 1807 and Wagram (*q.v.*) in 1809. If he did not succeed in a full attack on the flank, he contented himself with an outflanking movement. These are battles of intellect rather than of muscle in spite of their slaughter and destruction, yet had he paid more attention to minor tactics his battles would have been even more intellectual.

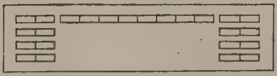


FIG. 10.—FORMATION OF AN ATTACK OF A DEMI-BRIGADE

In his Italian campaigns of 1796–97 we find full use made of line, column and skirmishers. At Lonato and Castiglione, the French work in battalion columns at deploying intervals, the columns being of double companies covered by skirmishers. At Rivoli (*q.v.*) it is much the same. At the crossing of the Tagliamento (1797) demi-brigades are used, the centre battalion being deployed, and the flanking battalions kept in double company columns with skirmishers in front. Such a formation enabled considerable frontal fire to be delivered without uncovering the flanks to cavalry attack. After 1800 we find a change, the act of distraction passing more and more from the infantry to the artillery. It was not that the French infantry were falling off in value, as has frequently been stated, for probably as late as 1812 they were equal to those of 1796. It was because Napoleon, like Frederick, had begun to realize that artillery is the superior arm. Even at Castiglione and Rivoli he massed the few guns he had. When guns are allotted to divisions as they were to Augereau's corps at Eylau and to Ney's at Friedland the infantry are repulsed. But after Aspern (*q.v.*) in 1809 Napoleon fully grasped Frederick's system, and increased his guns from two to three to each 1,000 infantry. He also created a central artillery reserve of 126 guns, and allotted a reserve artillery to each *corps d'armée*. From Wagram (1809) onwards "it is the number of pieces rather than that of battalions which henceforth serves as the measure of the relative strength of armies." Thus writes Napoleon: "The better the infantry, the more one must husband it and support it with good batteries. . . . The invention of powder has changed the nature of war: missile weapons are now become the principal ones: it is by fire and not by shock that battles are decided to-day. . . . The power of infantry lies in its fire. In siege warfare, as in the open field, it is the gun which plays the chief part; it has effected a complete revolution. *It is with artillery that war is made.*" Curious as it may seem, it was Napoleon's lack of appreciation of the value of the howitzer which caused him heavy casualties at the battle of Borodino (*q.v.*) in 1812, and decisive defeat at that of Waterloo (*q.v.*) in 1815.

Wellington.—In Napoleon's early campaigns we find the active defence playing an important part, for example at Rivoli and Arcola (1796), but once the emperor became the man of destiny, the reincarnation of Alexander, of necessity the offensive replaced this more cautious system of waging war. Yet fate must have it otherwise, for once he had decided that the gun was the decisive weapon, as he did after Aspern, he was immediately confronted by a general—Wellington—who made the active defence the backbone of his tactics. The method adopted by the Iron Duke and his generals was simplicity itself, and it invariably succeeded. It consisted in selecting a good covered position behind which the main force of infantry was deployed, and in front of which was extended a line of skirmishers trained on the system taught by Sir John Moore at his camp at Shorncliffe in 1803–1805. The French advanced in columns, company behind company, covered by skirmishers, and were met by musket, rifle and artillery fire, and severely mauled. When they neared their objective, the English rose from behind their cover, fired a volley, rushed forward lapping round the columns, and charging them in front and both flanks. The battle of Busaco in 1810 is probably the most perfect example of these tactics. At Albuera (*q.v.*) in 1811 the English attacked a mass of columns on a hill with the same result. Again were these tactics repeated with decisive effect at Salamanca (*q.v.*) in 1812 and finally at Waterloo.

The amazing thing was that Napoleon never seems to have grasped how easily they could be defeated. Frederick had been equally ignorant of the solution at the opening of the Seven Years' War, but once the Austrians began to use ground as cover against fire, he at once increased the number of his howitzers, and literally blew them out of their positions. Had Napoleon realized the power of the howitzer, and had the third of his artillery been howitzers, there is little doubt that at Waterloo he would have been able to demoralize the main force of Wellington's army who were sheltered from his cannon balls and grape shot, and so have paved the way for the advance of his squadrons and infantry columns. It is one of those enigmas of tactics that with all his genius he could not see this very simple solution as old as the battle of Hastings (*q.v.*) and beyond.

The Influence of the Rifle.—The 50 years which followed the battle of Waterloo are tactically most instructive. Over 20 years of devastating war, of battles, sieges and naval actions, of attacks and retreats, and manoeuvres taught the armies of Europe nothing, and from the military point of view Napoleon might as well have never been born. No sooner had the emperor been incarcerated in St. Helena than the rigid school of war, the men of the hoplite mind, took over control. Nevertheless in spite of their ponderous ideas the industrial revolution swept on. Invention followed invention, and amongst these were two of supreme tactical importance, namely, the percussion cap invented in 1814, and the cylindro-conoidal bullet invented in 1824.

The rifle had been long known, but hitherto all rifles and muskets had been fired by a flint and steel, and in rainy weather frequently misfired. The percussion cap signed the death warrant of the cavalry charge, and the conoidal bullet revolutionized artillery tactics. In 1839 a percussion musket was issued to the British infantry, and in 1851 they were equipped with the Minié rifle, a weapon with an effective range of 1,000 yards. In 1815 cavalry, artillery and infantry were in close contact, and operated by the general in chief as easily as a platoon is to-day. The guns were frequently placed in front of the infantry, and the cavalry close behind them. All this was changed by the rifle. The cavalry can no longer attack infantry, unless completely broken. The guns have to retire well in rear of the infantry, and as the range of the rifle is increased so is the distance between them and the infantry they are supporting. Thus the old battle order, which in idea had changed but slightly since the days of Gustavus Adolphus, was completely thrown out of joint. To operate an army as Wellington did at Waterloo was impossible; to render its separated parts co-operative demanded intelligence and not merely a powerful voice. The Prussians seeing the difficulty attempted to overcome it by replacing the general by an army fashioned like a clock, which once wound up was expected to tick out victory. The English maintained their fox-hunting generals, and the French, contemptuous of others, since they had produced one of the greatest geniuses in history, shrouded their ignorance in the glamour of his fame.

Tactics from 1849 to 1870.—The middle of the century ushered in a series of wars which lasted for 20 years. During this long period tactics underwent a profound change; the gun again and again asserted its superiority, yet the leaders of armies still maintained the supremacy of infantry. They could not see that as each campaign ended infantry had become more and more a supplement to artillery action. The battle of Temesvar, in 1849, was but a repetition of Ocaña in 1809, for artillery not only accomplished the act of demoralization, but brought both of these battles to a decisive issue. The war in the Crimea was largely an artillery war, mainly so on account of Sevastopol. True, the French massed their artillery as Napoleon had done, but between the British and the Russians the old and somewhat stale contest of line versus column was once again fought out, because the Russians still believed in shock by weight of numbers, which never takes place, and the British in deployment in order to develop fire power which seems obvious, but which apparently is not so to a semi-oriental, since the Russians repeated their tactics in 1878.

In 1859 rifled guns were issued to the French army, and this same year Napoleon III., emulating his uncle, decided on a war against Austria in Italy. The Austrian infantry were the better armed, as the Lorenz muzzle-loader was superior to the French Minié rifle. To compensate for their inferior rifle the French made extensive use of skirmishers, the Austrians normally remaining stationary. The broken nature of the ground favoured these tactics, as happened at Solferino (*q.v.*) in 1859. When Marshal Niel's firing line began to waver he brought up his reserves, and "the bayonet," as he writes in his report, apparently to please the emperor, "recovered everything that had been lost by the fire-fighting." His enemy, the Austrians, however, showed no initiative. They believed in the methodical battle as recommended by the Germans, that is, a gradual nourishing of the fighting-line until the enemy's strength is used up; only then would they attack him with their last reserves. What actually happened was that the nourishing of their firing line starved their reserves to death, so that when the decision was signalled the reserves had volatilized. The French learnt little from this war, and never troubled to reflect on the causes of their successes. The Austrians, however, learnt "that the employment of artillery *en masse*, when it is to take general part in the action, must be made from the very beginning, and the infantry attack must really be the one to bring about the decision."

In 1859 the Austrian tactics were of a defensive nature, in 1866 they were diametrically opposite, that is they were offensive, and with these tactics they decisively defeated the Italians under La Marmora, at Custozza (*q.v.*) in 1866, though it should be remembered that their enemy had lost all power of taking the initiative. In Bohemia it was otherwise, for the solid masses of Austrians who, almost unprotected by skirmishers, attempted to rush the Prussians armed with the needle gun, were decimated. In the Prussian army, however, the employment of the arms in co-operation had been neglected. Their general staff had studied the French infantry tactics of 1859, but their artillery tactics had been overlooked. They considered that the bulk of the guns should be held in reserve for the final act of disruption, and that distraction could best be attained by a methodical infantry fight. One-third of the guns were to support the attack, one-third to reinforce it, and the remaining third to be held back in reserve. Thus was the battle of Trautenau fought on June 27, 1866, and that of Nachod, on the same day, was fought almost entirely without artillery. At Skalitz, the next day, it was much the same. After this battle the Prussians suddenly woke up to the value of artillery, and at Königgrätz (*q.v.*) the methodical attack was replaced by the manoeuvre battle, and artillery in place of being held in reserve for some problematical decision was brought forward, as was notably the case in the II. Army.

In the American Civil War (*q.v.*) (1861–65) the most prominent tactical lessons were the power of the rifle on the defence, and the ever increasing use of entrenchments to enhance this power. The gun now became definitely the backbone of the defence, and as the Americans still possessed many smooth-bore guns the discharge of case-shot on the attackers was frequently devastating. Nevertheless the defence was devoid of strategical results, and lack of strategy on the part of the Southern Armies ended the war.

In 1870 the Prussians possessed the superior gun and the French the superior rifle. The French having watched the failure of the Austrian offensives in 1866 determined to base their tactics on the defensive. Moltke, who was a believer in defensive tactics, was thus compelled to assume the offensive. At Spicheren (Aug. 6, 1870) the Prussian tactics were methodical since reinforcements came forward gradually. At Gravelotte (*q.v.*) (Aug. 18) the battle was one of manoeuvre prepared by an overwhelming artillery fire. Sedan (*q.v.*) (Sept. 1) was essentially an artillery battle, and the result of a finely executed strategical manoeuvre. In all the battles of this war, whenever the infantry fought in successive efforts, and were predominantly employed, the result was "the complete dissolution of the body of troops engaged, divisions as well as corps, and extraordinary losses." Breech-loader met breech-loader, and unless the attacker could by artillery fire adequately break down the defender, the attack was repulsed unless it was delivered against a flank.

To all who possessed the slightest tactical perception it was apparent that the leading lesson of this war was that artillery had definitely become the stable element in the fight. Other lessons were: That in certain circumstances the defender can be so completely broken by gun fire that the infantry attack can be dispensed with; that infantry armed with the breech-loading rifle need pay no longer any attention to cavalry; that, to initiate an attack, all the artillery must be brought into line as soon as possible, and must not only crush the enemy's artillery but prepare the infantry advance by a lengthy bombardment. Yet, in spite of this, as the war showed, fronts had become inviolable, for, throughout the war, neither the French nor the Germans succeeded in taking a single position by a frontal attack. The infantry breech-loading phalanx was unbreakable, and cavalry though they could turn it were incapable of attacking it in flank or rear.

Tactical Theories, 1875–1900.—In 1870–71 the French lost battle after battle, yet they came out of the war as oblivious to its lessons as did Frederick's mule after its tenth campaign. From 1875 to 1900 the French regulations maintain the complex system of firing line, supports, local reserves and reserves in echelon. The infantry regulations do not even mention artillery, which is supposed to have completed its task by the time the infantry attack is launched. The power of fire was recognized, and in order to develop it to the full, about 1895, whole battalions were moved forward in single rank without intervals between the men, and were called "skirmishing lines." Behind these walls of rifle fire "decisive attacks," whatever these might mean, were to be launched forward by brigades and divisions in mass. In an official report written in 1875 we read: "Troops massed in column, or in line in close order, can no longer manoeuvre, fight or even remain in position under fire." Twenty years later this lesson having been forgotten, the regulations extol dense formation, not for marching and manoeuvring only, but for the attack itself. "Troupes de choc," "Masse de manoeuvre" and such like metaphysical terms were invented. It was considered that well-led troops must overcome all obstacles. A veritable spell fell not only upon the army of France but on all the armies of Europe.

The South African War, 1899–1902.—The South African War did little to dispel this hallucination. Artillery action was negligible, and infantry formations, which at first were dense, were thinned out into a line of men at from ten to 50 paces between individuals. To command such a line was impossible. To those who could read tactics aright the outstanding lesson was the power of the rifle on the defensive. At Modder River (1899) the British had 3,000 men on a front of 7,000yd.; at Colenso in the same year 4,500 on a front of 13,000yd., and at Magersfontein (1899) 5,000 on a similar frontage. These fronts could not be pierced. Again, as had been learnt in 1870, frontal attacks even against weakly held positions were no longer possible. The war ended through the gradual attrition of the Boers.

The Russo-Japanese War, 1904–1905.—The Russo-Japanese War (*q.v.*) did more than confirm the lessons of the South African War, for it demonstrated clearly the uselessness of the frontal attack, the power of the rifle and machine gun on the defensive, and that, as Napoleon had said 100 years earlier, "it is with artillery that war is made." In broken ground the Japanese made use of moderately thick skirmishing lines, but in open country they had the wisdom to thin them out to from five to ten paces between men, the men being rushed forward in twenties 20 to 30 paces at the time. The Russian fire tactics were execrable, nevertheless the Japanese assault generally failed, and to avoid casualties night operations became prevalent.

This war is remarkable in that to-day we can see in it a small edition of the World War of ten years later. The machine gun when efficiently handled by trained men, which was not the case in the South African War, added enormously to the defence. The artillery was driven further and further back by the bullet, until the gunners were compelled to seek cover by ground and cease firing over their sights. Trenches appeared everywhere, not a single battlefield remained untrenched. Whenever it was possible these trenches were protected by wire entanglements. Frontal attacks, save as fixing operations, were altogether out of the question, and at each great battle, and notably so at the Yalu (1904), Liao-Yang (1904) and Mukden (1905), it was a Japanese threat of envelopment carried out by infantry and artillery, since cavalry had lost all offensive power, which compelled the Russians to retire.

The main lesson, however, was one which had been steadily maturing since Frederick massed his guns at Leuthen: it was the ever growing power of artillery. Maj. J. M. Home of the British army, and attached to the Russian army, saw this clearly, and in one of his official reports may be read the following:—"The great impression made on my mind by all I saw is that artillery is now the decisive arm and that all other arms are auxiliary to it. The importance of artillery cannot be too strongly insisted upon, for, other things being equal, the side which has the best artillery will always win. . . . So strongly am I convinced of the immense importance of artillery that it seems almost a question for deliberate consideration whether artillery should not be largely increased even at the expense of the other arms. . . . With the extraordinary development of artillery it begins to appear as though infantry fire action cannot usefully be employed at ranges beyond 600yd., as beyond that distance the hostile guns ought to be able to prevent infantry from using their rifles." The battles of the Balkan War of 1912 in no way contradicted this statement. The war in Manchuria was brought to an end in 1905 not through tactical or strategical action, but by revolution and attrition. Both sides were virtually worn out, and Russia was threatened by rebellion and disaster.

The Tactics of the Unlimited Offensive.—The lessons of the wars in South Africa and Manchuria were entirely lost on the general staffs of European armies. The enormous power of modern weapons on the defensive was completely overlooked. A new school, the Moral School of War, rose in the ascendent. In France Col. de Grandmaison was its high prophet; his theory of war was simplicity itself. It was: "A man seized by the throat and who is occupied in guarding himself cannot attack you in flank or in rear." Therefore rush on the enemy with all forces united and overwhelm him, or in his own words "Frapper fort, frapper tous ensemble." The French "Conduite des Grandes Unités" of 1913 was based on this doctrine. It was pointed out that all past French disasters had been due to the defensive! That after the South African War the theory of the inviolability of fronts had been propounded, and had been given the lie direct in the Russo-Japanese War! That all could be overthrown by the offensive; that the enemy's position must be taken with the bayonet, and that when once the battle is launched it must be pushed forward regardless of cost to the last man!

The doctrine laid down in the German training manuals is identical. Cavalry must be used in mass: "No squadron should wait till it is attacked; it should always attack first." "Artillery should enter into action almost like one blow, in masses." "The infantry of the main body should simultaneously make a united attack." And again: "The infantry should cultivate its natural propensity for the offensive. All its actions must be dominated by this one thought: *Forward, upon the enemy cost what it may.*" Such was the frenzy which smote French and German tactics like a pestilence. The art of war was to be replaced by a dog-fight, each side was to fly at its antagonist's throat and shake him to pieces. The whole process was so irrational as to be mad. Two years before the South African War, and 18 years before the World War, M. Bloch, a Polish banker, had seen this clearly. He said that the future of war would not be fighting but famine, "not the slaying of men but the bankruptcy of nations. . . . Everybody will be entrenched in the next war. It will be a great war of entrenchments. The spade will be as indispensable to a soldier as his rifle. . . . All wars will of necessity partake of the character of siege operations. . . . Your soldiers may fight as they please; the ultimate decision is in the hands of *famine.*" Had the general staffs of European armies been as clear-sighted as M. Bloch, there would have been no question as to the nature of the tactics of the next war.

THE ARTILLERY CYCLE

Return to the Phalanx and the Legion, 1914.—The picture of the World War as painted by M. Bloch was exact because his colours were the tactics of the military schools, and his perspective the outlook of a war artist and not of a war artisan. His was not so much a remarkable forecast as a remarkable synthesis derived from a remarkable analysis of the military theories of his day. The South African War showed that his deductions were well founded, and the war in Manchuria proved definitely that he was right, yet so obsessed were soldiers by the metaphysical power with which in their theories they had endowed infantry, that they had become completely hypnotized by the glint of their bayonets. The war might have been very different from the above picture if the means of waging it had been changed, or even if the weapons it was fought with had been revalued and differently proportioned.

The controlling factor was, however, neither "famine" nor "the unlimited offensive," it was the industrial revolution, and it mattered not what was done or said by the soldier during peace time, in war the military factors of this revolution would out. Soldiers, blinded as they were, could not see this; they could not see that science and industry were the controlling forces in the approaching war. They talked of *morale*, but forgot "fear"; they advocated offensive action but neglected defensive power. They studied history not to discover truth but to prove their doctrines. They could not see that since cavalry had lost its power, tactics as an art had been thrown out of joint, and had retrogressed to the phalangial order. Further, they were oblivious to the fact that when phalanx met phalanx there would be no assault—for the assault was as dead as the charge. To hit at the decisive point had now become so difficult as to be tactically almost impossible. The act of annihilation had vanished, the acts of dislocation and disruption had vanished, all that was left of the battle were the acts of contact, of approach and of partial distraction. Therefore the war must be a war of attrition, of maximum slaughter and minimum profit; therefore M. Bloch was right.

When war was declared, once again did the phalanx meet the legion. The German phalanx was 250m. long, and the French legion was distributed in front of its left wing on a little more than half this frontage. The French grand tactics were absurd, namely, to attack the front of the phalanx, an operation which has nearly always ended in failure. Those of the Germans were simplicity itself, namely, to lap round the left flank of the French legion and attack it in rear. They failed because the right wing of the phalanx was itself attacked in flank at the battle of the Marne (*q.v.*) in 1914. At the battle of Tannenberg (*q.v.*) in 1914 the Russians were routed because they were attacked in rear; and at the battle of Megiddo (*q.v.*) in 1918 the Turks were routed for a similar reason. The major tactical problem on every front was the rear attack, and to frustrate such an attack each front in turn crystallized out into a trench line, as M. Bloch had predicted.

The Supremacy of Static Artillery, 1915–1917.—To break these entrenched fronts cavalry were useless, they could not charge them; infantry were useless, they could not assault them—though in 1914 and 1915 such attempts were foolishly made. More than 100 hundred years had gone by since Napoleon had said: "It is with artillery that war is made." No one had heeded him, no single soldier of eminence had definitely proclaimed that the gun was the superior arm. Since the battle of Ravenna, fought in 1512, whenever a supreme military genius had arisen the gun had proved the superior weapon on the battlefield. Gustavus proved this, Frederick proved this, Napoleon proved this, and Moltke proved this, yet on the death of each of these great captains the sprouting artillery cycle had been trodden into the dust by the officially minded soldier. At length, in 1915, 400 years after Ravenna, no professional feet were big enough to stop its growth.

In the spring of 1915 the long delayed artillery cycle opened with the battle of Neuve Chapelle (*q.v.*), a brilliantly conceived attack but one on so restricted a front that it was doomed to failure. In the autumn of this year, surprise was set aside and replaced by method, method ultimately depending on shell production. Little by little it was discovered that it was no longer the infantry who attacked but the artillery; that it was first necessary to destroy the defences of the enemy before attempting to capture them. The supreme tactical lesson of 1915 was: "Artillery conquers and infantry occupies." Tactics were thus reduced to a matter of push of pikes, or rather—push of shells.

In 1916 infantry had become so immobile, that a rolling barrage was introduced. Not only was it necessary to bombard an enemy's position for days on end, but to establish a wall of shells in front of the infantry, a shield of fire which slowly moved forward in front of the infantry. This wall replaced the old infantry firing line, the infantry supporting it. The infantry attack was as dead as the infantry assault. All infantry could now do was to carry out the approach and the contact, and when the limit of gun range was reached, the approach ceased. Nevertheless the battle of the Somme (*q.v.*) in 1916 cost the British 475,000 casualties, and the battle of Verdun (*q.v.*) in 1916 cost the French 350,000 and the Germans 500,000. In 1917 this elephantiasis of shell fire reached its zenith in the third battle of Ypres (*q.v.*). To prepare this battle the British massed 120,000 gunners, who in the initial bombardment, lasting 19 days, fired 4,283,000 shells, weighing 107,000 tons and costing £22,000,000. This battle lasted approximately three and a half months, and each square mile of mud gained cost the British army 8,222 casualties.

The Supremacy of Mobile Artillery, 1917–1918.—Thus far the artillery cycle had proved a grotesque failure, the reasons being that grand tactics were at fault. In all these battles the central idea was to use artillery to blow a hole through the enemy's defences in order to facilitate the advance of the infantry, who were in their turn to facilitate the advance of the cavalry. It was this conception of tactical action and not the gun which was to blame, since if such penetration were effected, this in itself would not render infantry and cavalry invulnerable to the bullet, and the bullet was the father of the trench. The problem was not to advance infantry and cavalry, but to advance the guns, and this demanded that their crews and teams should be rendered bullet proof. The problem was to produce a mobile self-protective gun. Once produced it could advance and blow the enemy back, and behind it the infantry could follow to occupy ground, and the cavalry to collect prisoners. In brief, as the artillery barrage had replaced the old infantry firing line, the problem now was how to replace this barrage by a moving line of guns and howitzers. This problem was solved by the tank which definitely established the artillery cycle.

Return to the 1914 Model.—The armies which fought in 1918 were very different from the armies which entered the war in 1914. Cavalry and infantry had steadily dwindled in importance, and artillery had rapidly come to the fore; nevertheless so conservative is the spirit of the soldier that in 1919, in spite of vastly increased machine gun power, all armies as quickly as possible reverted to the 1914 model. Lethal and non-lethal chemicals were prohibited, tanks, guns and aircraft were reduced in numbers on wholesale lines, and infantry, who were impotent during the war, were once again proclaimed the predominant arm. In the British Field Service Regulations of 1924 it was stated: "Infantry is the arm which in the end wins battles. . . . The rifle and the bayonet are the infantryman's chief weapons. The battle can be won in the last resort only by means of these weapons." Tactically the war had been fought in vain; nevertheless in spite of the war, and in spite of the conservatism of soldiers, science and industry will win through. The artillery cycle has come to stay for its period, and there can be no possible doubt that armies will be mechanized.

Lessons of the Three Cycles.—As this is so, the question arises: Can past tactics assist the tacticians of to-day to predict the tactics and army organization of to-morrow? A brief summary of what happened during the last 1,500 years will show that this question can be answered in the affirmative. In the cavalry cycle war as an art virtually disappears because mobility is founded on no stable base. There is no possibility of holding an enemy, consequently movements are chaotic, and it is only when the infantry cycle is well advanced that cavalry tactics once again become an art, movements being replaced by manoeuvres. No sooner has this high order of tactics been established, than the increased power of the musket reduces the power of cavalry, and as cavalry loses power to manoeuvre, infantry becomes paralytic. Infantry can hold infantry, but they have no stable base to manoeuvre from. To make good this deficiency artillery is established as the base of action, and infantry tactics assume a high order. Manoeuvre is again established, but as infantry can move but slowly tactical manoeuvre is largely replaced by strategical manoeuvre, which under Napoleon assumes its highest form. Artillery now becomes so powerful, that infantry, following in the footsteps of cavalry, can no longer develop movement from their artillery base. Artillery then becomes the predominant arm, and as guns cannot move in face of infantry fire, and as infantry can no longer manoeuvre under gun fire, in 1915 the result is static warfare. To reinstate manoeuvre, that is to develop offensive mobility from a protective stable base, the tank, or mobile armoured gun, is introduced. The base of action of the tank is the static gun. In fact the tank bears the same tactical relationship to the horse-drawn gun as the cavalry once did to the infantry.

To-day this inherent defect which characterized the classical artillery cycle can be overcome once it is realized that it is now possible to make a radical change in the element of movement. Hitherto it has been muscular (human or animal); to-day, based as it is on petrol and oil power, it can be made mechanical. Consequently two great categories of artillery can be established, namely, mobile offensive and mobile protective artillery; the second forming the base of action of the first, the second holding and the first hitting the enemy. Thus true manoeuvre is once again rendered possible.

This change in the element of movement will strongly influence the element of protection. Since the initiation of the infantry cycle, protection has in nature been mainly indirect, but in the last war, the full advent of the artillery cycle, it became direct, and, as happened in the classical artillery cycle, it took the form of entrenchments, the symbol and soul of the passive defence. Mechanical power now enables the soldier to replace direct protection as afforded by the trench by direct protection as afforded by armour, as happened in the cavalry cycle, which followed the classical artillery cycle. The influence of this on the last tactical element, namely, weapon-power, will also be most marked, because not only will shock weapons disappear, but the smaller missile-throwing weapons also.

The combination of these remodelled tactical elements will re-establish tactics as an art, and the anatomy of battle will once again take its full form. The decisive point of attack will once again become the rear of the enemy's army. The approach will be made rapidly not only by road but across country, consequently the nature of strategy will be changed. Hitherto strategy has been based on roads and railways, it has been linear. Linear movements demand column formations, but as the artillery cycle develops, area warfare will replace linear warfare, and fronts may be anywhere. The old deployed fronts which protect the rear (the decisive point) in approach and in attack will vanish, and will be replaced by a mobile elastic square within which the old rear will be established; the rear will in fact become the centre. The attack will be divided into the act of demoralization which is more and more likely to be waged against the command of the enemy, the brains of his army, than against the nerves of his men. And the act of decision will aim more at restricting the mobility of the enemy's main force than in physical destruction of its organization. The enemy once held, the act of annihilation will take place.

For naval tactics *see* NAVAL STRATEGY AND TACTICS.

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(J. F. C. F.)

TAEL (tāl). The tael is a Chinese weight of rather more than an ounce. It is usually applied to silver, and as the Chinese internal currency is based upon silver, the tael has become, for many important purposes, the monetary unit of China. This statement, however, is by itself incomplete and requires some explanation and qualification.

The original coinage of China consisted of copper coins known as li or cash. These are minted with a hole through the middle, and as each one is worth only $\frac{1}{40}$ of a penny or so, it was customary to string a whole bundle together. Again nominally, 1,000 cash equal one tael of silver, but this ratio naturally varies with the relative price of copper and silver, and owing to this and also to the confusion into which the Chinese coinage has fallen, the present ratio is rather greater than 1,000.

As already said, the tael represents a definite weight of silver. It is not in internal circulation—for, as shown later, all silver coinage takes the form of dollars of one sort or another—but is used for many important purposes as money of account. Silver is imported in the form of ingots and recast into the form of shoes. This work demands the highest degree of craftmanship, and the shoes are in themselves a work of art. They vary slightly from centre to centre in their silver content, but those of the finest silver are known as "sycee." These shoes are weighed in taels.

Unfortunately the tael is not a constant weight, nor does it consist of fineness of silver. There are many taels in existence, all varying in both these important respects. The most important taels are now described:—

(1) **The Haikwan Tael.**—This weighs about 583·3 grains of silver, 1,000 fine. All customs duties are payable in this tael, and as a result, it forms the unit in which foreign trade and exchange are carried on. The Chinese rate of exchange is always quoted in London in pence to the Haikwan tael, and as a rule foreign bills of exchange are reckoned in and payable in taels (unless drawn in sterling or other foreign currency). This tael thus forms the link between China and abroad, and therefore is the most important of all.

(2) **The Kuping Tael.**—This weighs about 573·9 grains of silver, 1,000 fine. It is the unit in which all Government taxes, other than customs duties, are payable.

(3) **The Shanghai Tael.**—This weighs about 545·25 grains of silver, 980 fine. It is the unit in which northern China trade is carried on, but to further confuse the issue, it is ordained by custom that 98 Shanghai taels weight of silver is full payment for a debt of 109 Shanghai taels in money.

The internal silver currency of China takes the form of silver dollars. The earliest of these was the Carolus dollar. This is now disappearing. Next came the Mexican dollar, which, owing to its high reputation for purity, has enjoyed a wide circulation in many parts of the world. The former Chinese empire at the end of the 19th century tried to coin and introduce its own silver dollar, called the Dragon dollar, while just before the World War, the new Chinese republic introduced a new dollar. The weakness of all Chinese money is that each province has its own mint, which works according to its own rules, with the result that continued debasement has undermined public confidence. The same objection applies to the many note issues.

It is impossible to describe the chaotic condition that has arisen during the troubles of post-war years. All that can be said is that, before China can have a national currency, she must establish a stable national Government. Meanwhile the use of silver taels and silver dollars is well understood by bankers and traders, and provides a satisfactory medium for the conduct of trade. (*See* also Currency.) (N. E. C.)

TAENIA, in architecture, the uppermost member of the architrave (*q.v.*) of one of the classic orders. (*See* Order.) In the Tuscan and Doric orders it is a projecting fillet, decorated, in the Doric order, with the regulae (*q.v.*) and guttae (*q.v.*). In the Ionic, Corinthian and Composite orders it is enriched with one or more mouldings.

TAFARI MAKONNEN, RAS: *see* Makonnen, Ras Tafari.

TAFFETA, a term strictly denoting a light, thin and plain texture of silk possessing a high sheen or gloss and finished in a manner that imparts to it the "rustle" or "scroop" peculiar to certain types of closely-woven, plain silk textures produced from spun silk yarn. The warp and weft may be of corresponding denier or counts, approximately, while the number of warp threads and picks per inch may also correspond. Taffeta is sometimes embellished with a very small brocade or "float" figuring of warp or weft, and may either be woven from skein-dyed yarn, or else piece-dyed after weaving. Some qualities of taffeta fabrics are artificially "loaded" (*i.e.*, weighted) with metallic salts, and are therefore more liable to split or crack when creased or folded. It is used chiefly for dress, millinery and similar purposes.

The word "taffeta," however, is now applied as a description of many other varieties of fabrics produced from silk, wool, cotton and combinations of these materials. Chiffon taffeta is of a softer texture and finish than that of ordinary taffeta. One variety of taffeta is produced from a silk warp and Botany wool weft; while another variety, described as "wool taffeta," is woven entirely of fine wool yarn both for warp and weft, which makes a fine and close texture of light weight, with a smooth surface. Some varieties of taffeta are produced from a cotton warp and fine Botany weft, whilst others are woven entirely with two-fold cotton yarn of fine counts, and finished with a stiff "finish" to simulate the "scroop" peculiar to silk fabrics.

TAFILÁLT or **TAFILET** (*i.e.*, "The Country of the Filáli," as its inhabitants are called, because descended from the Arabian tribe of Hilál, settled there in the 11th century), important oasis of the Moroccan Sahara, ten days' journey south of Fez, across the Atlas. It is celebrated for its dates, to the successful cultivation of which, soon after the arrival of an ancestor of the reigning dynasty of Morocco (hence called the Filáli Sharifs, *i.e.*, descendants of Mohammed) *c.* A.D. 1250, this dynasty owes its rise.

Tafilált is a succession of ksurs (fortified villages) and palm groves which correspond to the zone irrigated by the Wad Ziz, and stretch over a length of about 50 kilometres. It comprises seven districts, Wad-Ifli, Seffalat, Ghorfa, Sifa, Beni-Mohammed, Tanijut, and Wad-Malah; the largest centre is Bu-Am, an important market. The sedentary natives, numbering about 150,000, are exploited by the Aït-Atta nomads, and live in poverty on their palm groves. The industry is the tanning of goat-skins to obtain *filali* leather, which has a great reputation. The *takaut* (*Tamarix articulata*) yields gall for tanning. Since 1648 it has been the custom of Moorish sultans to despatch superfluous sons and daughters to Tafilált. In Ifli, the central portion, formerly existed the town of Sigilmasa, founded by Miknása Berbers in 757 B.C. It was on the direct caravan route from the Niger to Tangier, and attained a considerable degree of prosperity.

The first European to visit Tafilált was Rene Caillie (1828), the next Gerhard Rohlfs (1864). A later visit to the oasis by W. B. Harris is described in his book *Tafilet* (London, 1895).

TAFT, LORADO (1860–), American sculptor, was born at Elmwood, Ill., on April 29, 1860. He graduated at the University of Illinois in 1879, and from 1880 to 1883 studied in the École des Beaux Arts, Paris. In 1886 he became instructor at the Art institute, Chicago, lecturing there, at the Chicago university, and elsewhere in the United States. He was elected to the National Academy in 1911; from 1914 to 1917 he was director of the American Federation of Art. Among his works, in addition to much portraiture, are: "Sleep of the Flowers" and "Awakening of the Flowers," both made for the Columbian exposition; "Despair" (1898); "Solitude of the Soul" (1900) and "Fountain of the Lakes" (1903); "Black Hawk" (1912), figure of an American Indian at Oregon (Ill.); Thatcher memorial fountain (1918) at Denver (Colo.); and "The Fountain of Time" (1920) at Chicago. In 1920 he published *Modern Tendencies in Sculpture;* and in 1924 a new edition of *The History of American Sculpture*, an exhaustive and authoritative work first issued in 1903.

TAFT, WILLIAM HOWARD (1857–), the 27th president and tenth chief justice of the United States, was born in Cincinnati, O., on Sept. 15, 1857. His father, Alphonse Taft, was attorney general in President Grant's cabinet (1876–1877) and minister to Austria (1882–4) and to Russia (1884–5). William Howard Taft graduated second (salutatorian) in his class at Yale college in 1878, and at the Law school of Cincinnati college, in 1880, dividing the first prize for scholarship. In the same year he was admitted to the Ohio bar. In 1881 he was appointed assistant prosecuting attorney of Hamilton county (in which Cincinnati is situated), but resigned in 1882 on being appointed U.S. collector of internal revenue for the first district of Ohio. In 1883 he returned to the law. From 1885 to 1887 he served as assistant solicitor of Hamilton county, and in the latter year was appointed judge of the superior court of Ohio, to fill a vacancy, being elected in the next year. In 1890, he was appointed solicitor-general of the United States by President Harrison. In 1892 he was appointed U.S. circuit judge for the sixth circuit. From 1896–1900 he also served as professor and dean of the law department of the University of Cincinnati.

Governor of Philippines.—In 1900 he was appointed by President McKinley to the presidency of the Philippine commission. He served as such from March 13, 1900 to Feb. 1, 1904, becoming governor *ex officio* on the establishment of civil government, on July 4, 1901 (*see* Philippine Islands). The delicate matter of confiscated church lands was arranged by Taft in a personal interview with Pope Leo XIII., in the summer of 1902. The pope sent a special delegate to appraise the lands, and the sum of $7,239,000 was paid for them in Dec. 1903.

Secretary of War.—In Feb. 1904, Taft returned to the United States to become secretary of war. In Sept. 1906, on the downfall of the Cuban Government and the intervention of the United States he took temporary charge of affairs in that island (Sept.–Oct.). In the next year (March–April) he inspected the Panama canal and also visited Cuba and Porto Rico. He again visited the Philippines to open the first legislative assembly (Oct. 16, 1907). On this tour he visited Japan, and on Oct. 2, at Tokyo, made a speech which had an important effect in quieting the apprehensions of the Japanese on the score of the treatment of their people on the Pacific coast. While secretary of war, Taft entirely reorganized the work of carrying on the construction of the Panama canal, and selected Col. George W. Goethals, whom President Roosevelt put in entire charge of the work. From that moment the enterprise assumed a new vigour, the work was completed and was opened to traffic in 1913.

President.—In 1908 Taft was favoured by President Roosevelt as his successor, and in the November election, was victorious over William Jennings Bryan, the Democratic nominee, by a popular majority of 1,269,900 votes (Taft, 7,679,006; Bryan, 6,409,106) and by a majority of 159 votes in the electoral college. In accordance with his pre-election pledge, he called the Congress to meet in extra session on March 15, 1909, to revise the tariff. The final bill known as the Payne-Aldrich Act was approved by the president on Aug. 5, 1909, although in many respects it was not the measure he desired. The income of the Government under the Dingley tariff had proved inadequate to meet its current expenses, the estimated deficit for the fiscal year ending July 1, 1909, being $100,000,000. He therefore recommended to the Congress the adoption of resolutions to amend the Constitution by expressly granting Congress power to levy an income tax without apportionment among the several States. For the purpose of meeting the immediately anticipated deficiency in the revenues, he recommended the adoption of a provision in the Tariff Bill imposing an annual special excise tax upon corporations organized for profit, measured by a percentage on their net incomes. Pursuant to these recommendations a proposed amendment to the Constitution was passed by both Houses of Congress, afterwards ratified by the requisite number of the States, and became the 16th amendment, and there was included in the Payne-Aldrich Act a provision imposing the proposed annual special excise tax upon corporations, measured by 1% of their net incomes.

Payne-Aldrich Tariff Act.—While the Payne-Aldrich Act was much criticized, because it failed to reduce duties on imports to the extent expected, yet it marked a distinct step towards a lower scale of import duties, and opened the door to the free exchange of commerce with the Philippines. By the enactment of the maximum and minimum tariff provisions, it placed a powerful weapon in the hands of the American Government for the protection of American commerce against unduly discriminatory practices by foreign Governments. It also, for the first time in American history, provided for the establishment of a tariff board to study the questions which lie at the foundation of the protective system.

While Congress was considering the Tariff Bill, the president called upon the heads of the departments of Government to prepare, in advance of the usual time, their estimates for the fiscal year ending June 30, 1911, admonishing them to reduce expenses wherever it could be done. These estimates were then considered by the president and cabinet, and for the first time in American history, a comprehensive budget was prepared. As a result of these efforts, a cut was made of about $55,000,000 in the estimates for the fiscal years 1910 and 1911. In June 1910, the Congress granted the president's request for an appropriation to enable him to employ competent persons to study the methods of transacting the public business of the executive departments and other Government establishments, and to recommend such legislation as might be necessary to carry into effect changes found to be desirable that could not be accomplished by executive action alone. President Taft caused a commission to be organized, and as a result of its studies, sent to Congress four special messages transmitting the reports of the commission, dealing with particular subjects, pointing out defects in the organization and conduct of the business and changes that might be made advantageously.

Federal Budget Urged.—In his message of Jan. 17, 1912, the president called attention to the fact that the United States was the only great nation whose Government was operated without a budget, and recommended the adoption of an annual budget. Nothing was done by Congress in these matters, but many, if not most, of the improvements in the organization and conduct of the administrative branch of the Government which have been adopted in more recent years were first formulated and recommended by President Taft. He also recommended to Congress the enactment of amendments to the interstate commerce law, the establishment of a postal savings bank system, the enactment of laws giving the interstate commerce commission the power to determine upon the uniform construction of appliances used by railway trainmen in the operation of trains and to intervene and investigate the reasonableness of a proposed increase in railway rates before they became effective; of amendments making the Employer's Liability Act more easy to enforce; of laws carrying out with intelligent discrimination the principle of conserving the national resources; the establishment of a national health bureau; requiring publicity of campaign contributions; regulating the procedure of Federal courts concerning the issue of injunctions; and readjusting the regulations concerning postage of second class mail matter. Most of these recommendations were embodied in laws passed by the Congress. By executive order, the President placed the positions of secretaries in the diplomatic service in much the same position as those in the consular service, and introduced into both the principle of appointment for reasons of ascertained fitness and promotion by merit.

Arbitration Treaties.—In 1910 and 1911, President Taft negotiated with the Governments of France and Great Britain identical treaties, signed on Aug. 3, 1913, intended to be models for a series of treaties providing firstly, for the arbitration of all differences which might arise between the parties which it was not possible to adjust by diplomacy, and which were justiciable in their nature, and secondly, for the creation of a joint high commission of inquiry, to which should be referred for impartial investigation, any justiciable controversy between the parties before submission to arbitration, and also any other controversy, even if the parties were not agreed that it fell within the scope of the first article; the report of such commission not to be regarded as a decision on the questions submitted. The first of these provisions embodied in effect the agreement reached in the treaty between the United States and France of Feb. 6, 1928. The second furnished a model for the treaties negotiated by Secretary Bryan in 1914, known as the Bryan Conciliation Treaties. Together, they represented a greater advance in provisions for the peaceful settlement of international controversy than any the world had known. The U.S. Senate qualified its approval by such extensive reservations, that the president withdrew the treaties from further consideration. In 1910, President Taft initiated negotiations with the British Government for the establishment of a reciprocal trade agreement between the United States and the Dominion of Canada. Instead of embodying the desired tariff changes in the formal shape of a treaty, it was agreed that the Governments of the two countries should use their utmost efforts to bring about such changes by concurrent legislation at Washington and Ottawa. It was further agreed that a considerable list of articles produced in both countries should be reciprocally free. As to another group, common rates of duties upon importation from either country into the other were fixed. The proposed legislation was, however, defeated in the dominion parliament, and the effort failed.

As the construction of the Panama canal approached completion, a bill was introduced in Congress to provide for its operation and for the government of the Canal Zone. Taft was of the opinion that as the United States had built the canal at its own expense, it was entitled to permit the use of the canal by American merchant ships without payment of tolls. Great Britain claimed that this would be a violation of the Hay-Pauncefote Treaty. While not admitting the contention, the president expressed his willingness to arbitrate the question. The bill, as passed, embodied the president's views, but the next Congress modified the act by removing the discrimination.

Other Events in Administration.—President Taft's administration was characterized by a systematic and vigorous enforcement of the anti-trust laws. The decisions by the U.S. Supreme Court in 1911, of the prosecutions which had been initiated by President Roosevelt against the Standard Oil trust and the American Tobacco combination, and which were argued in the Supreme Court by Attorney General Wickersham, gave an authoritative interpretation to the act, which was at once put into effect by the Department of Justice, and for the first time after the enactment of the law in 1890, a careful, systematic effort was made by the Government to enforce its provisions. Both the oil trust and the tobacco combination were dissolved in such manner as to restore healthy competition in those industries without destruction of the value of their securities held by innocent parties. A large number of combinations in restraint of trade were either put an end to by judicial process, or voluntarily desisted from a continuance of the practices which had been adjudged to be illegal.

During Taft's administration, many vacancies occurred in the Federal judiciary. He was called upon to appoint six justices of the Supreme Court, including a chief justice. On the death of Chief Justice Fuller, in 1910, President Taft nominated as his successor, Associate Justice Edward D. White, a Democrat, a former Confederate soldier, and a Roman Catholic—a nomination which was confirmed by the Senate at once.

Conservation of the natural resources of the nation was one of the subjects which had greatly occupied the attention of the president and his administration. While Taft was in full sympathy with the objects of this policy, he did not approve of some of the means adopted by that administration. In making up his cabinet, he did not include James R. Garfield, secretary of the interior under President Roosevelt, and on Jan. 7, 1910, he dispensed with the services of Gifford Pinchot, the forester. These men, with a number of other adherents of Roosevelt, initiated a campaign against President Taft, based upon the representation that he was opposed to the conservation policy of Roosevelt. Their first attack upon his Administration was directed against Secretary Ballinger, who had succeeded Garfield. A complaint by L. R. Glavis, an agent in the land office in the Department of the Interior, of Ballinger's action with regard to certain coal land entries in Alaska known as the Cunningham claims, which President Taft on investigation held to be unfounded, and which led to the dismissal of Glavis from the service, gave rise to a Congressional investigation into the conduct of the Interior department by Ballinger. After prolonged hearings a report was made by the committee exonerating secretary Ballinger, but failing to win the confidence of the public, he resigned in the spring of 1911.

In the regular Republican convention at Chicago, the total number of delegates summoned was 1,078, with 540 necessary to a choice. Taft had 561 votes on the first and only ballot and was declared the nominee. Roosevelt and his progressive supporters, claiming that part of his delegates had been stolen through the action of a hostile committee, refused to accept the results of the convention, organized one of their own, known as the "Bull Moose" convention, nominated Roosevelt for the presidency, and carried on an aggressive campaign against Taft, which resulted in splitting the Republican vote in almost every State, and thus electing Woodrow Wilson, the Democratic nominee, as president. The electoral vote was: for Wilson, 435, Roosevelt, 88 and Taft, 8. The popular vote, however (Wilson, 6,285,-214; Roosevelt, 4,126,020; Taft, 3,483,922), showed a much closer contest. This Party schism served in large measure to obscure the merits of President Taft's administration.

Subsequent Career.—On retiring from the presidency in 1913, Taft became Kent professor of law at Yale, but devoted much time to lecture engagements. In the same year he was elected president of the American Bar Association, and in 1914 first president of the American Institute of Jurisprudence, organized to improve law and its administration. Taft was an active promoter of the League to Enforce Peace, but after America's entrance into the World War, he supported the Administration, taking the ground that victory was necessary to the attainment of lasting peace. In 1918, he was appointed by President Wilson a member of the national war labour board for arbitrating labour disputes. In 1919, he endorsed the Peace Treaty of Versailles, regarding its most important part to be the Covenant of the League of Nations. He spoke throughout the country on behalf of the league urging reservations if these would secure ratification. He supported Warren G. Harding, the Republican candidate for president in 1920. On the death of Chief Justice White, on June 30, 1921, he was appointed by President Harding chief justice of the United States.

Taft is the author of *Popular Government; its Essence, its Performance, and its Perils* (1913); *The Anti-Trust Act and the Supreme Court* (1914); *The United States and Peace* (1914); *Ethics in Service*, Yale lectures (1915); *Our Chief Magistrate and His Powers*, Columbia lectures (1916) and *The Presidency: its Duties, its Powers, its Opportunities and its Limitations*, lectures at the University of Virginia (1916). (G. W. Wi.)

TAGALOG, a tribe of eastern Mindanao, in the Philippines, formerly head-hunters, particularly on occasions of the deaths of prominent tribesmen; they made wood or stone figures to accommodate the souls of deceased persons (*Relacion de las Islas Philipinas*, anon., *c.* 1595). They are now Christians, but very superstitious. They practice circumcision, make excellent soldiers, sailors, boat-builders, fishermen and artisans; they are good agriculturalists, cultivating rice on irrigated terraces; they are fond of cock-fighting, and women have equality with men.

See Sawyer, *Inhabitants of the Philippines* (1900).

TAGANROG, a Russian seaport in the North Caucasian area, in 47° 12′ N., 38° 50′ E., on the north shore of the Gulf of Taganrog, which is a north-eastern arm of the Sea of Azov. It is connected by rail with the north, and also with Rostov-on-Don to the east. It has three harbours, and several grain warehouses. The anchorage is 5 to 6 ft. at the loading pier, but there is no regular port accommodation, and the usual anchorage ground, 18 to 20 ft. deep, is 25 to 30 m. from Taganrog. It is icebound for three or four months in winter, and the depth of water near the town may be diminished as much as 7 ft. by a prolonged east wind. Its imports include fruits (dried and fresh), nuts, oil, wine, coffee, tobacco, woollen goods, cement and manufactured iron goods, and its exports grains, macaroni, linseed, rape seed, caviare, wool, butter and oilcake. Many of the exports are brought by lighters or local steamers from Rostov-on-Don. The town has a fishing industry and manufactures metal goods (especially instruments) and paper. A colony was founded on the site by Pisan merchants in the 13th century, but was destroyed by the Mongols. Later it was occupied by the Turks. Peter the Great attempted to gain possession of the promontory, but it was not annexed to Russia until 1769. Its commercial importance dates from the construction of the railway linking it with Kharkov. The Anglo-French fleet bombarded and partially destroyed the town in 1855.

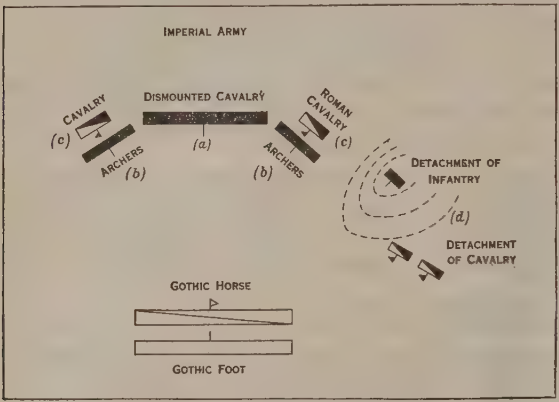
TAGES, a minor Etruscan deity, the grandson of Jupiter, and founder of the art of divination in Etruria. According to the story, during the ploughing of a field near Tarquinii a being of boyish appearance sprang out of the furrow. The shouts of the ploughman (Tarchon) brought to the spot all the people of Etruria, whom the boy proceeded to instruct in the art of divination. Having done this, he suddenly disappeared. His instructions were for some time handed down orally, but were subsequently committed to writing, and formed the twelve books of Tages, containing a complete system of Etruscan lore.

Bibliography.—*See* Cicero, *De Div.* ii. 23; Ovid, *Metam.* xv. 553; Mommsen, *Hist. of Rome* (Eng. tr.), bk. i. ch. 12.

TAGINAE, BATTLE OF (A.D. 552). The battle of Taginae was fought in July 552. It terminated the Gothic Wars of the Emperor Justinian, and was won over the Gothic King

Baduila by the eunuch Narses, a general who in ability rivalled the great Belisarius, his contemporary. Taginae is situated below the Apennines near modern Gubbio. Narses had crossed the head of the valley of the Chiascio when Baduila arrived and seized its main outlet. The Goth ranged the whole of his horsemen in front, his infantry, mostly archers, he drew up in second line. His aim was to ride down the imperial army in one terrific charge.

Belisarius had noted the weakness in the Gothic tactics, namely, that there was no co-operation between lance and bow. Narses now aimed at this co-operation, but in a novel form which closely resembles the combined tactics made use of by Edward III. at Créçy. He dismounted his cavalry (*Foederati*) and formed a phalanx 8,000 strong, on the wings of which he drew up 8,000 archers with their outer flanks thrown forward. In rear of these he posted his Roman cavalry to combine fire and shock. His left flank he rested on a small hill, which he occupied by a force of infantry and at the foot of which he deployed a few squadrons of cavalry.



BATTLE OF TAGINAE (JULY, A.D. 552), WON BY NARSES, GENERAL OF THE EMPEROR JUSTINIAN, OVER BADUILA, KING OF THE GOTHS

At noon Baduila, ignoring the archers, suddenly charged his enemy's centre, expecting to overwhelm it, for infantry he held in contempt. He was met by a tremendous converging fire of arrows which slew and dismounted hundreds of his knights. After several assaults he clinched with the imperial centre—its protective base of action—which held him firm whilst his flanks were plied with arrows. At length, exhausted, the Gothic horsemen broke back, when immediately Narses launched his mounted squadrons driving them in confusion on to their infantry which were ridden over. The victory was complete.

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TAGLIACOZZO, a town of the Abruzzi, Italy, in the province of Aquila, 56 m. by rail E.N.E. of Rome, and 10 m. W. of Avezzano. Pop. (1921) 7,823, town; 8,961, commune. It lies 2,428 ft. above sea-level, at the mouth of the deep ravine of the Imele. It contains several old churches, notably S. Francesco, with a fine rose window in the façade, and mediaeval houses. The palace, built at the end of the 14th century by the Orsini, is fine, with interesting paintings in the interior. At the end of 1268 a battle took place here between Conradin of Hohenstaufen and Charles of Anjou, which resulted in the defeat of Conradin.

TAGORE, SIR RABINDRANATH (1861–), Indian poet and author, was born in Calcutta on May 6, 1861, the youngest son of Maharshi Devendranath and grandson of Prince Dwarkanath Tagore. After a private education in India he was sent to England in 1877 to study law, but soon returned to India, and while still quite young commenced writing for Bengali periodicals. In 1901 he established the famous Shantiniketan, a school at Bolpur, 93 m. from Calcutta, which developed into an important educational institution conducted on unconventional lines, and now approaches an international university. In 1913 Tagore was awarded the Nobel prize for literature, and utilized the amount, £8,000, for the up-keep of his school. He has visited Europe on several occasions and travelled also in Japan and the United States. He accepted a knighthood in 1915, but in 1919 resigned it as a protest against the methods adopted for the repression of disturbances in the Punjab. In later years, however, he offered no objection to the use of this title. Tagore is interested in politics only in so far as it concerns the deeper life of India, and he desires that the nationalist movement should consider social reforms before political freedom. By his abundant writings, which are permeated by a sense of the beauty of the universe, by a love of children and of simplicity, and by a consciousness of God, Tagore has done much to interpret for the West the more serious reflections of the people of Bengal.

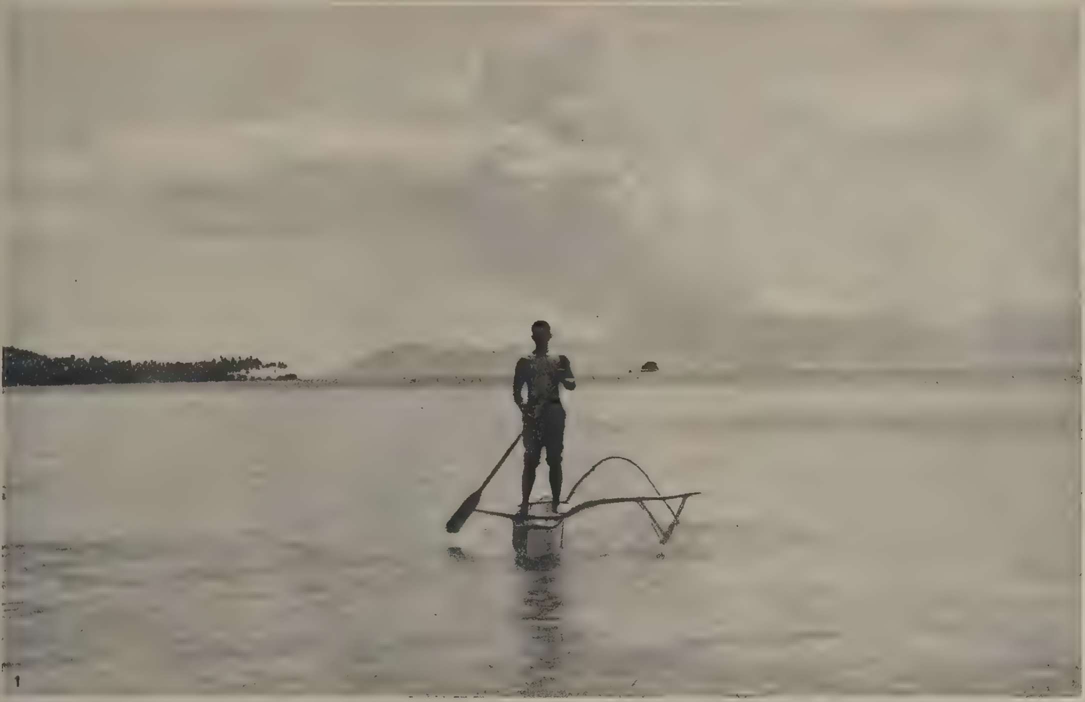
His most important works which have been translated into English are *Gitanjali* (1913); *The Crescent Moon* (1913); *Chitra* (1914); *The Post-Office* (1914); *The Gardener* (1914); *One Hundred Poems of Kabir* (1915); *Fruit-Gathering* (1916); *Stray Bird* (1916); *The Lover's Gift and Crossing* (1917); *Nationalism* (1917); *Lectures on Personality* (1917); *My Reminiscences* (1917); *The Parrot's Training* (1918); *The Home and the World* (1919); *Sakuntala* (1920); *Red Oleanders* (1925). *See* E. Thompson: *R. Tagore, Poet and Dramatist* (Oxford, 1926).

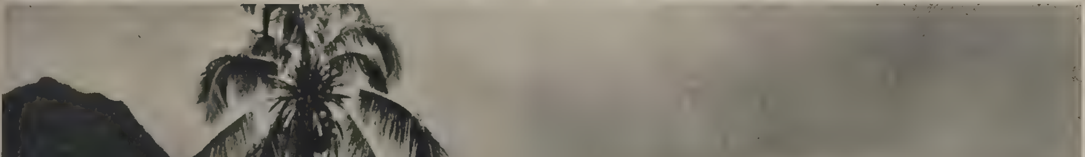
TAGUS, the longest river of the Iberian peninsula. Its length is 565 m., of which 192 are on or within the frontier of Portugal, and the area of its basin is about 31,850 sq.m. The basin is comparatively narrow, and the Tagus, like the other rivers of the Iberian tableland, generally flows in a rather confined valley, often at the bottom of a rocky gorge, as at Toledo and Alcántara, below the general level of the adjacent country. The river rises on the western slope of the Muela de San Juan (5,225 ft.), a mountain which forms part of the Sierra de Albarracin, 88 m. E. of Madrid. Thence the Tagus flows at first north-westwards, but, after receiving the Gallo on the right, it flows west, and then south-west or west-south-west, which is its general direction for the rest of its course. Regular river navigation begins only at Abrantes, a few miles below which the Tagus is greatly widened by receiving on its right bank the impetuous Zezere from the Serra da Estrella. Passing Santarem, the highest point to which the tide ascends, and the limit of navigation for large sailing vessels and steamers, the river divides below Salvaterra into two arms which enclose a deltaic formation, a low tract of marshy alluvium known as the Lezirias, traversed by several minor channels. Both branches terminate in a broad tidal lake immediately above Lisbon (*q.v.*). The Tagus estuary, though partly blocked by a bar of sand, is one of the chief harbours of south-western Europe.

TAHITI, the largest and most important of the French Society islands in the Pacific ocean, in 17° 38′ S., 149° 30′ W. Area about 600 sq.m. and population (1924), 7,145. The chief town is Papeete, with 4,601 inhabitants, of whom 2,126 are French. For an account of the physical structure, climate, flora and fauna and general geography *see* Pacific Islands.

History.—The discovery and early exploration of the Society islands is treated under that heading. In 1788, when Lieutenant Bligh, in the "Bounty," visited Tahiti, the leading chief was Pomare, whose family had been pre-eminent in the island for more than a century. Aided by 16 of the "Bounty" mutineers, and armed with guns procured from Bligh and a Swedish vessel, Pomare greatly strengthened his power and brought to a successful close a long struggle with Eimeo.

The attempt at colonization by the Spaniards in 1774 was followed by the settlement of 30 persons brought, in 1797, by the missionary ship "Duff." Though befriended by Pomare I. (who lived till 1805), they had many difficulties, especially from the constant wars, and at length they fled with Pomare II. to Eimeo and ultimately to New South Wales, returning in 1812, when Pomare renounced heathenism. In 1815 he regained his power in Tahiti. For a time the missionaries made good progress—a printing press was established (1817), and coffee, cotton and





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SCENES IN TAHITI

1. Tahitian pearl diver in outrigged canoe. These natives become very proficient in the art of managing their tiny craft. A delicate sense of balance is one of their necessary qualifications
2. Inland view of Tahiti showing conical peaks, coconut palms and luxuriant undergrowth characteristic of the island's landscapes

sugar were planted (1819); but soon there came a serious relapse into heathen practices and immorality. Pomare II. died of drink in 1824. His successor, Pomare III., died in 1827, and was succeeded by his half-sister Aimata, the unfortunate "Queen Pomare (IV.)." In 1828 a new fanatical sect, the "Mamaia," arose, which gave much trouble to the missions. The leader proclaimed that he was Jesus Christ, and promised to his followers a sensual paradise. In 1836 the French Catholic missionaries in Mangareva attempted to open a mission in Tahiti. Queen Pomare, advised by the English missionary and consul, Pritchard, refused her consent, and removed by force two priests who had landed surreptitiously and to whom many of the opposition party in the state had rallied. In 1838 a French frigate appeared under the command of Abel Dupetit-Thouars, and extorted from Pomare the right of settlement for Frenchmen of every profession. Pritchard opposed this, and caused Pomare to apply for British protection; but this was a failure, and the native chiefs compelled the queen, against her will, to turn to France. A convention was signed in 1843, placing the islands under French protection, the authority of the queen and chiefs being expressly reserved. Dupetit-Thouars now reappeared, and, alleging that the treaty had not been duly carried out, deposed the queen and took possession of the island. His high-handed action was not countenanced by the French Government; but while, on formal protest being made from England, it professed not to sanction the annexation, it did not retrace the steps taken. Two years were spent in reducing the party in the islands opposed to French rule; an attempt to conquer the western islands failed; and at length, by agreement with England, France promised to return to the plan of a protectorate and leave the western islands to their rightful owners. Pomare died in 1877, and her son Ariane (Pomare V.) abdicated in 1880, handing over the administration to France, and in the same year Tahiti, including Eimeo, was proclaimed a French colony. In 1903 the whole of the French establishments in the Eastern Pacific were declared one colony, and the then existing elective general council was superseded by the present administration. Since this Federation more trade has visited Tahiti and in 1925 a constant service of shipping between Papeete, the Tuamotus, Marquesas, Leeward islands and San Francisco was increased by four steamers.

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TAHR (*Hemitragus jemlaicus*), a shaggy-haired, brown Himalayan wild goat, characterized by its short, triangular and sharply keeled horns. Besides the tahr the genus includes the wariatu or Nilgiri ibex (*H. hylocrius*), from south India, and the smaller *H. jayakeri*, from south Arabia. Tahr frequent the worst ground of all ruminants.

TAILLE, the equivalent of the English *tallage* (*q.v.*), was in France the typical direct tax of the middle ages, just as the word *tonlieu* was the generic term for an indirect tax. Other words used in certain districts in the same sense as *taille* were *queste* (*questa, quista*), *fouage* (*foragium*), *cote.* The essence of the tax denoted by these names was that the amount was fixed *en bloc* for a whole group of persons, and afterwards divided among them in various ways. In ancient French law we find three forms of *taille:* the *taille servile*, *taille seigneuriale* and *taille royale.*

The *taille servile* can scarcely be termed a tax; it was rather a tax which had degenerated into a source of profit for certain individuals. Every lord who possessed serfs could levy the *taille* on them, and originally this was done arbitrarily (*a volonté*) both as to frequency and amount. It always remained a characteristic feature of serfdom, but was limited and fixed, either by contracts or concessions from the lord (*taille abonnée*), or by the customs.

The *taille seigneuriale* was a true tax, levied by a lord on all his subjects who were neither nobles nor ecclesiastics; but the writer holds that, when feudalism was set up, the right to levy it did not belong to every lord, but only to the lord having the *haute justice.* But he levied it by right, without the necessity for any contract between him and those who paid it. He fixed the sum to be paid by each group of inhabitants, who then had to see that it was assessed, collected and paid to the lord, electing commissaries (*preud hommes*) from among themselves for this purpose. The seigniorial *taille,* like the servile, had the character of a personal tax (*taille personelle*), a rudimentary tax on income, every man being taxed according to his wages or other income. The king originally had only the right of levying the *taille* in places where he had retained the exercise of the *haute justice.* At that time there was no royal *taille,* strictly speaking; it was only the seigniorial *taille* transferred to the Crown, but it was one of the first taxes his right to levy which upon all the inhabitants of the domain of the Crown, whether serfs or *roturiers,* was recognized. The general *taille,* for the benefit of the king, became more frequent, and tended to become permanent. This transformation was confirmed, rather than effected, by the *ordonnance* of 1439. Its immediate object was, not the regulation of the *taille,* but the organization of the *compagnies d'ordonnance, i.e.,* the heavy cavalry which the king from that time on maintained on a permanent footing. Military expenses thus becoming permanent, it was natural that the *taille*, the tax which had long been devoted to meeting the expenses of the royal wars, should also become permanent. This was contained implicitly in the *ordonnance* of 1439, which at the same time suppressed the seigniorial *taille,* as competing too closely with the royal *taille* by imposing a double burden on the taxpayer. A kind of seigniorial *taille* continued to exist besides the servile *taille,* but this kind presupposed a title, a contract between the taxable *roturier* and the lord, or else immemorial possession, which amounted to a title. (*See* FRANCE: *Law and Institutions.*)

Throughout the *pays d'élections* the *taille* was almost universally personal (*taille personnelle*); *i.e.,* a tax on the whole income of the taxpayer, whatever its source. It was also a distributory tax (*impôt de repartition*); every year the king in his council fixed the total sum which the *taille* was to produce in the following year; he drew up and signed the *brevet de la taille* (warrant), and the contribution of the individual taxpayer was arrived at in the last analysis by a series of subdivisions.

In certain districts the *taille* was real (*taille reelle*); *i.e.,* a tax on real property. It was not an equal tax falling on all landowners, but the question as to whether a certain estate was to be taxed or not was decided according to the quality of the property, and not that of the owner. The *biens nobles* (*fiefs*) and the *biens ecclesiastiques* were exempt; *tenures roturières,* however, by whomsoever held, were taxed. A small part of the *pays d'élections* was also *pays de taille réele.* But it was the chief form of tax in the *pays d'états,* and even there an attempt had generally been made to check the exemption of nobles' property. It has been shown that in these districts the *taille* had originally been personal, having become real by a curious evolution. In these districts there were *cadastres,* or *compoix-terriers* (land registers), which allowed of a non-arbitrary assessment; and at the end of the *ancien régime* merely needed revision.

In certain provinces where the royal *taille* was levied there were neither *élections* nor *généralités,* and the whole administration of the tax was in the hands of the *intendants.* These were the provinces of the east and north, which were united to the Crown at a period when the power of the *intendants* was already fully developed; they were sometimes known as *pays d'imposition.*

See FRANCE: *Law and Institutions;* Auger, *Code des tailles* (1788); Henri Sée, *Les Classes rurales et le régime domanial en France au Moyen Âge* (1901). (J. P. E.; X.)

TAILLEFER, the surname of a bard and warrior of the 11th century, whose exact name and place of birth are unknown. He accompanied the Norman army to England in 1066, and obtained permission from William to strike the first blow at the battle of Hastings, where he was killed. Mention of Taillefer is made by Guido, bishop of Amiens, in his *Carmen de bello Hastingensi,* v. 931–944 (in *Mon. Hist. Brit.,* 1848) and by Henry of Huntingdon in his *Historia Anglorum* (in *Rer. Brit. med. aevi script.,* p.

763, ed., Arnold, London, 1879); and his prowess is depicted on the Bayeux tapestry. The statement of Wace in the *Roman de Rou,* 3rd part, v. 8035–62, ed. Andresen (Heilbronn, 1879), that Taillefer went before the Norman army singing of Charlemagne and of Roland and the vassals who died at Roncevaux, has been considered important in demonstrating the existence of a comparatively early tradition and song of Roland.

See W. Spatz, *Die Schlacht von Hastings* (Berlin, 1896); Freeman, *History of the Norman Conquest.*

TAILOR, one who cuts out and makes clothes (Fr. *tailleur,* from *tailler,* to cut, Lat. *talea,* a thin rod, a cutting for planting). Formerly the tailor, or *cissor,* made apparel for both men and women, and not merely outer garments, but also articles of linen and the padding and lining of armour—whence the style "Taylors and Linen Armourers" applied to the Merchant Taylors Company of the City of London in their earliest charters. But the word is now generally limited to those who make the outer (cloth) garments for men, and less frequently for women, though a phrase such as "shirt-tailor" is occasionally met with. In modern usage, too, it commonly has the implication that the garments are made to the order, and to the measure, of the individual purchaser, as opposed to ready-made clothing, which means articles of apparel manufactured in large quantities in a series of stock or standard sizes, such that any purchaser may expect to find among them one that will fit him with more or less accuracy. The clothing trade was originally confined to goods of the poorest grades, but it has come, both in Great Britain and in America, to include articles of good, though not of the first, quality. It probably first came into existence at seaport towns, where, to meet the convenience of sailors returning from long voyages and requiring their wardrobes to be replenished at short notice, the "outfitters" kept stocks of ready-made garments on sale; but it made no considerable progress until after the middle of the 19th century, when the introduction of the sewing-machine brought about the possibility of manufacturing in large quantities. Its development was attended with gradually increasing subdivision of labour and, to a large extent, with the disappearance of the tailor as a skilled craftsman.

The first step was for a garment, such as a coat, to be completed by the joint efforts of a family. Then followed the "task system," which in America was the result of the influx of Russian Jews that began about 1875. Under it a team of three men, with a "presser" and a girl to sew on the buttons, divided the work between them. Payment was made by the "task," *i.e.,* a specified number of garments, the money being divided between the members of the team in certain proportions. Often several teams would be run by a contractor, who naturally selected the cheapest workshops he could find and packed them as full of workers as possible; and when through stress of competition he had to accept lower prices the plan he adopted was to increase the number of garments to a task, leaving the pay unaltered. The result was the introduction of many of the worst features of the "sweating system," the workers having to work excessively long hours in order to finish the task, which in some cases meant as many as 20 coats a day. In the "factory" or "Boston" system the subdivision is still more minute, and as many as 100 persons may be concerned in the production of one coat. The amount of tailoring skill required in a worker is even further reduced, but the premises come under the regulation of the factory laws. The factory system has also cheapened production in a legitimate way, because it has enabled mechanical power for driving sewing-machines, and also expensive labour-saving machinery, to be introduced to an extent not practicable in small shops. (*See* CLOTHIERS; *Wholesale.*)

TAIN, royal and police burgh and parish, county of Ross and Cromarty, Scotland. Pop. (1921) 1,551. It is within 1 m. of Dornoch Firth, 25½ m. N.E. of Dingwall by the L.M.S.R. The name is from the Icelandic *thing,* "assembly" or "court." The industries include distilling and woollen manufactures, and the town is a market and distributing centre. In the centre of the town is a picturesque tower, once a gaol. Duthac (locally called Duthus), a saint of the 11th century, is believed to have been a native, and the ruined chapel near the station is supposed to have been his shrine. To the collegiate church of St. Duthus, a Decorated building, founded by James III. in 1471, James IV. made several pilgrimages in penance for his father's death. The building was used as the parish church till 1815, when it fell into disrepair, but it was restored between 1871 and 1876. It has monuments to Patrick Hamilton, the martyr, and Thomas Hog (1628–1692), the Scottish divine. Three and a half miles S.E. are the remains of the Early English abbey of Fearn, founded at Edderton in 1230 by Farquhar, 1st earl of Ross, and transferred hither in 1338. Patrick Hamilton became titular abbot in 1517, and after his martyrdom the abbey was added to the bishopric of Ross.

TAINE, HIPPOLYTE ADOLPHE (1828–1893), French critic and historian, the son of Jean Baptiste Taine, an attorney, was born at Vouziers on April 21, 1828. J. B. Taine died on Sept. 8, 1840, leaving a moderate competence to his widow, his two daughters, and his son. Taine was educated at the Collège Bourbon, where he formed lifelong friendships with Prévost-Paradol, for many years his most intimate friend, Planat, the future "Marcelin" of the *Vie Parisienne,* and Cornélis de Witt, who introduced him to Guizot when the latter returned from England in 1846. Taine passed from the Collège Bourbon to the École Normale, but in 1851 he was refused the fellowship in philosophy which was universally regarded as his due. Nevertheless the minister of public instruction appointed him to a professorship at Toulon, which he exchanged for one at Nevers. But he refused to express explicit approval of the coup d'état of Dec. 27, 1851. Consequently he was removed to an inferior post; next year saw a further step downward, and he accordingly applied for, and received, indefinite leave of absence. In a few months his two dissertations, *De personis Platonicis* and the essay on La Fontaine's fables were finished, and May 30, 1853 he took his doctor's degree. This was the last act of his university career; his life as a man of letters was now to begin.

No sooner had he deposited his dissertations at the Sorbonne than he began to write an essay on Livy for one of the competitions set by the Academy. Here again the moral tendency of his work excited lively opposition, and after much discussion the competition was postponed till 1855; Taine toned down some of the censured passages, and the work was crowned by the Academy in 1855. In the beginning of 1854 Taine, after six years of uninterrupted effort, broke down and was obliged to rest. The year 1854 was an important one in the life of Taine. His enforced leisure, the necessity of mixing with his fellowmen, and of travelling, tore him from his cloistered existence and brought him into more direct contact with reality. He lived with his mother in the Isle Saint-Louis, and now he once more associated with his old friends, Planat, Prévost-Paradol and About. He made the acquaintance of Renan, and through Renan that of Sainte-Beuve, and he renewed friendly relations with M. Havet, who for three months had been his teacher at the École Normale. These years (1855–56) were Taine's periods of greatest activity and happiness in production. In 1855 he published seventeen articles in the *Revue de l'Instruction publique,* and twenty in 1856 on the most diverse subjects, ranging from Menander to Macaulay. From 1857 onwards he was a regular contributor to the *Journal des Débats.*

But he was seeking a larger field. In January 1856 his history of English literature was announced, and in 1855–56 he published in the *Revue de l'Instruction publique* a series of articles on the French philosophers of the 19th century, which appeared in a volume at the beginning of 1857. In this volume he energetically attacked the principles which underlie the philosophy of Victor Cousin and his school. The book closes with the sketch of a system in which the methods of the exact sciences are applied to psychological and metaphysical research. The work itself met with instantaneous success, and Taine became famous. In 1858 appeared a volume of *Essais de Critique et d'Histoire;* in 1860 *La Fontaine et ses Fables,* and a second edition of the *Philosophes Français.*

In 1864 Taine succeeded Viollet-le-Duc as professor of the history of art and aesthetics at the École des Beaux Arts. Renan's appointment at the Collège de France and Taine's candidature for the Polytechnic School had alarmed Mgr. Dupanloup, who in 1863 issued an *Avertissement à la Jeunesse et aux Pères de Famille,* which consisted of a violent attack upon Taine, Renan and Littré: Renan was suspended, and Taine's appointment to Saint Cyr would have been cancelled but for the intervention of the Princess Mathilde. In December 1863 his *Histoire de la Littérature Anglaise* was published, prefaced by an introduction in which Taine's determinist views were developed in the most uncompromising fashion. In 1864 Taine sent this work to the Academy to compete for the Prix Bordin. M. de Falloux and Mgr. Dupanloup attacked Taine with violence; he was warmly defended by Guizot: finally, after three days of discussion, it was decided that as the prize could not be awarded to Taine, it should not be awarded at all. After three attempts to secure admission to the Academy Taine was elected in November 1878.

The period from 1864 to 1870 was perhaps the happiest of Taine's life. He derived pleasure from his employment at the Beaux Arts and Saint Cyr, which left ample leisure for travel and research. In 1865 appeared *La Philosophie de l'Art,* in 1867 *L'Idéal dans l'Art,* followed by essays on the philosophy of art in the Netherlands (1868), in Greece (1869), all of which short works were republished later (in 1880) as a work on the philosophy of art. In 1865 he published his *Nouveaux Essais de Critique et d'Histoire;* from 1863 to 1865 appeared in *La Vie Parisienne* the notes he had taken for the past two years on Paris and on French society under the sub-title of "Vie et Opinions de Thomas Frédéric Graindorge," published in a volume in 1867, the most personal of his books, and an epitome of his ideas. In 1867 appeared a supplementary volume to his history of English literature, and in January 1870 his *Théorie de l'Intelligence.* In 1868 he married Mademoiselle Denuelle, the daughter of a distinguished architect. He had made a long stay in England in 1858, and had brought back copious notes, which, after a second journey in 1871, he published in 1872 under the title of *Notes sur l'Angleterre.*

Taine, deeply shaken by the events of 1870, now felt that it was the duty of every Frenchman to work solely in the interests of France. On Oct. 9, 1870 he published an article on "L'Opinion en Allemagne et les Conditions de la Paix," and in 1871 a pamphlet on *Le Suffrage Universel;* and his intention of writing on the French Revolution returned in a new and definite shape. He determined to trace in the Revolution of 1789 the reason of the political instability from which modern France was suffering. From the autumn of 1871 to the end of his life his great work, *Les Origines de la France Contemporaine,* occupied all his time, and in 1884 he gave up his professorship in order to devote himself wholly to his task; but he succumbed before it was finished, dying in Paris on March 9, 1893.

Les Origines de la France Contemporaine, Taine's monumental achievement, stands apart from the rest of his work. The problem which Taine set himself was to inquire why the centralization of modern France is so great that all individual initiative is practically non-existent, and why the central power, whether it be in the hands of a man or of an assembly, is the sole and only power; also to expose the error underlying two prevalent ideas:—(1) That the Revolution destroyed absolutism and set up liberty; the Revolution, he points out, merely caused absolutism to change hands. (2) That the Revolution destroyed liberty instead of establishing it; that France was less centralized before 1789 than after 1800. This also he shows to be untrue. France was already a centralized country before 1789, and grew rapidly more and more so from the time of Louis XIV. onwards. The Revolution merely gave it a new form. The *Origines* differ from the rest of Taine's work in that, although he applies to a period of history the method which he had already applied to literature and to the arts, he is unable to approach his subject in the same spirit; he loses his philosophic calm; he cannot help writing as a man and a Frenchman, and he lets his feelings have play; but what the work loses thus in impartiality it gains in life.

Taine was the philosopher of the epoch which succeeded the era of romanticism (1820–50) in France. The ideal of the newer generation was truth; their watchword liberty; to get as near as possible to scientific truth became their object. Taine must ever be regarded as one of the most authoritative spokesmen of this period.

Taine served science unfalteringly, without looking forward to any possible fruits or result. In his work we find neither enthusiasm nor bitterness, neither hope nor yet despair; merely a hopeless resignation. The study of mankind was Taine's incessant preoccupation, and he followed the method already described. He made a searching investigation into humanity and his verdict was one of unqualified condemnation. In "Thomas Graindorge" we see him aghast at the spectacle of man's brutality and woman's folly. In man he sees the primeval savage, the gorilla, the carnivorous and lascivious animal, or else the maniac with diseased body and disordered mind, to whom health, either of mind or body, is but an accident. Taine is appalled by the *bête humaine;* and in all his works we are conscious, as in the case of Voltaire, of the terror with which the possibilities of human folly inspire him. It may be doubted whether Taine's system, to which he attached so much importance, is really the most lasting part of his work. For Taine was an artist as well as a logician, an artist who saw and depicted what he saw in vital and glowing language. From the artist we get his essay on La Fontaine, his articles on Balzac and Racine, and the passages on Voltaire and Rousseau in the *Ancien Régime.* Moreover, not only was Taine an artist who had not escaped from the influence of the romantic tradition, but he was by his very method and style a romanticist. His emotions were deep if not violent, his vision at times almost lurid. He sees everything in startling relief and sometimes in exaggerated outline, as did Balzac and Victor Hugo. Hence his predilection for exuberance, strength and splendour; his love of Shakespeare, Titian and Rubens; his delight in bold, highly-coloured themes.

Taine's influence was great, and twofold. On his own generation it was considerable; during the epoch in which he lived, while a wave of pessimism was sweeping over French literature, he was the high priest of the cult of misanthropy, in which even science was held to be but an idol, worthy of respect and devotional service, but not of faith. In its turn came the reaction against positivism and pessimism, and an attempt at spiritual renascence. Around a man so remarkable as Taine a school is certain to form itself; Taine's school, which was one of positivist doctrines, rigid systems and resigned hopelessness, was equally certain to produce at some time or another a school of determined opponents to its doctrines and system. If, therefore, the tone which pervades the works of Zola, Bourget and Maupassant can be immediately attributed to the influence we call Taine's, it is also the influence of Taine which is one of the ultimate causes of the protest embodied in the subsequent reaction. (M. Bg.; X.)

Bibliography.—The official life, *H. Taine, sa vie et sa correspondance,* was published in 3 vols. in 1902–05 (Eng. trans. by Mrs. R. L. Devonshire, 1902–08). His friend, M. E. Boutmy, published an appreciative study of Taine's philosophy in his *Taine, Scherer, Laboulaye* (Paris, 1901). *See* also A. Sorel, *Nouveaux essais d'histoire et de critique* (1898); Gabriel Monod, *Les Maîtres de l'histoire* (Paris, 1894); Émile Faguet, *Politiques moralistes au XIXe siècle* (Paris, 1900); P. Lacombe, *La psychologie des individus et des sociétés chez Taine* (1906); P. Nève, *La philosophie de Taine* (1908); Victor Giraud, *Essai sur Taine, son oeuvre et son influence, d'après des documents inédits* (2nd ed., 1902); *Bibliographie de Taine* (Paris, 1902). A comprehensive list of books and articles on Taine is given in H. P. Thieme, *Guide bibliographique de la littérature française de 1800 à 1906* (Paris, 1907). For criticisms of Taine's historical work, *see* A. Aulard, *Taine, historien de la Révolution française* (1907); P. Lacombe, *Taine, historien et sociologue* (1909). *See* also A. Laborde-Mataa, *H. Taine* (1909); O. Engel, *Der Einfluss Hegels auf die Bildung der Gedankenwelt H. Taines* (Stuttgart, 1920); M. Barrès, *Taine et Renan* (1922); F. C. Roe, *Taine et l'Angleterre* (1923).

TAIT, ARCHIBALD CAMPBELL (1811–1882), English divine, archbishop of Canterbury, was born at Edinburgh on Dec. 21, 1811, of Presbyterian parents. He entered Balliol college in 1830 as a Snell exhibitioner from the University of Glasgow. He became fellow and tutor of Balliol and was also ordained deacon (1836) and priest (1838), and served the curacy of Baldon. He never sympathized with the principles of the Tractarian movement, and on the appearance of Tract 90 in 1841 he drafted the famous protest of the "Four Tutors" against it; but this was his only important contribution to the dispute. In 1842 he succeeded Arnold as headmaster of Rugby; and, after a serious illness in 1848, accepted a less strenuous appointment as dean of Carlisle in 1849. During his residence at Carlisle he served on the University Commission, restored his cathedral and did much excellent pastoral work. There too he suffered the great sorrow of his life. He had married Catharine Spooner at Rugby in 1843; in the spring of 1856, within five weeks, five of their children died of scarlet fever. He was consecrated bishop of London on Nov. 22, 1856. He became archbishop of Canterbury in 1868. His last years were interrupted by illness and saddened by the death in 1878 of his only son Craufurd, and of his wife.

Tait was constant in his attendance in parliament, and pressed on many measures of practical utility. The modification of the terms of clerical subscription (1865), the new lectionary (1871), the Burials Act (1880) were largely owing to him; for all of them, and especially the last, he incurred much obloquy at the time. The Royal Commissions on Ritual (1867) and on the Ecclesiastical Courts (1881) were due to him, and he took a large part in the deliberations of both.

Tait was less successful in dealing with matters which called for the higher gifts of a ruler, and especially in his relations with (*a*) the liberal trend in modern thought, and (*b*) the Catholic revival. (*i.*) His object in dealing with questions of faith, as in dealing with the ritual question, was primarily a practical one: he wished to secure peace, and obedience to the law as he saw it. Consequently, after his sympathies had led him to express himself favourably towards some movement, he frequently found himself compelled to draw back. He expressed a qualified sympathy with some of the writers of *Essays and Reviews,* and then joined in the censure of it by the bishops (1861). The same kind of apparent vacillation was found in his action in other cases; *e.g.*, in the Colenso case (1863), and in the controversy as to the use or disuse of the Athanasian symbol (1872). (*ii.*) Tait was concerned with the Catholic revival during the whole of his episcopate, and above all on the side of ritual. He had to deal with the St. George's-in-the-East riots in 1859, and the troubles at St. Alban's, Holborn, in their earlier stages (1867); he took part as assessor in the Privy Council judgment in the Ridsdale case (1877); he was more closely concerned than any other bishop with the agitation against confession in 1858, and again in 1877. His method throughout was the same: he endeavoured to obtain a compliance to the law as declared by the courts; failing this, he made the most earnest efforts to secure obedience to the ruling of the Ordinary for the sake of the peace of the Church; after this, he could do nothing. In fact Tait could hardly realize anything but the connection between the English Church and the State. From such a position there seemed to be no escape but in legislation for the deprivation of the recalcitrant clergy; and the Public Worship Regulation Act (1874) was the result. A widespread feeling of indignation spread not only among High Churchmen, but among many who cared little for the ritual practices involved. At length, when A. H. Mackonochie was on the point of being deprived of his benefice of St. Alban's, Holborn, for contumacy, the archbishop, then on his deathbed at Addington, took steps which resulted in the carrying out of an exchange of benefices (which had already been projected), which removed him from the jurisdiction of the court. This proved to be the turning-point; and the ritual difficulty was afterwards dealt with from a different point of view, and the Public Worship Regulation Act became practically obsolete. The archbishop died on Dec. 3, 1882.

See R. T. Davidson and D. Benham, *Life of Archbishop Tait,* 2 vols. (1891); A. C. Tait, *Catharine and Craufurd Tait* (1880).

TAIT, PETER GUTHRIE (1831–1901), Scottish physicist, was born at Dalkeith on April 28, 1831. After attending the Academy at Edinburgh and spending a session at the University, he went up to Peterhouse, Cambridge. As a fellow and lecturer of his college he remained in Cambridge until 1854, and then left to take up the professorship of mathematics at Queen's college, Belfast. There he joined Thomas Andrews (*q.v.*) in researches on the density of ozone and the action of the electric discharge on oxygen and other gases. From 1860 to 1901 he was professor of natural philosophy at Edinburgh, where he died on July 4, 1901.

His earliest work dealt mainly with mathematical subjects, and especially with quaternions (*q.v.*), of which he may be regarded as the leading exponent after their originator, Hamilton. With the help of Hamilton and Philip Kelland (1808–1879), he wrote two text books, *Elementary Treatise on Quaternions* (1867), and *Introduction to Quaternions* (1873). He also produced original work in mathematical and experimental physics. In 1864 he published a short paper on thermodynamics, and from that time his contributions to that and kindred departments of science became frequent and important. He worked on thermoelectricity and thermal conductivity, its variation with temperature and its relation to the electrical conductivity of the same material. (*See* HEAT.)

From 1879 to 1888 he was engaged on difficult experimental investigations, which began with an inquiry into the corrections required, owing to the great pressures to which the instruments had been subjected, in the readings of the thermometers employed by the "Challenger" expedition (*q.v.*) for observing deep-sea temperatures, and which were extended to include the compressibility of water, glass and mercury. Between 1886 and 1892 he published a series of papers on the foundations of the kinetic theory of gases; and about the same time he carried out investigations into impact and its duration.

A selection only from his papers, published by the Cambridge University Press, fills three large volumes. With Lord Kelvin he collaborated in writing the well-known *Treatise on Natural Philosophy.* "Thomson and Tait," as it is familiarly called, but only the first part of it was ever completed.

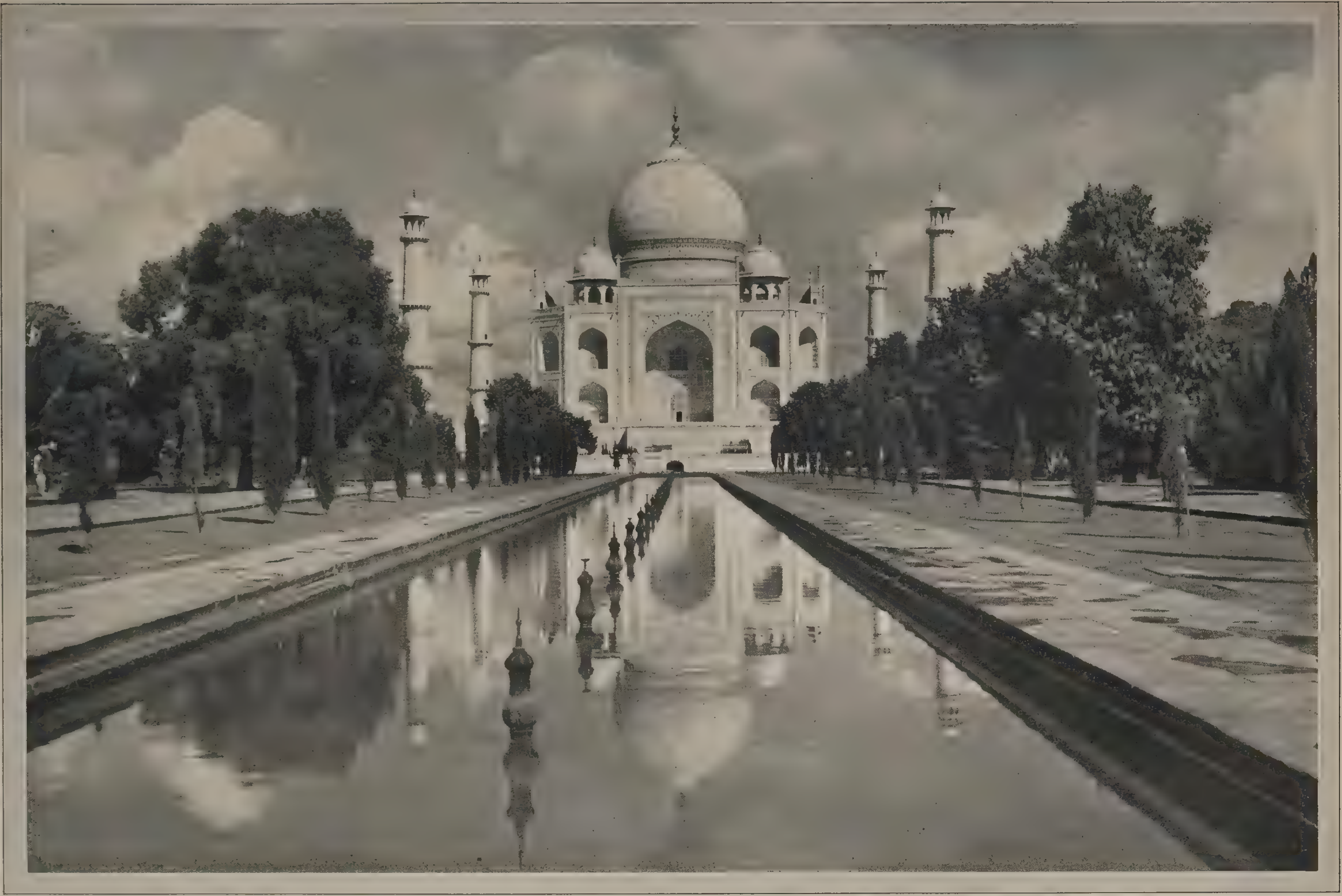
Tait collaborated with Balfour Stewart in the *Unseen Universe* which was followed by *Paradoxical Philosophy.*

TAI-YUAN, the chief city of the province of Shansi, China, first noticed about A.D. 450, but greatly developed after the expulsion of the Mongols by the building of a great wall in 1377. Its exposure to attack from Mongolia was the reason for this. It is situated on the Fen-ho river, in a well-peopled plain with many good villages, and is at an altitude of about 2,560ft. above sea-level. The valleys of the plain nearly all have coal mines, and coal is taken by cart to the capital, the population of which was estimated, early in the century, at a quarter of a million, but has been more recently calculated at about 80,000. It formerly made weapons. It has a university and is the terminus of a railway line from the east, which branches from the Peking-Hankow main line. Meteorological observations kept here show a rainfall of 11·6in. per annum, mainly from May to August, more than half the total falling in July, the month of highest average temperature (76·6°). The January average temperature is as low as 18·0°, and in most years a temperature as low as 4·5° is the average minimum for that month.

TAJIK, a subject race of Afghanistan, but the original Persian possessors of the soil, who still speak their mother tongue. The word as now used properly means Arab and was applied to those communities where Arabs settled at the time of the first Arab conquest. They are agriculturalists, organized in village communities, sometimes tenants of Afghan overlords, with headmen in their own villages. They are Sunnites. See *Tribes and Castes of the Punjab and N.W. Frontier Province,* vol. iv. (1914).

TAJIK REPUBLIC, an A.S.S.R. of Russian Central Asia, created in 1924, and lying between the Kirghiz A.S.S.R. on the north, and Afghanistan on the south, and between Uzbekistan on the west and Chinese Turkestan on the east. It consists of the great knot of mountain and plateau belonging to the Pamir-Alai system on the west of the Sarikol range.

Geography and Climate.—The boundary between Russia and Afghanistan, as laid down by the Pamir Boundary Commission in 1895, goes along the Lake Victoria affluent of the Oxus and eastwards along the Nicholas range, dividing the Great and Little Pamirs, so that all the head of the Little Pamir and the Wakhan valley lie in Afghanistan. The Alichur, Rang Kul, Kargosh (Kara Kul) and Sarez Pamirs are in the Tadzhik Republic; a *pamir*



BY COURTESY OF HERBERT G. PONTING, F.R.P.S.

THE TAJ MAHAL, SUPREME ACHIEVEMENT OF MOHAMMEDAN ART

This mausoleum of white alabaster was built (1629–1650) near Agra, India, by Shah Jahàn as the burial place for his favourite wife, Mumtaz-i-Mahal. The magnificent exterior is covered with arabesques and passages from the Koran in inlays of precious stones

(Persian *pai-mir* or foot of the mountain peak), is a valley stretching upward in a long slope to the mountain peak, and these high level valleys (Lake Victoria has an altitude of 13,400 ft.) are mainly of glacial formation. The chief ridges crossing the republic are the Turkestan, Zarafshan, Hissar, Trans-Alai, Peter the Great and Darvas. Mt. Kaufmann (23,386 ft.) is the highest peak in the U.S.S.R.

The eastern part of the republic is characterized by broad flat-bottomed valleys, with a series of lakes and low watersheds, and by a severe and dry climate, with an average January temperature as low as that of Novaya Zemlya. The range between day and night temperature is the greatest in the world, and in nine years only 2·3 in. of rain were recorded; this region is bleak and deserted. Of the lakes, Kara-kul (*q.v.*) is the largest, others are Shor-kul, Rang-kul, Yashil-kul, Zor-kul and Sarez. The latter was formed in 1911, from the Murgab (Bartang) river after an earthquake in consequence of which the stream was dammed up by a huge avalanche; Lake Yashik-kul was formed in a similar way.

The Amu-Daria or Oxus is the chief waterway, and under the name of Pandjh, serves as a boundary between Tadzhikstan and Afghanistan; it rises in the Hindu Kush as the Vakhan-darya. Most of the glacier-fed streams in the republic are tributaries of the Amu Daria and flow in a south-westerly direction. Along the right bank of this river and in the lower course of its tributaries, the Kafirnigan and Vaksha, is a desert, with a hot dry summer, which receives less than 10 in. of rainfall per annum.

Fauna and Flora.—The valleys on the west are deeper than those on the east and are divided by high, snowy ridges. The north-western lower slopes are well clad with forest, since they receive more moisture and are less parched in summer. The south-western slopes are less favourable to vegetation, and a south-eastern slope, which means great heat in summer, accompanied by dry winds from Mongolia, is least favourable. Thus in accordance with altitude, slope and type of soil many varieties of vegetation are represented, saxaul scrub, jungle grass, especially in the valleys of the Surkhan, Vaksha and Kyzyl-Su, where the tiger and deer are to be found, deciduous and coniferous forest, and alpine and sub-alpine pasture. Along the north-west runs the upper course of the Zarafshan, with its tributary, the Fan, but the Zarafshan valley here is infertile and difficult to irrigate because of the irregularity of the surface. The most fertile regions are the valleys in which Diushambe and Kurgan-Tyube are situated.

Population and Industry.—The types of dwelling are as varied as the climate and vegetation, *e.g.*, felt tents for the nomads, loess brick walls with a thatch of reeds for the primitive cultivator; the houses are always low, whatever their type, because of the frequent earthquakes. The chief occupation is stock raising of semi-nomadic type, *i.e.*, restricted to certain summer and winter pastures; true nomadism is fast dying out. The disturbances following the 1917 revolution much diminished the herds, the numbers of asses and mules, so essential for transport in this difficult region, are at their former level, cattle, sheep and goats are slowly increasing, but the numbers of camels and horses are still far below 1914 level.

Irrigation cultivation of cotton, rice, olives, vines and fruits in the more favoured valleys in 1926–27 was about 50% less than in 1914, since irrigation works once ruined need much time and capital for their restoration. Wheat and barley are the chief grain crops.

There are valuable minerals, including coal in the Ura-Tyube district and the Zarafshan basin, iron in the latter district and in the valley of the Vanch, where manganese also occurs. These minerals and gold are worked in a primitive way in some localities. Lead, sulphur, asbestos and salt are reported, and there are hot springs, especially at Diushambe. The natural wealth is, however, unsurveyed, and there is little prospect of exploitation in the present absence of means of transport. There are small peasant weaving, carpentry, leather and milling industries to supply local needs only, and of the six industrial enterprises in the republic, four cotton cleaning, one printing and one flour-mill, none was working in 1926–27.

There is no railway; the link with Uzbekistan is a winding road from Derbent to Diushambe, which can be used by motors from April to October only. A railway to link Diushambe via Termez with the trans-Caspian line is planned.

The population consists of Tadzhiks 74·6% and Uzbeks 21·2%, the rest being Kirghiz, Kazaks, Turkmens, Arabs and Jews. It numbered 827,449 in 1926, having been much diminished in the post-1917 disturbances, when many fugitives took refuge in Afghanistan.

The literacy rate is low throughout the republic and in the Badakshan area is probably less than 2%. Education is difficult in this wild country and not more than 12% of the children of school age are provided for; medical help is almost entirely lacking. The Tadzhiks are Mohammedans, but not of a strict type, and in the remoter areas much primitive nature worship survives. Diushambe (*q.v.*) (pop., 1926, 4,485) is the administrative centre.

The Mountain Badakshan Autonomous Area was created within Tadzhikstan in 1925, with Khorog (pop. 1,011) as its centre. It consists of the mountain knot in the south-east, of which 75% is stony and sandy high desert. The climate is severe, average January temperature −20° C, average July +10° C on the east, and −10° C, +22° C on the west. The population in 1926 was 28,374 and consisted of 88% Tadzhiks and 11·4% Kara-Kirghiz. In the east are nomad herdsmen, raising horses, mules, asses, camels, sheep and goats, while in the west scanty crops of rye and wheat supplement herding. Hunting and trapping of marten, fox and otter are additional sources of income and gold is extracted in a primitive way. (R. M. F.)

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TAJ MAHAL, the tomb built at Agra, India, by Shah Jehan for his wife, Mumtaz Mahal, where he is also buried. It was begun in 1632 (in which year the Shah ordered the stopping of all Hindoo temple-building), and was completed before 1650. The Taj Mahal is the most perfect example of the Mogul style and is by some considered the most beautiful building in the world. The tomb proper consists of a domed, square, white marble building, raised on a terrace from the corners of which rise four slim, white minarets. The whole is set in an exquisite garden surrounded by a red sandstone wall; a gate and a mosque are subsidiary elements in the composition. The tomb building itself is 186 ft. square, with a dome 58 ft. in internal diameter rising to a total height of 210 feet. The building is said to have cost over £3,000,000. It was probably designed by an architect named Ustad Isa, traditionally supposed to have been either Turkish or Persian. For a complete description *see* AGRA. *See* also INDIAN ARCHITECTURE.

TAKIN, a hollow-horned ruminant (*Budorcas taxicolor*), which inhabits the south-east corner of Tibet, while a second form is found further east, in the Moupin district. The takin is clumsily built, with yellowish-brown hair and curiously curved horns, which recall those of the gnu. Its nearest relatives appear to be the serows (*q.v.*).

TAKLA MAKAN, a desert area in Central Asia. This unit is the major division of that portion of the Tarim basin which stretches westwards from the lower course of the Tarim river to the Pamirs. Its borders on the west, north and east are formed by the Tiznaf, Yarkand and Tarim rivers respectively.

Speaking generally, the Takla Makan is a region of bare drift sand and moving sand dunes, a waterless area, except for the Khotan and Keriya rivers, which carry water northwards into the desert from the Kunlun. This sand dune desert is absolutely uninhabitable, except for a few scattered settlements along the banks of these rivers. These sandy wastes are found all the way down the right bank of the Tarim river to its confluence with Lake Kara-Buran, and then continue up the Charchan Darya and almost as far westward as Keriya.

The sand dunes proper of the Takla Makan occupy chiefly the south and south-west of the region, where the full force of the north-east wind is felt.

Between the lower Tarim river and the Charchan Darya, the surface conformation is different from that of the rest of the Takla Makan. Here the sand dunes are interrupted by tracts of perfectly level soil entirely destitute of sand. In the southernmost part of this area there are patches of reeds and tamarisks, and wells are to be found in this locality.

In the west, stretching from Yangi Hissar to the left bank of the Yarkand river, there is the region of moving sands known as Ordam Padshah. In the east, beyond the left bank of the Tarim river, there is a zone of high and barren sand ridges, extending beyond the river and filling the area between the foot of the Kuruk Tagh hills and the belt of wind-eroded desert along the western side of the ancient salt-encrusted Lop lake bed. In this region the sands are much less frequent than in the Takla Makan itself. Here the soil is of loose saline clay, bare in some places, overgrown in others with tamarisk bushes. The plants bind the soil with their roots into a solid mass, the intervals between the masses of plants being subject to the full erosive force of the winds. The drift-sand accumulates around the bushes and gradually a hillock of sand and tamarisks is formed. These hillocks are between 7 and 14 ft. high, and cover large tracts in this eastward extension of the sandy desert. In the sand dune desert proper of the Takla Makan, there are two systems of dunes; one system, of the high chains, stretches from east to west, while the transverse dunes run from north to south, or north-east to south-west. The steeper faces of the dunes are, for the most part, turned towards the south, the south-west and the west, that is, away from the direction of the prevailing winds, but in some regions face east.

Vegetation and animal life are extremely scarce. The former is practically confined to various steppe plants, kamish (reeds), tamarisks, almost invariably growing on root mounds, and poplars. The animals are hares, rats, and one or two other rodents, foxes, and, in a few places, the wild camel.

The climate is one of extremes. In the Charchan desert a temperature of −22° F has been observed in the depth of winter, and snow sometimes falls heavily there. During the sandstorms which sweep over the region in spring, the thermometer drops as much as 10° or 12° F below zero. On the other hand, a temperature as high as 86° F has been recorded at the end of April. This desert can only be crossed safely in the winter, when it is possible to transport ice on the backs of camels. Sometimes, for days together, the desert is enveloped in an impenetrable dust haze, which chokes and smothers every living creature.

In the second half of the 13th century, Marco Polo left a vivid description of this desert and related legends associated with it. (*See* also SIN KIANG, TARIM.)

TAKORADI, a port on the Gold Coast, British West Africa, in 4° 50′ N., 1° 45′ W. The main breakwater, 1½m. long, is built on a reef which extends 2 to 3m. from the rocky foreshore. The lee breakwater is ¾m. long: the enclosed area is 270ac. and in it ships up to 40ft. draught can lie. Ships 400ft. long and 20ft. draught can lie alongside the wharves. The port is excellently equipped and can handle 5,000 tons of cargo daily. It is the terminus of the western railway to Kumasi; is the chief port of the Gold Coast, and the only deep water harbour between Sierra Leone and Nigeria, *i.e.*, on 1,300m. of coast. On high ground overlooking the harbour is a model township, built to accommodate 150,000 inhabitants. The port was opened to general traffic in 1928.

TALAING, a name given to the Mon people of Pegu in Burma, now largely absorbed into and indistinguishable from the Burmese nation. The Mon are a remnant of the oldest known civilization of south-east Asia (*see* ASIA, FURTHER), speaking a language which connects with scattered survivals from the Mundas in Chhota Nagpur and the Khasis of Assam to Cambodia, and probably also to Yunnan and the Malay archipelago. The Mon, however, got their culture, their religion, now Buddhist but originally Hindu, and their literature from the Telingana coast of South India, and from the Telingas, whose culture they took and whose foreign blood they absorbed into their own stock, came the name Talaing. This culture was again passed on to the Burmese conquerors of Pegu and Burmese is written in the Talaing alphabet. Burmese law is largely derived from Talaing monastic writings, and Burmese historical tradition is full of Indian nomenclature and Indian legend. (*See* G. E. Harvey, *History of Burma* [1925].) (J. H. H.)

TALANA HILL, ACTION OF, Oct. 20, 1899: *see* SOUTH AFRICAN WAR.

TALAR, the throne of the Persian monarchs which is carved on the rock-cut tomb of Darius at Nakst-i-Rustan, near Persepolis.

TALAVERA DE LA REINA, a town of central Spain, in the province of Toledo; on the right bank of the river Tagus, and on the Madrid-Cáceres railway. Pop. (1920), 13,525. Talavera is of great antiquity, the Caesobriga of the Romans. Portions of the triple wall which surrounded it remain standing, and the Arco de San Pedro is one of its Roman gates restored. Among the ancient buildings are the Torres Albarranas, built by the Moors in the 10th century, and the Gothic collegiate church. The bridge of thirty-five arches across the Tagus dates from the 15th century.

Talavera, Battle of, 1809.—For the operations which culminated in the famous battle of Talavera, between the English and the French, and those which followed that engagement, *see* PENINSULAR WAR. Sir Arthur Wellesley (afterwards Duke of Wellington), the British commander, acting in co-operation with Lieutenant-General Cuesta's Spanish army, took position on July 27, 1809, on the Upper Tagus, protected by his advanced guard. His line, facing due east, ran north from the right bank of the river to a ridge running parallel to the Tagus, beyond which ridge, also parallel to the river, lay the Sierra de Montalban. Cuesta's men with their right flank resting on the river held Talavera itself and the close country to the northward of it; Wellesley's right connected with Cuesta's left, and his line stretched away northwards to the ridge already mentioned. The Sierra was not, on the first day, occupied, and even on the inner ridge itself the division of General Hill was, from a misunderstanding, very late in taking up its position. The whole front was covered by a rivulet running from the ridge to the Tagus. The battle was begun by the attack of two French divisions on the British advanced guard, which retired into the main position with severe loss and in some disorder. Marshal Victor's forces followed them up sharply, and soon came upon Wellesley's line of battle. For some time the retention of the ridge (owing to the delay of Hill's Division) was in doubt, but in the end the arrival of Hill's troops secured this all-important point for the Allied left. Meanwhile the Spaniards (though there was at first a temporary panic amongst them) and the right divisions of the British repulsed an attack in the plain, and the day closed with the armies facing each other along the rivulet and on the ridge. The losses had been heavy on both sides. Early on the 28th the battle was renewed by a furious attack on Hill's troops, whose left was now prolonged to the Sierra by the Allied cavalry and a division borrowed from Cuesta. King Joseph Bonaparte and Jourdan his chief of staff, who were present, were averse to fighting on this present ground, wishing to wait for Soult, whom they expected to come in on Wellesley's rear, and it was only after long discussion that the king gave a reluctant assent to Victor's plan of attack. That commander's divisions once more tried to oust Hill from the ridge, and once more failed before the steady volleys of the British line and the charge of the cavalry posted in this quarter (though, owing perhaps to defective ground-scouting, this nearly ended in disaster). At the same time Sebastiani's IV. corps, after a heavy bombardment, assaulted the Allied centre in the plain. Here the British and Spanish battalions held their own firmly, and a counter attack by Mackenzie's division hurled back the French in disorder. Yet another attack followed these failures, and came very near to achieving a great success. This time Lapisse's division of Victor's corps attacked the Allies' left centre, composed of the British Guards. The French columns were again checked by the British line, but here the counterstroke, unlike Mackenzie's, was carried too far, and the troops in the ardour of incautious pursuit were very severely handled and pushed back to the position by the French reserves; but Wellesley decided the day by a counter attack with the 48th regiment, made with great intrepidity and steadiness. The Guards, with splendid discipline, resumed their positions, and eventually the French fell back. Failure all along the line and heavy losses left King Joseph no alternative but to retire towards Madrid. The French lost 7,268 men out of 46,138 present, the British 5,363 out of 20,641; the Spanish losses were officially returned at 1,201 out of some 36,000 present.

TALBOT (Family). This is one of the few families in the English aristocracy which traces alike its descent and its surname from the Norman conquerors of England. The name of Richard Talbot occurs in Domesday Book as the holder of nine hides of land in Bedfordshire under Walter Giffard. There is no evidence that he came over to England with the Conqueror himself; and, as he did not hold of the king *in capite*, it is clear that he was not a leader. Talbot being a personal nickname and not derived from a place, those who bore it were not of necessity connected, and the early pedigree is obscure. But a Geoffrey Talbot took part with the empress Maud against King Stephen; and a Hugh Talbot held the castle of Plessis against Henry I. for Hugh de Gournay, and afterwards became a monk at Beaubec in Normandy. Richard Talbot, with whom the proved pedigree begins, obtained from Henry II. on his accession the lordship of Linton in Herefordshire, and from Richard I. the custody of Ludlow Castle. His descendants for some generations appear to have been wardens of various castles on the borders of Wales, and intermarried with the great families of this region. Under Edward II. a Gilbert Talbot was head of the house, and invaded Scotland in the king's company, but afterwards took part with Thomas of Lancaster against the king. He, however, was pardoned, and obtained from Edward III. a confirmation of the grant of the manor of Linton and other lands, being also summoned to parliament as a baron (1331).

His son Richard, who married a daughter and co-heiress of John Comyn of Badenoch, laid claim to lands in Scotland in her right, and, when restrained from entering that country by land (Edward III. having then made an alliance with King David), he joined in an expedition which invaded it by sea in the interests of Edward Baliol. Three years later he was taken prisoner, and redeemed for 2,000 marks, after which the king made him governor of Berwick. He took part also in Edward's wars against France, as did likewise his son Gilbert, who succeeded him. His wife brought him Goodrich Castle on the Wye, and at this time the family possessed lands in the counties of Oxford, Gloucester, Hereford and Kent. Gilbert's son Richard added to this inheritance by marrying the heiress of Lord Strange of Blackmere, and himself became under Richard II. one of the heirs of the earl of Pembroke, thus adding to his estates, lands in Berkshire, Wilts, Salop and Essex. Another Gilbert Talbot, grandson of the last, claimed to carry the great spurs at the coronation of Henry V., and had a commission to receive the submission of Owen Glendower and his adherents. He also distinguished himself in the invasion of Normandy. He left no male issue, and was succeeded by his brother John.

Hitherto the head of the house had borne the name of Lord Talbot; but this John, after obtaining by marriage the title of Lord Furnival, was for his services created earl of Shrewsbury. (*See* Shrewsbury, John Talbot, 1st earl of.)

John, the second earl of Shrewsbury, was the 1st earl's son by his first wife. He had been knighted at Leicester (1426) along with the infant king Henry VI., had served in the wars of France, and been made chancellor of Ireland during his father's lifetime, when he was only Lord Talbot. Afterwards he was made lord high treasurer of England, and in 1459 was rewarded for his services to the house of Lancaster with a grant of 100 marks a year out of the lordship of Wakefield, forfeited by Richard, duke of York. But next year he and his brother Christopher were slain at the battle of Northampton, fighting in the cause of Henry VI. His son John succeeded him, and then his grandson George, who fought for Henry VII. at Stoke, and whom King Henry VIII. sent as his lieutenant against the rebels in the Pilgrimage of Grace.

Francis, the 5th earl, took part in the invasions of Scotland under Henry VIII. and Edward VI., and was one of the two peers who alone opposed the bill for abolishing the pope's jurisdiction under Elizabeth. His son George, who succeeded, was the earl to whom the custody of Mary Stuart was committed, his task being rendered the more difficult by the intrigues of his second wife, Bess of Hardwick, the builder of Chatsworth, who was thrice married before her union with him. Two sons of this last earl succeeded one another, and the title then devolved on the lineal descendants of Sir Gilbert Talbot of Grafton in Worcestershire, third son of John, the 2nd earl.

Charles, the 12th earl, was raised by William III. to the dignity of a duke, but as he left no son this title died along with him in 1718, and the earldom of Shrewsbury devolved on his cousin Gilbert, a Roman Catholic priest.

From this time the direct line of Sir Gilbert Talbot of Grafton began to fail. A nephew three times succeeded to an uncle, and then the title devolved upon a cousin, who died unmarried in 1856. On the death of this cousin the descent of the title was for a short time in dispute, and the lands were claimed for Lord Edmund Howard (now Talbot), an infant son of the duke of Norfolk, under the will of the last earl; but the courts decided that, under a private act obtained by the duke of Shrewsbury shortly before his death, the title and bulk of the estates must go together, and the true successor to the earldom was found in Earl Talbot, the head of another line of the descendants of Sir Gilbert Talbot of Grafton, sprung from a second marriage of Sir Gilbert's son, Sir John Talbot of Albrighton. The head of this family in the beginning of the 18th century was a divine of some mark, William Talbot, who died bishop of Durham in 1730. His son Charles, who filled the office of lord chancellor, was created Baron Talbot of Hensol in Glamorganshire in 1733; and his son William was advanced to the dignity of Earl Talbot in 1761, to which was added Ingestre, the barony of Dynevor, with special remainder to his daughter, Lady Cecil Rice, in 1780. Then succeeded a nephew, who was created Viscount and Earl Talbot, and assumed by royal licence the surname of Chetwynd before Talbot, from his mother.

All the titles just mentioned have been united in the line of the Earl Talbot who successfully claimed the Shrewsbury title as the 18th earl, the earldom of Shrewsbury (1442) being now the oldest existing that is not merged in a higher title. The family seats (Alton Towers and Ingestre Hall) and the chief estates are in Staffordshire. The old badge of the family was a "talbot" or running hound. (J. Gai.; J. H. R.)

TALBOT, MARY ANNE (1778–1808), the "British Amazon," was born in London on Feb. 2, 1778. She believed herself to be the illegitimate child of the 1st Earl Talbot. Early in her career she eloped, in the disguise of a boy, with a captain. In 1792 she was a drummer in Flanders. In the capture of Valenciennes her lover was killed; and Mary Anne deserted and became cabin boy on a French lugger, which she asserted was captured by the British, who transferred her to the "Brunswick," where she served as a powder monkey, being wounded in Lord Howe's victory of June 1, 1794. For this she later received a small pension. When the wound healed she again went to sea, was captured by the French, and imprisoned for a year and a half. Her sex was not discovered until shortly afterwards she was seized by a pressgang. She finally became a household servant to Robert Kirby, a London publisher, who included an account of her adventures in his *Wonderful Museum* (1804) and in *Life and Surprising Adventures of Mary Anne Talbot* (1809). She died on Feb. 4, 1808.

TALBOT, WILLIAM HENRY FOX (1800–1877), English discoverer in photography, was born at Lacock Abbey, Wilts. on Feb. 11, 1800, and died there on Sept. 17, 1877. He was educated at Harrow and at Trinity college, Cambridge. Before L. J. M. Daguerre exhibited in 1839 pictures taken by the sun, Talbot had obtained similar success, and as soon as Daguerre's discoveries became known he communicated the results of his experiments to the Royal Society. In 1841 he made known his discovery of the calotype or Talbotype process, and after the discovery of the collodion process by Frederick Scott Archer in 1851 he devised a method of instantaneous photography. With Rawlinson and Hincks he was one of the earliest to decipher the cuneiform inscriptions from Nineveh.

His works include *Pencil of Nature* (1844); *Hermes or Classical and Antiquarian Researches* (1838–39); *Illustrations of the Antiquity of the Book of Genesis* (1839); *English Etymologies* (1846).

TALBOT OF HENSOL, CHARLES TALBOT, 1st Baron (1685–1737), lord chancellor of England, the eldest son of William Talbot, bishop of Durham, a descendant of the 1st earl of Shrewsbury, was educated at Eton and Oriel college, Oxford, and became a fellow of All Souls college in 1704. He was called to the bar in 1711, and in 1717 was appointed solicitor-general to the prince of Wales. Having been elected a member of the House of Commons in 1720, he became solicitor-general in 1726, and in 1733 he was made lord chancellor and raised to the peerage with the title of Baron Talbot of Hensol. He died on Feb. 14, 1737. Talbot enjoyed the reputation of a wit; he was a patron of the poet Thomson, and Butler dedicated his *Analogy* to the lord chancellor.

See Lord Campbell, *Lives of the Lord Chancellors and Keepers of the Great Seal* (8 vols. London, 1845–69); Edward Foss, *The Judges of England* (London, 1848–64); Lord Hervey, *Memoirs of the Reign of George II.* (London, 1848); G. E. C., *Complete Peerage,* vol. vii. (London, 1896).

TALC, a mineral which in its compact forms is known as *steatite,* or *soapstone.* It was probably the μαγνῆτις λίθος of Theophrastus, described as a stone of silvery lustre, easily cut. The name word comes indirectly from the Arabic *talq,* and is not connected with Swed. *tälja,* to cut. It was confused with mica by the older writers, and even now mica is sometimes known in trade as talc; while the term was formerly applied to foliated gypsum.

Talc is occasionally found in small hexagonal and rhombic plates with perfect basal cleavage, which are supposed to be monoclinic, and often occurs in foliated masses, sometimes with a curved surface, readily separating into thin, very flexible, non-elastic laminae. The plates give a six-rayed percussion-figure. Talc has a hardness of only about 1, and a specific gravity of from 2·6 to 2·8. Its extreme softness and its greasy feel are characteristic. The lustre on the cleavage face is pearly, or sometimes silvery, and one of the old names of the mineral was *stella terrae,* while German writers sometimes called it *Katzensilber.* The colour is white, grey, yellow or frequently green.

Talc is a magnesium silicate, $H_2Mg_3Si_4O_{12}$. It is generally regarded as a hydrous silicate, but the water is expelled only at a very strong heat, and may therefore be regarded as basic. By the action of heat the hardness of the mineral is greatly increased. Pseudomorphs are known after actinolite, pyroxene, etc., and the mineral has probably been generally formed by the alteration of ferro-magnesian silicates. Talc occurs chiefly in crystalline schists, usually associated with chlorite, serpentine and dolomite. Fine examples of apple-green colour are found at Mt. Greiner, in the Zillerthal, Tirol. Talc-schist is a foliated rock composed chiefly of talc, generally associated with quartz and felspar; but all soapy schists are not necessarily talcose.

The *steatites* of Pliny was a stone resembling fat, but otherwise undescribed. Being easily cut, steatite has always been a favourite material with the carver: it was used for Egyptian scarabs and other amulets, which were usually coated with a blue vitreous glaze; it was employed for Assyrian cylinder-seals and for other ancient signets, and ancient steatite carvings are found among the ruins of Rhodesia. By the Chinese steatite is largely used for ornamental carvings; but many of their "soapstone" figures are wrought in a compact pyrophyllite (*q.v.*), which is essentially different from talc. The name agalmatolite is often applied to the material of these figures, and was suggested by M. H. Klaproth from the Greek ἄγαλμα, an image. Pagodite is an old name for Chinese figure-stone.

Steatite is usually a white, grey, greenish or brown substance, occurring in veins or nodular masses or in lenticular bedded deposits. Pseudomorphs after quartz and dolomite occur near Wunsiedel in Bavaria. In some cases it is a product of the alteration of pyroxenic rocks, and the commercial mineral may be very impure. The ease with which steatite may be worked, coupled with its power of resisting heat, has led to its employment for vessels for household use, whence it is called "potstone"—the *lapis ollaris* of old writers; it is also used, especially in America, for sinks, stoves, firebricks, foot-warmers, tips for gas-burners and electric switchboards, and, when ground, as a filler for paper, for leather-dressing, for covering steam-pipes, as an ingredient in soap, for toilet-powder, for certain paints and as a lubricant. A fine granular variety, known as "French chalk" or "Spanish chalk," is used by tailors for marking cloth; slate pencils are made of steatite and pyrophyllite; and in Burma steatite pencils are used for writing on black paper. In the oxyhydrogen flame, steatite has been fused and drawn out into threads, like quartz-fibres.

Steatite- and talc-schists are widely distributed and have occasionally been used as building stones. When first raised the stone is soft, but hardens on exposure. Soapstone from Gudbrandsdal is used in the cathedral of Trondhjem, Norway. Veins of steatite occur in the serpentine of the Lizard district, Cornwall, and the mineral was used under the name of soap rock in the manufacture of the old Worcester porcelain. In North America its distribution is very extensive.

A fibrous steatite from New York State, used in the manufacture of paper, is known as agalite. Rensselaerite is a wax-like talcose substance, passing into serpentine, from St. Lawrence county, N.Y., named by E. Emmons in 1837 after S. Van Rensselaer, of Albany, N.Y. Beaconite is an asbestiform talc from Michigan, named by L. W. Hubbard. The term pyrallolite was given by Nils G. Nordenskiöld to a mineral from Finland, which appears to be talc pseudomorphous after pyroxene. Talcoid was K. F. Naumann's name for a white lamellar mineral from near Pressnitz in Bohemia. A blue earthy mineral from Silver City, New Mexico, known locally as "native ultramarine," is a magnesium silicate.

See "Talc and Soapstone" in vol. ii. of *Mineral Resources of the U.S.* (1909), and J. H. Pratt, "Economic Papers," No. 3, of *Geol. Surv. of N. Carolina* (1900); C. H. Smyth, Jr., "The Fibrous Talc Industry of St. Lawrence Co., N.Y.," in *Mineral Industry,* vol. ix. (1900); G. P. Merrill, *Non-metallic Minerals* (1904); and R. B. Ladoo, "Talc and Soapstone," *U.S. Bur. of Mines, Bull. No. 213* (1923).

TALCA, a province of Chile, bounded on the north by Colchagua, east by Argentina, south by Linares and Maule, and west by the Pacific. Area 6,909 sq.m., including the province of Curicó which in 1928 was incorporated with it. Pop. (1928) 210,000. In the east the Andean slopes cover a considerable part of its territory, and in the west another large area is covered by the coast range. Between these is the central valley of Chile in which the population and industries of the province are chiefly concentrated. The lower mountainous parts are well wooded. The intermediate plain, which is rolling and slopes gently to the south, is fertile and devoted to wheat, grapes and stock. The capital of the province is Talca (pop., 1920, 36,079), on the Río Claro, a tributary of the Maule, 156 m. by rail south of Santiago.

TALCAHUANO, a seaport of the province of Concepción, Chile, on the bay of Talcahuano, 8 m. N.W. of the city of Concepción. Pop. (1920) 22,084. It has the best harbour on the Pacific coast of South America, and is one of the most important ports of southern Chile. The Chilean Government has established its chief naval depot here.

TALE, a general term, in the usual acceptance of the word, for fictitious narratives, long or short, ancient or modern (O.Eng. *talu,* number, account, story; the word is common to many Teutonic languages; *cf.* Ger. *Zahl,* number, *Erzählung,* narrative, Du. *taal,* speech, language). In this article "tale" is used in a stricter sense, as equivalent to the German "Volks-märchen" or the French "conte populaire." Thus understood, popular tales mean the stories handed down by oral tradition from an unknown antiquity. So understood, popular tales are a subject in mythology. The Homeric epics, especially that of the *Odyssey,* contain adventures (those, for example, of the Cyclops and the husband who returns in disguise) which are manifestly parts of the general human stock of popular narrative. Other examples are found in the *Rigveda,* and in the myths which were handled by the Greek dramatists. The *Thousand and One Nights* (*q.v.*) is full of popular tales, and popular tales are the staple of the mediaeval *Gesta Romanorum,* and of the collections of Straparola and other Italian story-tellers. In all these and similar gatherings the story, long circulated from mouth to mouth among the people, is handled with conscious art. In the *Histoires ou contes du temps passé* of Perrault (Elzevir, 1697), we have one of the earliest collections of tales which were taken down as they were told by nurses to children.

The success of Perrault's popular tales brought the genre into literary fashion, and the Comtesse d'Aulnoy invented, or in some cases adapted, "contes," which still retain a great popularity. But the precise and scientific collection of tales from the lips of the people is not much earlier than our century. The chief impulse to the study was given by the brothers Grimm. The first edition of their *Kinder- und Haus-Märchen* was published in 1812. The English reader will find a very considerable bibliography of popular tales, as known to the Grimms, in Mrs. Alfred Hunt's translation, *Grimm's Household Tales, with Notes* (1884). In addition to the *märchen* of Indo-European peoples, the Grimms became acquainted with some Malay stories, some narratives of Bechuanas, Negroes, American Indians and Finnish, Estonian and Magyar stories.

For European tales, the bibliography in the translation of Grimm already referred to may be used, and the Maisonneuve collection, *Les Littératures populaires,* may be recommended. There are abundant materials and discussions in Frazer's *The Golden Bough. See* also NOVEL. (A. L.; X.)

TALENT, the name of an ancient Greek unit of weight, the heaviest in use both for monetary purposes and for commodities (*see* MEASURES AND WEIGHTS). (Lat. *talentum,* adaptation of Gr. *τάλαντον*, balance, weight, from root *ταλ-*, to lift, as in *τλῆναι*, to bear, *τάλας*, enduring, *cf.* Lat. *tollere,* to lift, Skt. *tulā,* balance.) The weight itself was originally Babylonian, and derivatives were in use in Palestine, Syria and Egypt. In mediaeval Latin and also in many Romanic languages the word was used figuratively, of will, inclination or desire, derived from the sense of balance, but the general figurative use for natural endowments or gifts, faculty, capacity or ability, is due to the parable of the talents in Matt. xxv.

TALFOURD, SIR THOMAS NOON (1795–1854), English judge and author, the son of a brewer, was born at Reading on May 26, 1795. He was educated at Hendon, and at Reading grammar school. At the age of 18 he was sent to London to study law under Joseph Chitty, the special pleader. Early in 1821 he joined the Oxford circuit, having been called to the bar at the middle Temple in the same year. He became a serjeant-at-law in 1835, and a judge of the common pleas in 1849. He was M.P. for Reading, and carried an International Copyright Bill against stormy opposition in 1842. Dickens dedicated the *Pickwick Papers* to him. On the literary side, he contributed to various magazines, and his legal writings on literary subjects included "On the Principle of Advocacy in the Practice of the Bar" (in the *Law Magazine,* Jan. 1846), and his famous *Speech for the Defendant in the Prosecution, the Queen* v. *Moxon, for the Publication of Shelley's Poetical Works* (1841).

But Talfourd cannot be said to have gained any position among men of letters until the production of his tragedy *Ion,* which was privately printed in 1835, and produced in the following year at Covent Garden theatre. Other less successful plays followed. Talfourd died in court during the performance of his judicial duties, at Stafford, on March 13, 1854.

In addition to the writings above-mentioned, Talfourd was the author of *The Letters of Charles Lamb, with a Sketch of his Life* (1837); *Recollections of a First Visit to the Alps* (1841); *Vacation Rambles and Thoughts,* comprising recollections of three continental tours in the vacations of 1841, 1842 and 1843 (2 vols., 1844); and *Final Memorials of Charles Lamb* (1849–50).

TALGARTH, a small town in Breconshire, South Wales, situated on the Ennig near its junction with the Llynfi (a tributary of the Wye), in the north-west section of the Black mountains. It is served by the G.W.R. Pop. (of Parish) 1921, 1,881. A fortified station (Dinas) occupies a hill 2½ m. S.E. of Talgarth, and commands the pass to Crickhowell and the eastern part of the vale of Usk. The region shows evidences of Norman and English penetration and an early distinction between the lowland (English Talgarth) and the upland (Welsh Talgarth) in which the Welsh laws of property etc., prevailed until the end of the middle ages. The region has associations with early nonconformity and there is a Congregational church at Tredwestan founded in 1662. Howel Harris, one of the founders of Welsh Methodism was born in 1713 at Trevecca, 1 m. S.W., and here in 1752 he established a religious "family." Talgarth has a small agricultural trade.

TALIENWAN, an open bay or roadstead on the east side of the Liaotung peninsula, Manchuria. It was leased to Russia by China in 1898 with the naval fortress of Port Arthur, from which it is distant 40 m., the lease being transferred to Japan in 1905. The Russian town of Dalny (now Dairen) was built upon the west side of the bay, which is known as Port Victoria. Talienwan is in railway connection with Niuchwang and Peking and is also connected with Europe by way of the Siberian railway. It was the rendezvous of the British fleet during the Anglo-China war of 1860, whence the names Port Arthur and Port Victoria.

See DAIREN.

TALIESSIN (tăl'ĭ-sĭn), a late 6th century British bard, to whom is attributed the collection of poems known as the *Book of Taliessin. See* WELSH LITERATURE.

TALLADEGA, a city of Alabama, U.S.A., the county seat of Talladega county, 35 m. E. of Birmingham, in the foot-hills of the Blue Ridge, at an altitude of 560 feet. It is served by the Atlanta, Birmingham and Coast, the Louisville and Nashville, and the Southern railways. Pop. 6,546 in 1920 (41% negroes); estimated locally at 8,200 in 1928. It is the seat of the State schools for the deaf and the blind and of Talladega college for negroes (Congregational, 1867). Talladega was once the site of an Indian village, where, on Nov. 9, 1813, General Andrew Jackson won a decisive victory over 1,000 "Red Sticks" (Creek Indians) who opposed the extension of white settlement in Indian territory.

TALLAGE was a tax which in England could be imposed by a feudal lord upon his unfree tenants. The king could tallage the towns and his demesne manors. A lesser lord could tallage his demesne manors. The royal tallage of the boroughs to some extent took the place of Danegeld under Henry II., the latter tax having ceased to be very profitable. Growing prosperity made tallages justifiable. Moreover Henry had a better machinery for the assessment and collection of tallage than any king before him. His judges, financial as well as legal experts, were going round the shires more frequently than any previous royal ministers. They could assess the tallages, and the Exchequer (*q.v.*) could see that they were paid. The tax might be arranged by the judges in one of two ways; they might bargain with the town or manor to provide a definite sum for the king, or they might tallage the individual burgesses. The former practice was more usually followed. In the 13th century the custom of summoning representatives from the boroughs to meet the king and his magnates in parliament grew more frequent and the practice of taking tallages from the towns began to fall out of use, since grants were made to the king in the parliament. Nevertheless he kept his right of tallaging the boroughs. Edward I. took a tallage in 1304, his son in 1312. His grandson tried to take one in 1332, but owing to opposition took a grant from parliament instead. In the 12th century the lord seems to have been able to tallage his men at will; his exactions were bounded only by the custom of the manor, which might either limit his right narrowly or allow him considerable latitude in the matter. Beginning with the Inquest of Sheriffs in 1170 the kings took more and more interest in the relations between lord and man, and in time the right of the lord to tallage his men was closely restricted. He had to obtain a license from the king before he could take a tallage. The right of towns, too, to tax individual burgesses was very narrowly limited. The king would allow a tallage to be taken for a necessary public work, or for the payment of sums due to him, but he kept a careful watch on the taxing powers of the borough magistrates. (D. M. S.)

TALLAHASSEE, the capital city of Florida, U.S.A., and the county seat of Leon county; in the northern part of the

State, on Federal highway 90, midway between Jacksonville and Pensacola, and 20 m. N. of the Gulf of Mexico. It has a municipal airport, and is served by the Georgia, Florida and Alabama and the Seaboard Air Line railways. Pop. 6,415 in 1925 (State census), of whom 2,975 were negroes; estimated locally at over 13,000 in 1928. It has a fine location, being situated on a hill 216 ft. above sea-level, in a region of rolling hills, numerous lakes and streams, giant magnolia trees and majestic oaks which are hung with Spanish moss. The streets are wide and well shaded. The State capitol, the Supreme Court and Library building, the Governor's mansion and other public buildings, are dignified and pleasing. The city is a shipping point for cotton, corn, tobacco, fruit and vegetables; has railroad shops and various manufacturing industries; and is the seat of the Florida State college for women and the State Normal and Industrial school for negroes. It has a commission-manager form of government. Tradition says that the Spaniards, about 1638, fortified a hill near the present site of Tallahassee, during a war with the Apalachee Indians. About 1818 most of the Indians were driven out of this region and a settlement was made by the whites, and in 1824 Tallahassee was chosen by the U.S. Government to be the capital of the Territory of Florida. From 1821 it was the home of Charles Louis Napoleon Achille Murat (1801–47; the eldest son of Joachim Murat), who became an American citizen, married a grand-niece of George Washington, and held various municipal offices in Tallahassee. Florida's Ordinance of Secession was adopted by a state convention meeting in Tallahassee on Jan. 10, 1861.

TALLBOY (partly a translation and partly a corruption of the French *hautbois*), a double chest of drawers. Whereas the chest of drawers in its familiar form (sometimes in the 18th century called a "lowboy") contains three long and two short drawers, the tallboy has five, six or seven long drawers, and two short ones. It is a very late 17th century development of the smaller chest. The early examples are of walnut, but by far the largest proportion of the many that have survived are of mahogany, that being the wood most frequently employed in the 18th century for the construction of furniture, especially the more massive pieces. Occasionally the walnut at the beginning of the vogue of the tallboy was inlaid, just as satinwood varieties were inlaid, depending for relief upon carved cornice-mouldings or gadrooning, and upon handsome brass handles and escutcheons.

TALLEMANT, GÉDÉON, SIEUR DES RÉAUX (1619–1692), French author, was born at La Rochelle on Nov. 7, 1619. He belonged to a wealthy middle-class family of Huguenot persuasion; the name des Réaux he derived from a small property which was purchased by him in the year 1650. In the *Historiettes* he gives finished portraits of Voiture, Balzac, Malherbe, Chapelain, Valentin Conrart and many others; Blaise Pascal and Jean de la Fontaine appear in his pages; and he chronicles the scandals of which Ninon de l'Enclos and Angélique Paulet were centres. They are invaluable for the literary history of the time. He died in Paris on Nov. 6, 1692.

Des Réaux was a poet of some merit and contributed to the *Guirlande de Julie*, but it is by his *Historiettes* that he is remembered. The work remained in manuscript until it was edited in 1834–36 by MM. de Châteaugiron, Jules Taschereau and L. J. N. de Monmerqué, with a notice on Tallemant by Monmerqué. A third edition (6 vols. 1872) contains a notice by Paulin Paris. Tallemant had begun *Mémoires pour la régence d'Anne d'Autriche*, but the manuscript has not been found. *See* also E. Magne, *La joyeuse jeunesse de Tallemant des Réaux* (1921).

TALLEYRAND-PÉRIGORD, CHARLES MAURICE DE (1754–1838), French diplomatist and statesman, was born at Paris on Feb. 12 or 13, 1754, the son of lieutenant-general Charles Daniel de Talleyrand-Périgord. His parents, descended from ancient and powerful families, were in constant attendance at the court of Louis XV. In his third or fourth year, while under the care of a nurse in Paris, he fell from a chest of drawers and injured his foot for life. This accident darkened his prospects; for though by the death of his elder brother he should have represented the family and entered the army, yet he forfeited the rights of primogeniture, and the profession of arms was thenceforth closed to him. At the age of eight he was sent to the Collège d'Harcourt at Paris, and, at thirteen to St. Sulpice, where he conceived a dislike of the doctrines and discipline thrust upon him. After a visit to his uncle, the archbishop of Reims, he returned to St. Sulpice to finish his preliminary training for the church, but in his spare time he read the works of Montesquieu, Voltaire and other writers who were beginning to undermine the authority of the *ancien régime*, both in church and state. As subdeacon he witnessed the coronation of Louis XVI. at Reims, but he did not take priest's orders until four years later. While rejecting the authority of the church in the sphere of dogma and intellect, he observed the proprieties of life, and respected the outward observances of religion.

During his life at Paris he frequented the salon of Madame de Genlis, and there formed his ideas in favour of political and social reform. After taking his licentiate in theology in March 1778, he gave little more attention to theological studies. Nevertheless his ability and his social position gained for him in the year 1780 the position of agent-general of the clergy of France. The growing claims of the state on the exchequer of the clergy made his duties responsible. At the extraordinary assembly of the clergy in 1782 he made proposals, by one of which he sought, though in vain, to redress the most glaring grievances of the underpaid *curés*. Though the excellence of his work as agent-general in the years 1780–86 was fully acknowledged, yet he did not gain a bishopric until the beginning of the year 1789, probably because the king disliked him as a freethinker. He now became bishop of Autun, and was installed on March 13.

The Revolution.—The first important act of the new bishop was to draw up a programme of the reforms which he desired to see carried out by the States General of France. It comprised the following items: the formation of a constitution which would strengthen the monarchy by calling to it the support of the whole nation, the drafting of a scheme of local self-government on democratic lines, the reform of the administration of justice and of the criminal law, and the abolition of the most burdensome of feudal and class privileges. This programme was adopted by the clergy of his diocese as their *cahier*, or book of instructions to their representative at the States General, namely Talleyrand himself.

His influence in the estate of the clergy, however, was cast against the union of the three estates in a single assembly, and he voted in the minority of his order which in the middle of June opposed the merging of the clergy in the National Assembly. The folly of the court, and the weakness of Louis XVI. at that crisis, probably convinced him that the cause of moderate reform and the framing of a bicameral constitution on the model of that of England were hopeless. Thereafter he inclined more and more to the democratic side, though for the present he concerned himself mainly with financial questions. In the middle of July he was chosen as one of the committee to prepare a draft of a constitution; and in the session of the Assembly which Mirabeau termed the *orgie* of the abolition of privileges (Aug. 4) he intervened in favour of discrimination and justice. On Oct. 10, that is, four days after the insurrection of women and the transference of the king and court to Paris, he proposed to the Assembly the confiscation of the lands of the church to the service of the nation, but on terms rather less rigorous than those in which Mirabeau (*q.v.*) carried the proposal into effect on Nov. 2. He identified himself in general with the Left of the Assembly, and supported the proposed Departmental System which replaced the old Provincial System early in 1790. At the federation festival of July 14, 1790 (the "Feast of Pikes") he officiated at the altar reared in the middle of the Champ de Mars. This was his last public celebration of mass. For a brilliantly satirical but not wholly fair reference to the part then played by Talleyrand, the reader should consult Carlyle's *French Revolution*, vol. ii., bk. i., ch. 12. The course of events harmonized with the anti-clerical views of Talleyrand, and he gradually loosened the ties that bound him to the church. He took little part in, though he probably sympathized with, the debates on the measure known as the Civil Constitution of the Clergy, whereby the state enforced its authority over the church to the detriment of its allegiance to the pope.

When the Assembly sought to impose on its members an oath of obedience to the new decree, Talleyrand and three other bishops complied out of the thirty who had seats in the Assembly. The others, followed by the greater number of the clergy throughout France, refused, and thenceforth looked on Talleyrand as a schismatic. He did not long continue to officiate, as many of the so-called "constitutional" clergy did; for, on Jan. 21, 1791, he resigned the see of Autun, and in the month of March was placed under the ban of the church by the pope.

Just before his resignation he had been elected, with Mirabeau and Sieyès, a member of the department of Paris; and for some eighteen months he supported the cause of order in the turbulent capital. Though he was often on strained terms with Mirabeau, their views generally coincided. Talleyrand's reputation for immorality, however, was as marked as that of Mirabeau. While excelling Mirabeau in suppleness and dexterity, Talleyrand lacked the force of character possessed by the great "tribune of the people"; and his influence was gradually eclipsed by the Girondins and the Jacobins.

Debarred from election to the second National Assembly (known as the Legislative) by the self-denying ordinance passed by the "constituents," Talleyrand, at the close of 1791, sought to enter the sphere of diplomacy for which he was well equipped by his mental qualities and his clerical training. The condition of affairs on the continent seemed to French enthusiasts to presage an attack by the other Powers on France. In reality those Powers were far more occupied with the Polish and Eastern questions than with the affairs of France; and the declaration of Pilnitz, drawn up by the sovereigns of Austria and Prussia, which appeared to threaten France with intervention, was recognized by all well-informed persons to be "a loud-sounding nothing." The French foreign minister, Delessart, believed that he would checkmate all the efforts of the *émigrés* at the continental courts provided that he could confirm Pitt in his intention of keeping England neutral. For that purpose Delessart sent Talleyrand, well known for his Anglophil tendencies, to London, but in the unofficial or semi-official capacity which was rendered necessary by the decree of the Constituent Assembly referred to above. Talleyrand arrived in London on Jan. 24, 1792, and found public opinion so far friendly that he wrote off to Paris, "Believe me, a *rapprochement* with England is no chimera." Pitt received him cordially; and to Grenville the envoy stated his hope that the two free nations would enter into close and friendly relations, each guaranteeing the other in the possession of its existing territories, India and Ireland being included on the side of Britain. The British government returned no definite answer to this proposal, but Talleyrand was convinced that Great Britain would not intervene against France unless the latter attacked the Dutch Netherlands.

He returned to Paris on March 10, to persuade the foreign minister (Dumouriez now held that post) of the need of having a fully accredited ambassador at London. The ex-Marquis Chauvelin was appointed, with Talleyrand as adviser. But the overthrow of the monarchy on Aug. 10 and the September massacres rendered hopeless all attempts at an *entente cordiale* between the two peoples; and the provocative actions of Chauvelin undid all the good accomplished by the tact and moderation of Talleyrand. The latter now sought to escape from France, where events were becoming intolerable; he succeeded in obtaining a passport to leave Paris on Sept. 14, and landed in England on the 23rd, avowedly on private business, but still animated by the hope of averting a rupture between the two governments. In this he failed. The provocative actions of the French Convention, especially their setting aside of the rights of the Dutch over the estuary of the Scheldt, had brought the two nations to the brink of war, when the execution of Louis XVI. (21st of Jan. 1793) made it inevitable. Talleyrand was expelled from British soil and made his way to the United States. There he spent thirty months in a state of growing uneasiness and discontent with his surroundings.

The Directory.—The course of events after the Thermidorian reaction of July 1794 favoured his return to France. Thanks to the efforts of Daunou and others his name was removed from the list of *émigrés,* and he set sail for Europe in November 1795. Landing at Hamburg in the January following, he spent some time there in the company of his friends Madame de Genlis and Reinhard; and when party rancour continued to abate at Paris, he returned thither in September. After a time he was recommended by Madame de Staël to the Director Barras for the post of minister of foreign affairs. He gained the post of foreign minister, entering on his duties in July 1797.

Talleyrand, despite the weakness of his own position (he was as yet little more than the chief clerk of his department), soon came to a good understanding with Bonaparte, and secretly expressed to him his satisfaction at the terms which the latter dictated at Campo Formio (Oct. 17, 1797). The *coup d'état* of Fructidor (September 1797) had perpetuated the Directory and led to the exclusion of the two "moderate" members, Carnot and Barthélémy; but Talleyrand saw that power belonged really to the general who had brought about the *coup d'etat* in favour of the Jacobinical Directors headed by Barras.

With the renewal of war on the continent Talleyrand had little or no connection. His powers as minister were limited, and he regretted the extension of the area of war. Moreover, in the autumn of 1797 his reputation for political morality (never very bright) was overclouded by irregular dealings with the envoys of the United States sent to arrange a peaceful settlement of certain disputes with France. Talleyrand refused to clear himself of the charges made against him as his friends (especially Madame de Staël) urged him to do; and the incident probably told against his chances of admission into the Directory, which were discussed in the summer of 1798. A year later he resigned the portfolio for foreign affairs (July 20, 1799), probably because he foresaw the imminent collapse of the Directory. If so, his premonitions were correct. Their realization was assured by the return to France of the "Conqueror of the East" in October. The general and the diplomatist soon came to an understanding, and Talleyrand tactfully brought about the alliance between Bonaparte and Sieyès (*q.v.*) (then the most influential of the five Directors) which paved the way for the *coup d'état* of Brumaire. (*See* FRENCH REVOLUTION and NAPOLEON I.)

Talleyrand's share in the actual events of the 18th, 19th Brumaire (9th, 10th of November) 1799 was limited to certain dealings with Barras on the former of those days. About midday he took to Barras a letter, penned by Roederer, requesting him to resign his post as Director. By what means Talleyrand brought him to do so, whether by persuasion, threats or bribes, is not known; but on that afternoon Barras left Paris under an escort of soldiers. With the more critical and exciting events of the 19th of Brumaire at St. Cloud Talleyrand had no direct connection; but he had made all his preparations for flight in case the blow failed. His reward for helping on the winning cause was the ministry for foreign affairs, which he held from the close of December 1799 on to the summer of 1807. In the great work of reconstruction of France now begun by the First Consul, Talleyrand played no unimportant part. His great aim was to bring about peace, both international and internal. He had a hand in the pacific overtures which Bonaparte, early in the year 1800, sent to the court of London; and, whatever may have been the motives of the First Consul in sending them, it is certain that Talleyrand regretted their failure. After the battle of Marengo an Austrian envoy had to come to Paris in response to a proposal of Bonaparte, and Talleyrand persuaded him to sign terms of peace. These were indignantly repudiated at Vienna, but peace was made between the two Powers at Lunéville on Feb. 9, 1801.

As regards French affairs, Talleyrand used his influence to help on the repeal of the vexatious laws against *émigrés,* nonjuring priests, and the royalists of the west. He was also in full sympathy with the policy which led up to the signature of the Concordat of 1801–2 with the pope (*see* CONCORDAT); but it is probable that he had a hand in the questionable intrigues which accompanied the closing parts of that complex and difficult negotiation. At the end of June 1802 the pope removed Talleyrand from the ban of excommunication and allowed him to revert to the secular state. On Sept. 10, 1803, owing to pressure put on him by Bonaparte, he married Madame Grand, a *divorcée* with whom he had long been living.

During the meeting of Italian notables at Lyons early in 1802 Talleyrand was serviceable in manipulating affairs in the way desired by Bonaparte, and it is known that the foreign minister suggested to them the desirability of appointing Bonaparte president of the Cisalpine Republic, which was thenceforth to be called the Italian Republic. In the negotiations for peace with England which went on at Amiens during the winter of 1801–2 Talleyrand had no direct share, these (like those at Lunéville) being transacted by Napoleon's eldest brother, Joseph Bonaparte (*q.v.*). On the other hand he helped the First Consul in assuring French supremacy in Switzerland, Italy and Germany. In Germany the indemnification of the princes who lost all their lands west of the Rhine was found by secularizing and absorbing the ecclesiastical states of the empire. This unscrupulous proceeding, known as the Secularizations (February 1803), was carried out largely on lines laid down by Bonaparte and Talleyrand; and the latter is known to have made large sums of money by trafficking with the claimants of church lands.

While helping to establish French supremacy in neighbouring states and assisting Bonaparte in securing the title of First Consul for life, Talleyrand sought all means of securing the permanent welfare of France. He worked hard to prevent the rupture of the peace of Amiens in May 1803, and he did what he could to prevent the sale of Louisiana to the United States earlier in the year. These events, as he saw, told against the best interests of France and endangered the gains which she had secured by war and diplomacy. Thereafter he strove to moderate Napoleon's ambition and to preserve the European system as far as possible. The charges of duplicity or treachery made against the foreign minister by Napoleon's apologists are in nearly all cases unfounded. This is especially so in the case of the execution of the duc d'Enghien (March 1804), which Talleyrand disapproved. The evidence against him rests on a document which is now known to have been forged. On the assumption of the imperial title by Napoleon in May 1804, Talleyrand became grand chamberlain of the empire, and received close on 500,000 francs a year.

The Empire.—Talleyrand had rarely succeeded in bending the will of the First Consul. He altogether failed to do so with the Emperor Napoleon. His efforts to induce his master to accord lenient terms to Austria in November 1805 were futile; and he looked on helplessly while that Power was crushed, the Holy Roman Empire swept away, and the Confederation of the Rhine set up in central Europe. In the bargainings which accompanied this last event Talleyrand is believed to have reaped a rich harvest from the German princes most nearly concerned. On July 6, 1806, Napoleon conferred on his minister the title of prince of Benevento, a papal fief in the Neapolitan territory.

In the negotiations with England which went on in the summer of 1806 Talleyrand had not a free hand; they came to nought, as did those with Russia which had led up to the signature of a Franco-Russian treaty at Paris by d'Oubril which was at once disavowed by the tsar. The war with Prussia and Russia was ended by the treaties of Tilsit (7th and 9th of July 1807). Talleyrand had a hand only in the later developments of these negotiations; and it has been shown that he cannot have been the means of revealing to the British government the secret arrangements made at Tilsit between France and Russia, though his private enemies, among them Fouché, have charged him with acting as traitor in this affair.

Talleyrand had long been weary of serving a master whose policy he more and more disapproved, and after the return from Tilsit to Paris he resigned office. Nevertheless Napoleon retained him in the council and took him with him to the interview with the Emperor Alexander I. at Erfurt (September 1808). Talleyrand disapproved of the Spanish policy of Napoleon which culminated at Bayonne in May 1808; and the stories to the contrary may in all probability be dismissed as idle rumours. On Talleyrand now fell the disagreeable task of entertaining at his new mansion at Valençay, in Touraine, the Spanish princes virtually kidnapped at Bayonne by the emperor. They remained there until March 1814. At the close of 1808, while Napoleon was in Spain, Talleyrand entered into certain relations with his former rival Fouché (*q.v.*), which aroused the solicitude of the emperor and hastened his return to Paris. He subjected Talleyrand to violent reproaches, which the ex-minister bore with his usual ironical calm.

After the Danubian campaign of 1809 and the divorce of Josephine, Talleyrand used the influence which he still possessed in the imperial council on behalf of the choice of an Austrian consort for his master, for, like Metternich (who is said first to have mooted the proposal), he saw that this would safeguard the interests of the Habsburgs, whose influence he felt to be essential to the welfare of Europe. He continued quietly to observe the course of events during the disastrous years 1812–13; and even at the beginning of the Moscow campaign he summed up the situation in the words, "It is the beginning of the end." Early in 1814 he saw Napoleon for the last time; the emperor upbraided him with the words: "You are a coward, a traitor, a thief. You do not even believe in God. You have betrayed and deceived everybody. You would sell even your own father." Talleyrand listened unmoved, but afterwards sent in his resignation of his seat on the council. It was not accepted. He had no share in the negotiations of the congress of Châtillon in February–March 1814. On the surrender of Paris to the allies (March 30, 1814), the Emperor Alexander I. took up his abode at the hôtel Talleyrand, and there occurred the conference wherein the statesman persuaded the tsar that the return of the Bourbons was the only possible solution of the French problem, and that the principle of legitimacy alone would guarantee Europe against the aggrandizement of any one state or house. As he phrased it in the Talleyrand *Memoirs:* "The house of Bourbon alone could cause France nobly to conform once more to the happy limits indicated by policy and by nature. With the house of Bourbon France ceased to be gigantic in order to be great." These arguments, reinforced by those of the royalist agent de Vitrolles, convinced the tsar; and Talleyrand, on April 1, convened the French senate (only 64 members out of 140 attended), and that body pronounced that Napoleon had forfeited the crown. Ten days later the emperor recognized the inevitable and signed the Act of Abdication at Fontainebleau. The next effort of Talleyrand was to screen France under the principle of legitimacy and to prevent the schemes of partition on which some of the German statesmen were bent. Thanks mainly to the support of the tsar and of England these schemes were foiled; and France emerged from her disasters with frontiers which were practically those of 1792.

The Restoration.—At the congress of Vienna (1814–15) for the settlement of European affairs, Talleyrand, as the representative of the restored house of Bourbon in France, managed adroitly to break up the league of the Powers (framed at Chaumont in February 1814) and assisted in forming a secret alliance between England, Austria and France in order to prevent the complete absorption of Poland by Russia and of Saxony by Prussia. The new triple alliance had the effect of lessening the demands of those Powers and of leading to the well-known territorial compromise of 1815. Everything was brought into a state of uncertainty once more by the escape of Napoleon from Elba; but the events of the Hundred Days, in which Talleyrand had no share—he remained at Vienna until June 10—brought in the Bourbons once more; and Talleyrand's plea for a magnanimous treatment of France under Louis XVIII. once more prevailed in all important matters. On July 9, 1815, he became foreign minister and president of the council under Louis XVIII., but diplomatic and other difficulties led him to resign his appointment on Sept. 23, 1815, Louis, however, naming him high chamberlain and according him an annuity of 100,000 francs. The rest of his life calls for little notice except that at the time of the July Revolution of 1830, which unseated the elder branch of the Bourbons, he urged Louis Philippe, duke of Orleans (*q.v.*), to take the throne offered to him by popular acclaim. The new sovereign offered him the portfolio for foreign affairs; but Talleyrand signified his preference for the embassy in London. In that capacity he took an important part in the negotiations respecting the founding of the new kingdom of Belgium. In April, 1834 he crowned his diplomatic career by signing the treaty which brought together as allies France, Great Britain, Spain and Portugal; and in the autumn of that year he resigned his embassy. During his last days he signed a paper signifying his reconciliation with the Roman Catholic Church and his regret for many of his early actions. The king visited his death-bed. His death, on May 17, 1838, called forth widespread expressions of esteem for the statesman who had rendered such great and varied services to his country. He was buried at Valençay. He had been separated from the former Madame Grand in 1815 and left no heir.

The Talleyrand *Mémoires* were edited by the duc de Broglie in 5 vols. (Paris, 1891–92). They have been translated into English by A. Hall, 5 vols. (London, 1891–92). Of his letters and despatches the following are the chief collections:—G. Pallain, *La mission de Talleyrand à Londres en 1792* (Paris, 1889), and *Le ministère de Talleyrand sous le Directoire* (Paris, 1891); P. Bertrand, *Lettres inédites de Talleyrand à Napoléon,* 1800–09 (Paris, 1889); G. Pallain, *Talleyrand et Louis XVIII.* (Paris, 1881), and *Ambassade de Talleyrand à Londres* (1830–34), 2 vols. (Paris, 1891).

Among the biographies, or biographical notices, of Talleyrand the following are, on the whole, hostile to him: G. Touchard Lafosse, *Talleyrand, histoire politique et vie intime* (Paris, 1848); G. Michaud, *Hist. politique et privée de Talleyrand* (Paris, 1853); A. Pichot, *Souvenirs intimes sur Talleyrand* (Paris, 1870); Sainte-Beuve, "Talleyrand," in *Nouveaux lundis,* No. xii.; and Villemarest, *Talleyrand.* The estimate of him of Sir H. L. E. Bulwer Lytton in his *Historical Characters,* 2 vols. (London, 1867) and that of Lord Brougham in *Historical Sketches of Statesmen,* 3 vols. (London, 1845, new edition), are better balanced, but brief. Of recent biographies of Talleyrand the best are Lady Blennerhasset's *Talleyrand* (Berlin, 1894, Eng. translation by F. Clarke, 2 vols. London, 1894); *Talleyrand, a Biographical Study,* by Joseph McCabe (London, 1906); and Bernard de Lacombe, *La vie privée de Talleyrand* (1910); C. Dupuis, *Le Ministère de Talleyrand en 1814* (2 vols., 1919). (J. H. Ro.)

TALLIEN, JEAN LAMBERT (1767–1820), French revolutionary, was born in Paris in 1767. He entered a printer's office, and by 1791 he had reached the position of overseer of the printing department of the *Moniteur.* While thus employed he conceived the idea of the *journal-affiche,* and after the arrest of the king at Varennes in June 1791 he placarded a large printed sheet on all the walls of Paris twice a week, under the title of the *Ami des Citoyens, journal fraternel.*

This enterprise, financed by the Jacobin Club, made him well known to the revolutionary leaders; and he made himself still more conspicuous in organizing the great "Fête de la Liberté" on April 15, 1792, in honour of the released soldiers of Château-Vieux, with Collot d'Herbois. He was active in the events of Aug. 10, and was made clerk to the Revolutionary Commune of Paris. At the close of September he resigned his post on being elected a deputy to the Convention by the department of Seine-et-Oise. He took his seat upon the Mountain, and was one of the most vigorous Jacobins, particularly in his defence of Marat, on Feb. 26, 1793; he was elected a member of the Committee of General Security on Jan. 21, 1793. He took an active part in the *coups d'état* of May 31 and June 2, which resulted in the overthrow of the Girondists. On Sept. 23, 1793, he was sent with Claude Alexandre Ysabeau (1754–1831) to Bordeaux. This was the month in which the Terror was organized under the superintendence of the Committees of Public Safety and General Security.

Tallien showed himself one of the most vigorous of the proconsuls sent over France to establish the Terror in the provinces and soon awed the great city. Among his prisoners was Thérèse, the divorced wife of the comte de Fontenay, and daughter of the Spanish banker, François Cabarrus, one of the most fascinating women of her time, and Tallien not only spared her life but fell in love with her. Suspected of "Moderatism" on account of this incident, Tallien increased, in appearance, his revolutionary zeal, but from the lives Thérèse saved by her entreaties she received the name of "Our Lady of Thermidor," after the 9th of Thermidor. Tallien was even elected president of the Convention on March 24, 1794. Robespierre began to see, however, that he must strike at his own colleagues in the committees if he was to carry out his theories; but they determined to strike first, and on the great day of Thermidor Tallien opened the attack upon Robespierre. Robespierre and his friends were guillotined; and Tallien, as the leading Thermidorian, was elected to the Committee of Public Safety. He suppressed the Revolutionary Tribunal and the Jacobin Club and fought bravely against the insurgents of Prairial. He was supported by Thérèse, whom he married on Dec. 26, 1794, and who became the leader of the social life of Paris. His last political achievement was in July 1795, when he was present with Hoche at the destruction of the army of the *émigrés* at Quiberon, and ordered the executions which followed.

Tallien's political importance came to an end with the Convention for, though he sat in the Council of Five Hundred, the moderates attacked him as terrorist, and the extreme party as a renegade. Madame Tallien also tired of him, and became the mistress of the rich banker Ouvrard. Bonaparte took him to Egypt in his great expedition of June 1798, and he edited the *Décade Egyptienne* in Cairo. But General J. F. Menou sent him away from Egypt, and he was captured by an English cruiser and taken to London, where he had a good reception among the Whigs and was well received by Fox. On returning to France in 1802 he obtained a divorce from his wife (who in 1805 married the comte de Caraman, later prince de Chimay), and was for some time without employment. At last he was appointed consul at Alicante, and remained there until he lost the sight of one eye from yellow fever. On returning to Paris he lived on his half-pay, and his latter days were spent in poverty. He died in Paris on Nov. 16, 1820.

Tallien left an interesting *Discours sur les causes qui ont produit la Révolution française* (1791) and a *Mémoire sur l'administration de l'Égypte à l'arrivée des Français. See* "Tallien et l'Expédition d'Égypte" in *La Révolution Française: Revue d'histoire moderne et contemporaine,* t. iii. p. 269. On Madame Tallien *see* Arsène Houssaye, *Notre Dame de Thermidor* (1866); J. Turquan, *Souveraines et grandes Dames: La citoyenne Tallien, témoignages des contemporains et documents inédits* (1898); and Louis Gastine, *La belle Tallien* (1909).

TALLINN, a seaport of Estonia, the capital of the republic, in 59° 26′ N., 24° 46′ E., on a bay in the south coast of the Gulf of Finland. Pop. (1926) 127,000. Vessels drawing 30 ft. can enter or leave the port and lie alongside the quays. There are floating docks and shipbuilding and repairing yards. The chief exports are textiles, cereals, timber, paper, and Portland cement, and the imports foodstuffs, cotton and coal. There are electric cranes and four ice-breakers. The town has textile, paper, cement, and timber industries; an International Industrial Fair is held annually in June. The grey towers topped with red tiles, the narrow cobbled streets, the remains of the castle and the city walls give the town an attractive appearance and it is developing as a tourist centre. It was formerly called Reval.

A Danish settlement on the high Silurian crag known as the Domberg existed in 1093, and the Danish king Valdemar II. built a castle in 1219, captured by the Livonian Knights in 1228, but returned to the Danes in 1237. Merchants from Lübeck and Bremen settled here in the 13th century and it became a port of the Hanseatic League. It was fortified early in the 14th century, and in 1343 sustained a siege by the revolted Estonians. Valdemar III. sold Reval and Estonia to the Teutonic Knights in 1346, but on the dissolution of the order, in 1561, Estonia and Reval surrendered to the Swedish king Erik XIV. A great conflagration in 1433, the pestilence of 1532, the bombardment by the Danes in 1569, and the Russo-Livonian War, destroyed its trade. The Russians besieged Reval in 1570 and 1577, and in 1710 it was surrendered to Peter the Great, who immediately began the erection of a military port for his Baltic fleet. His successors continued to fortify the access to Reval from the sea, large works being undertaken, especially in the early years of the 19th century. It passed from Russian to Estonian rule in 1918.

TALLIS (Tallys, Talys or Tallisius), **THOMAS** (*c.* 1515–1585), justly styled "the father of English cathedral music," was born probably before 1515. It has been conjectured that, after singing as a chorister at old Saint Paul's under Thomas Mulliner, he obtained a place among the children of the chapel royal. He is known to have become organist at Waltham abbey, where, on the dissolution of the monastery in 1540, he received, in compensation for the loss of his preferment, 20s. for wages and 20s. for reward. In the library of the British Museum there is preserved a volume of ms. treatises on music, once belonging to the abbey, on the last page of which appears his autograph, "Thomas Tallys"—the only specimen known. Not long after his dismissal from Waltham, Tallis was appointed a gentleman of the chapel royal.

One of the earliest compositions by Tallis to which an approximate date can be assigned is the well-known *Service in the Dorian Mode,* consisting of the *Venite, Te Deum, Benedictus, Kyrie, Nicene Creed, Sanctus, Gloria in Excelsis, Magnificat* and *Nunc Dimittis,* for four voices, together with the *Preces, Responses, Paternoster* and *Litany,* for five, all published for the first time, in the Rev. John Barnard's *First Book of Selected Church Music,* in 1641, and reprinted, with the exception of the *Venite* and *Paternoster,* in Boyce's *Cathedral Music* in 1760. (Boyce's omission of the very beautiful *Venite* is hard to account for.) That this work was composed for the purpose of supplying a pressing need, after the publication of the second prayer-book of King Edward VI. in 1552, there can be no doubt. Written in the style known among Italian composers as *lo stile famigliare, i.e.,* in simple counterpoint of the first species, *nota contra notam,* with no attempt at learned complications of any kind, it adapts itself with equal dignity and clearness to the expression of the verbal text it is intended to illustrate. In self-restraint the *Litany* and *Responses* bear a close analogy to the *Improperia* and other similar works of Palestrina.

Tallis raised the English school to a height which it was to maintain until the death of its last representative, Orlando Gibbons, in 1625. Though this school is generally said to have been founded by Dr. Tye, there can be no doubt that Tallis was its greatest master, and that it was indebted to him alone for the infusion of new life and vigour which prevented it from degenerating, as some of the earlier Flemish schools had done, into a mere vehicle for the display of fruitless erudition. Like every other great musician of the period, he produced occasionally works confessedly intended for no more exalted purpose than the exhibition of his stupendous skill. In his canon *Miserere nostri* (given in Hawkins's *History of Music*) the intricacy of the contrapuntal devices seems little short of miraculous; yet the resulting harmony is smooth and normal, and only the irregular complexity of the rhythm betrays the artificiality of its structure. The famous forty-part motet, *Spem in alium,* written for eight five-part choirs, stands on a far higher plane, and the *tour de force* of handling freely and smoothly so many independent parts is the least remarkable of its qualities. It was edited by Dr. A. H. Mann in 1888 (London, Weekes and Company). (In the sixth volume of *Tudor Church Music* [Oxford University Press, 1928] all the forty parts are printed on one page.) The art with which the climaxes are built up shows that Tallis's object in writing for forty voices is indeed to produce an effect that could not be produced by thirty-nine. But this illustrates one phase only of Tallis's many-sided genius, which shines with equal brightness in the eight psalm tunes (one in each of the first eight modes) and unpretending little *Veni Creator,* printed in 1567 at the end of Archbishop Parker's *First Quinquagene of Metrical Psalms.*

In 1575 Tallis and his pupil William Byrd—as great a contrapuntist as himself—obtained from Queen Elizabeth royal letters patent granting them the exclusive right of printing music and ruling music-paper for twenty-one years; and, in virtue of this privilege, they issued, in the same year, a joint work, entitled *Cantiones quae ab argumento Sacrae vocantur, quinque et sex partium,* containing sixteen motets by Tallis and eighteen by Byrd, all of the highest degree of excellence. Some of these motets, adapted to English words, are now sung as anthems in the Anglican cathedral service. But no such translations appear to have been made during Tallis's lifetime; and there is strong reason for believing that, though both he and Byrd outwardly conformed to the new religion, and composed music expressly for its use, they remained Catholics at heart.

Tallis's contributions to the *Cantiones Sacrae* were the last of his compositions published during his lifetime. He died on November 23, 1585, and was buried in the parish church at Greenwich, where a quaint rhymed epitaph, preserved by Strype, and reprinted by Burney and Hawkins, recorded the fact that he served in the chapel royal during the reigns of Henry VIII., Edward VI., Mary, and Elizabeth. This was destroyed with the old church about 1710; but a copy has since been substituted. Portraits, professedly authentic, of Tallis and Byrd, were engraved by Vandergucht in 1730 for Nicolas Haym's projected *History of Music,* but never published. One copy only is known to exist. A list of the printed and manuscript works of Tallis will be found in Grove's *Dictionary.*

TALLOW, the solid oil or fat of ruminant animals, but commercially obtained almost exclusively from oxen and sheep. The various methods by which tallow and other animal fats are separated and purified are dealt with in the article OILS. Ox tallow occurs at ordinary temperatures as a solid hard fat having a yellowish white colour. The fat is insoluble in cold alcohol, but it dissolves in boiling alcohol, in chloroform, ether and the essential oils. The hardness of tallow and its melting-point are to some extent affected by the food, age, state of health, etc., of the animal yielding it, the firmest ox tallow being obtained in certain provinces of Russia, where for a great part of the year oxen are fed on hay. New tallow melts at from 42·5° to 43° C., old tallow at 43·5°, and the melted fat remains liquid till its temperature falls to 33° or 34° C. Tallow consists of a mixture of two-thirds of the solid fats palmitin and stearin, with one-third of the liquid fat olein.

Mutton tallow differs in several respects from that obtained from oxen. It is whiter in colour and harder, and contains only about 30% of olein. Newly rendered it has little taste or smell, but on exposure it quickly becomes rancid. Sweet mutton tallow melts at 46° and solidifies at 36° C.; when old it does not melt under 49°, and becomes solid on reaching 44° or 45° C. It is sparingly soluble in cold ether and in boiling alcohol. (*See* OILS AND FATS.)

TALLOW TREE, in botany, the popular name of a small tree, *Sapium sebiferum,* family Euphorbiaceae, a native of China, but cultivated in India and other warm countries. The seeds are thickly coated with a white greasy substance—so-called vegetable tallow—from which candles are made, and which is also used in soap-making and dressing cloth. The butter tree or tallow tree of Sierra Leone is *Pentadesma butyracea,* family Guttiferae. The fruit, which is 4 to 5 in. long and about 3 in. in diameter, has a thick fleshy rind abounding in a yellow greasy juice, used as butter.

TALLY. The wooden tally used in reckoning comes from two primitive notions; that of notching (scoring) a piece of wood for counting, as Robinson Crusoe did, and that of the broken stick shared between two parties to a bargain: the developed tally combines both. Use of this double tally, once prevalent all over Europe, is still frequent in the less advanced countries and not unknown in most. In England, though now nearly obsolete, it was exceedingly common mediaevally and its methods were highly developed; it endured long in certain connections; and its nomenclature survives in many words; to score at cricket (in Pickwick's day "to notch") derives from the single tally, and the verb "to tally" comes obviously from the double one; and other derivatives are many, if not quite so direct.

In England, however, the chief interest of the tally centres in its public use. This is earlier even than the very early "exchequer" organization (*see* EXCHEQUER); by a date not long after 1100 it was a settled system—a system, moreover, carefully differentiated from any private one and used for money only; and the tally continued to be the recognized form of receipt for payments into the Royal Treasury down to 1826. During this long period, though there were modifications of wording, it changed little outwardly save for a continually increasing length; the original 9in. being extended in one extreme example which still survives at the Bank of England to 8ft. 6 inches. This, however, is due solely to the increased number of thousands (notches of the thickness of a man's hand) which the tally might be required to show; and (apart from any difficulty due to the writing) a 13th century clerk could have interpreted it; the revolutionary changes lie, not in the tally's form, but in its employment.

The Assignment System.—At a very early date anticipation of the royal revenue became habitual and in this practice the tally was invaluable; nothing was easier than to "levy" a tally for a sum due for payment later and to "assign" this as payment to a royal creditor. Probably, at certain periods, creditors themselves had little objection to a practice which, in an age of difficult transport and clumsy currency, held many advantages. At the same time it might obviously lead to the lowering of royal credit and to endless confusion in accounts. Assignments were, in effect, payments; but tallies were essentially receipts; and as such, from the 13th century onwards, were all entered on "receipt rolls" and, later, figured in numerous supplementary series of records. Moreover an "assignment" tally frequently went wrong, and the mediaeval administrator could think of no better device than to substitute a fictitious "loan" on the roll, so as to square the account. The roll of "receipts" might thus include actual payments of cash, sums credited long before they were paid or due, and entries which indicate no payment at all, but rather a debt to be cleared later. The difficulties of the modern historian desiring to use these (exceedingly important) records, with none of the contemporary clerk's expert knowledge, needs no emphasis.

The Last Tally, 1826.—By Pepys' time tally-making at Westminster had become a ritual involving numerous officials, much delay and many fees, and from then onwards periodical attempts were made to destroy it. But vested interest successfully withstood reform till the 18th century; and it was not till 1826 that the last tally was levied and a system of "indented cheque receipts" substituted. A few years later (1834) reforming zeal celebrated its triumph by destroying (in the furnaces which heated the House of Lords) the whole accumulation of ancient tallies, with disastrous results; the old Houses of Parliament were burned and, incidentally (till the casual discovery in 1909, in the Chapel of the Pyx, of about 1,300 Exchequer tallies, practically all "stocks" of the 13th century), English historians were left without an essential clue to the understanding of some of the richest record series in the national collections.

BIBLIOGRAPHY.—*See* Hilary Jenkinson, "Tallies," *Archaeologia*, lxii. (1911) and lxxiv. (1924). For tallies in a foreign country *see* M. Gmür, *Schweizerische Bauernmarken und Holzurkunden* (Berne, 1917). (H. JE.)

TALMA, FRANÇOIS JOSEPH (1763–1826), French actor, was born in Paris on Jan. 15, 1763. His father, a dentist there, and afterwards in London, gave him a good English education, and he returned to Paris, where for a year and a half he practised dentistry. He made his *début* at the Comédie Française as Seide in Voltaire's *Mahomet* (Nov. 21, 1787). Talma was among the earliest advocates of realism in scenery and costume, being aided by his friend the painter David. His first essay in this direction took the form of appearing in the small rôle of Proculus in Voltaire's *Brutus*, with a toga and Roman headdress, much to the surprise of an audience accustomed to 18th century costume on the stage whatever the period represented might be. Talma possessed in perfection the physical gifts of a great tragedian. At first somewhat stilted and monotonous in his manner, he became by perfection of art a model of simplicity. Talma married Julie Carreau, in whose salon were the principal Girondists.

In 1808 the emperor had taken him to Erfurt and made him play the *Mort de César* to a company of crowned heads. Five years later he took him also to Dresden. Talma was also a friend of Joseph Chénier, Danton, and Camille Desmoulins. In Chénier's anti-monarchical *Charles IX.*, produced on Nov. 4, 1789, a prophetic couplet on the destruction of the Bastille made the house burst into a salvo of applause, led by Mirabeau. This play aroused political dissensions in the Comédie Française which led Talma to establish a new theatre known for a time as the Théâtre de la République, on the site of the present Théâtre Français. Here he won his greatest triumphs. He made his last appearance on June 11, 1826, as Charles VI. in Delaville's tragedy, and he died in Paris on Oct. 19, of that year.

Talma was the author of *Mémoires de Lekain, précédés de réflexions sur cet acteur et sur l'art théâtral*, contributed to the *Collection des mémoires sur l'art dramatique*, and published separately (1856) as *Réflexions de Talma sur Lekain et l'art théâtral*. See *Mémoires de F. J. Talma, écrits par lui-même, et recueillis et mis en ordre sur les papiers de sa famille*, by Alex. Dumas (1850); J. B. J. I. P. Regnault-Warin, *Mémoires sur Talma* (1904).

TALMAGE, THOMAS DE WITT (1832–1902), American Presbyterian preacher, was born near Bound Brook, N.J., on Jan. 7, 1832. He was educated at the present New York university and at the Reformed Dutch theological seminary at New Brunswick, New Jersey. In 1856 he became pastor of a Reformed church at Belleville, N.J., thereafter holding pastorates successively at Syracuse, Philadelphia, Brooklyn and Washington, District of Columbia. During the last years of his life he devoted himself to editing, writing and lecturing. He died in Washington on April 12, 1902.

TALMUD, the great Rabbinical thesaurus which was reduced to writing during the second, fourth and sixth centuries of the Christian Era.

Contents.—The Talmūd (Hebrew "teaching, learning") consists of the *Mishnāh* (Heb. "[oral] repetition, teaching"), a systematic collection of religious-legal decisions developing the laws of the Old Testament, and the *Gĕmārā* (Aramaic "completion, decision," or perhaps also "teaching"), supplementary material, legal and otherwise. Mishnah stands in contrast to *Miqrā* "reading, scripture"; its Aram. equivalent is *Mathnīthā*, from *tĕnā*, "to repeat," whence the appellation *Tannā*, "teacher." These and the terms Gemara, Talmud, etc., are more fully explained in H. L. Strack's invaluable *Einleitung in den Talmud* (Leipzig, 1908), pp. 2 *sqq.* The whole was in two great recensions, Palestinian and Babylonian. Other material related to the Mishnāh is preserved in the *Tōsephtā* (Aram. "addition") and the *Midrāshīm*, and since all these, together with the *Targūmīm*, represent the orthodox Rabbinical literature connecting the Old Testament with mediaeval and modern Judaism, the reader should also consult the articles JEWS (parts ii. and iii.), MIDRASH, TARGUM, and for more detailed and critical treatment the references given to the *Jewish Encyclopedia*.

The Mishnah is a more or less careful arrangement of the extant Oral Law (*see* below). It forms the foundation of the Gemara, and is divided into six *Sĕdārīm* or Orders, each containing a number of *Massektōth* ("weavings," *cf.* the etymology of "text") or Tractates. These are subdivided into *Pĕrāqīm* ("sections") or chapters, and these again into paragraphs or sentences (*Mishnayōth*). For a full list of these and of editions and translations, see *Jew. Enc.*

The Origin of the Mishnah.—A careful distinction was drawn between the Written Law, the Mosaic Tōrāh and the rest of the Scriptures (תּוֹרָה שֶׁבִּכְתָב), and the Oral Law, or Tōrāh by Mouth (תּוֹרָה שֶׁבְּעַל פֶּה). The latter has become codified in the Mishnah. The traditional view is well illustrated in the words ascribed to R. Simeon Lakish, 3rd century A.D.: "What is that which is written, 'I will give thee the tables of stone, and the Law and the Commandment, which I have written, that thou mayest teach them (Ex. xxiv. 12)?' 'Tables,' these are the Ten Words (the Decalogue); the 'Law' is the Scripture; 'and the commandment,' that is the Mishnah: 'which I have written,' these are the Prophets and Writings (*i.e.*, The Hagiographa), 'to teach them,' that is the Gemara—thus instructing us that all these were given to Moses from Sinai." Literary and historical criticism places the discussion on another basis when it treats the Mosaic Tōrāh *in its present form* as a post-exilic compilation (about 5th century B.C.) from sources differing in date, origin and history. There is no *a priori* reason why other legal enactments should not have been current when the compilation was first made; the Pentateuchal legislation is incomplete, and covers only a small part of the affairs of life. Laws must be adjusted from time to time to meet changing needs, and new teaching must justify itself by a reinterpretation of the old writings. Just as the stern common law of the Semites was modified by the milder legislation of the Pentateuch, so, in process of time, further developments ensued. Rabbinic law turned the Lex Talionis into monetary compensation. The

Pharisees were the liberalizing party and stood for the Spirit of the Scriptures, to the letter of which the conservative Sadducees clung. (For an illuminating example *see* J. Z. Lauterbach in *Heb. Union College Annual,* iv. Cincinnati, 1927, pp. 173 *seq.*) It is probable that this process was largely an unconscious one; and even if conscious, the analogy of the conventional "legal fiction" and the usual anxiety to avoid the appearance of novelty is enough to show that it is not to be condemned. Contemporary custom or ideals could appear to have ancient precedents, or by means of an exegetical process they could be directly connected with old models. In the Old Testament many laws in the Mosaic legislation are certainly post-Mosaic and the value of not a few narratives lies, not in their historical or biographical information, but in their treatment of law, ritual, custom, belief, etc. Thus, the problem of the origin or antiquity of the unwritten Oral Law, a living and fluid thing, lies outside the scope of criticism; of greater utility is the study of the particular forms the laws have taken in the written sources which from time to time embody the ever-changing legacy of the past.

Growth of the Mishnah and Gemara.—According to the traditional view the canon of the Old Testament closed with the work of Ezra. He was followed by the *Ṣōphĕrīm,* "scribes" (or the men of the great Synagogue), to the Maccabaean age, and these again by the "Pairs" (*zūgōth,* Gr. *ζυγόν*) the reputed heads of the Sanhedrin, down to the Herodian age (150–30 B.C.). The last culminate in Hillel (*q.v.*) and Shammai, the founders of two great rival schools, and to this famous pair the work of collecting *hălākōth* ("legal decisions") has been ascribed. The ensuing period of the *Tannā'īm,* "teachers" (about A.D. 10–220), is that of the growth of the Mishnah. (On the various teachers, especially the Haggadists, *see* W. Bacher, *Agada der Babylon. Amoräer,* pub. Strassburg, 1879; *A. d. Tannaiten,* pub. 1884, new edition begun in 1903; *A. d. Pal. Amoräer,* pub. 1892.)

Among the best known representatives of the schools are Rabban (a title given to Hillel's descendants) Gamaliel, the Phil-Hellene and teacher of the apostle Paul (Acts xxii. 3) and his son Simeon (Josephus, *Life,* § 38 *seq., Wars,* iv. 3, 9), and Rabban Joḥanan b. Zakkai, founder of the seat of learning at Jamnia (Jabneh). A little later (about A.D. 90–130) are the famous Gamaliel ii., Eliezer b. Hyrqanos (at Lydda), and Ishmael b. Elisha, the last of whom founded the school at Usha and is renowned for his development of the rules of exegesis framed by Hillel. With Rabbi Aqība (*q.v.*) and the synods of Jamnia (about A.D. 90 and 118) a definite epoch in Judaism begins. At Jamnia, under the presidency of Gamaliel II. and Eleazar b. Azariah, a collection of traditional *halakoth* was formed in the tractate *'Eduyyōth* (larger than and not to be identified with IV., 7). Here, likewise, was discussed the canonicity of the Song of Songs and of Ecclesiastes, and it is probable that here Aqība and his colleagues fixed the official text of the canonical books. Aqība had an important share in the early development of the Mishnah (Strack, pp. 19, 89); and, in the collecting of material, he was followed notably by the school of Ishmael (about A.D. 130–160), which has left its mark upon the early halakic Midrashim. The more interesting names include R. Meir, a well-known haggadist, R. Simeon b. Yoḥai, R. Jose b. Ḥalaphta and R. Jehudah b. 'Ilā'i. But, as collections of decisions were made by prominent teachers from time to time, confusion was caused by their differences as regards both contents and teaching (*Sotah,* 22*a*; *Shabb.* 138*b*). Consequently, towards the close of the second century a thoroughly comprehensive effort was made to reduce the *halakoth* to order.

Judah, grandson of Gamaliel II., known as the Prince or Patriarch (*nāsī'*), as *Rabbēnū* ("our teacher"), or simply as "Rabbi" *par excellence,* was the editor. He gathered together the material, using Meir's collection as a basis, and although he did not write the Mishnah as it now is, he brought it into essentially its present shape. His methods were not free from arbitrariness; he would attribute to "the wise" the opinion of a single authority which he regarded as correct; he would ignore conflicting opinions or those of scholars which they themselves had afterwards retracted, and he did not scruple to cite his own decisions.

The period of the *'Ămōrā'īm,* "speakers, interpreters" (about A.D. 220–500), witnessed the growth of the Gemara, when the now "canonical" Mishnah formed the basis for further amplification and for the collecting of old and new material which bore upon it. In Palestine learning flourished at Caesarea, Sepphoris, Tiberias and Usha; Babylonia had famous schools at Nehardea (from the 2nd century A.D.), Sura, Pumbeditha and elsewhere. Of their teachers (who were called Rabbi and Rab respectively) several hundreds are known. R. Ḥiyya was redactor of the *Siphrā* on Leviticus; to him and to R. Hoshaiah the compilation of the *Tōsephtā* is also ascribed. Abbā Arīka or Rab, the nephew of the first mentioned, founded the school of Sura (A.D. 219). Rab and Shemuel (Samuel) "the astronomer" (died A.D. 254) were pupils of "Rabbi" (*i.e.,* Judah, above), and were famed for their knowledge of law; so numerous were their points of difference that the Talmud will emphasize certain decisions by the statement that the two were agreed. The Gemara is much indebted to this pair and to Joḥanan b. Nappāḥā (199–279). The latter, founder of the great school of Tiberias, has indeed been venerated, on the authority of Maimonides, as the editor of the Palestinian Talmud; but the presence of later material and of later names, *e.g.,* Manī b. Jona and Jose b. Abin (Abun), refute this view. The Babylonian Rabbah b. Naḥmani (died *c.* 330) had a dialectical ability which won him the title "uprooter of mountains." His controversies with R. Joseph b. Ḥiyya (known for his learning as "Sīnai"), and those between their disciples Abaye and Rābā are responsible for many of the minute discussions in the Babylonian Gemara. Meanwhile the persecutions of Constantine and Constantius brought about the decay of the Palestinian schools, and, probably in the 5th century, their recension of the Talmud was essentially complete. In Babylonia, however, learning still flourished, and with Rab Ashi (352–427) the arranging of the present framework of the Gemara may have been taken in hand. Under Rabba Tosĕpha'a (died 470) and Rabina, *i.e.,* Rab Abina (died 499), heads of the academy of Sura, the Babylonian recension became practically complete.

Finally, the *Sabōrā'ē,* "explainers, opiners" (about 500–540), made some additions of their own in the way of explanations and new decisions.

The Palestinian Recension of the Mishnah and Gemara is called "the Talmud of the Land of Israel," or "T. of the West"; a popular but misleading name is "the Jerusalem Talmud." It is an extremely uneven compilation. "What was reduced to writing does not give us a work carried out after a preconcerted plan, but rather represents a series of jottings answering to the needs of the various individual writers, and largely intended to strengthen the memory" (Schechter). Political troubles and the unhappy condition of the Jews probably furnish the explanation; hence also the abundance of Palestinian haggadic literature in the Midrashim, whose "words of blessing and consolation" appealed more to their feelings than did the legal writings. The Pal. Talmud did not attain the eminence of the sister recension, and survives in a very incomplete form, although it was perhaps once fuller. It now extends only to Orders I.–IV., with the omission of IV. 7 and 9, and with the addition of part of VI. 7.

The Two Versions.—The Babylonian Talmud (or Tal. Babli) contains the Gemara to 36½ tractates, but the material is relatively very full, and it is about three times as large as the Pal., although the Gemara there extends to 39 tractates. In the latter the Gemara follows each paragraph of the Mishnah; in the former, references are usually made to the leaves (the two pages of which are called *a* and *b*), the enumeration of the *editio princeps* being retained in subsequent editions. The Mishnah is written in a late literary form of Hebrew; but the Gemara is in Aramaic (except the *Baraithas*), that of the Bab. T. being an Eastern Aram. dialect (akin to Mandaitic), that of the Pal. T. being Western Aram. (akin to Biblical Aram. and the Targums). Greek was well understood in cultured Palestine; hence the latter recension uses many Greek terms which it does not explain; whereas in the Bab. T. they are much less common, and are sometimes punningly interpreted. The Pal. Tal. is the more concise, but it is remarkable for the numerous repetitions of the same passages; these are useful for the criticism of the text, and for the light they throw upon the incompleteness of the work of compilation. The Bab. Tal., on the other hand, is diffuse and freer in its composition, and it is characterized by the exuberance of Halakah, which is usually rather subtle and far-fetched. Both Talmuds offer a good field for research.

Especially interesting are the *Baraithas* which are preserved in the Gemara in *Hebrew*; they are "external" decisions not included in the more authoritative Mishnah, but they differ from and are sometimes older than the Mishnic material, with which they sometimes conflict (so in particular as regards the rejected decisions of the school of Shammai). They usually begin: "our Masters taught," "it is taught," or "he taught," the verb *tĕnā* (*cf. Tannā'īm,* "teachers") being employed (*see* further *Jew. Ency.* ii. 513 *seq.*). Parallel to the Mishnah is the *Tōsephtā,* an independent compilation associated with R. Nehemiah (a contemporary of Meir and Simeon b. Yoḥai), Ḥiyya b. Abba and others; it is arranged according to the Mishnic orders and tractates, but lacks IV. 9 and V. 9–11. The halakoth are fuller and sometimes older than the corresponding decisions in the Mishnah, and the treatment is generally more haggadic. The method of making the discussions part of an interpretation of the Old Testament (halakic Midrash), as exemplified in the *Tōsephtā,* is apparently older than the abstract and independent decisions of the Mishnah—which presuppose an acquaintance with the Pentateuchal basis—and, like the employment of narrative or historical Midrash (*e.g.,* in the Pentateuch, Chronicles and Jubilees), was more suitable for popular exposition than for the academies.

The Responses of the Geonim.—The Palestinian Talmud, although used by the Qaraites in their controversies, fell into neglect, and the Babylonian recension became, what it has since been, the authoritative guide. With the *Gĕōnīm,* the heads of Sura and Pumbeditha (about 589–1038), we enter upon another stage. The "canonical" Mishnah and Gemara were now the objects of study, and the scattered Jews appealed to the central bodies of Judaism in Babylonia for information and guidance. The Geonim in their "Responses" or "Questions and Answers" supplied authoritative interpretations of the Old Testament or of the Talmud, and regulated the application of the teaching of the past to the changed conditions under which their brethren now lived. The legal, religious and other decisions formulated in the pontifical communications of one generation usually became the venerated teaching of the next, and a new class of literature thus sprang into existence. (*See* GAON.)

Meanwhile, as the Babylonian schools decayed, Talmudic learning was assiduously pursued outside its oriental home, and some Babylonian Talmudists apparently reached the West. However, the fortunes of the Talmud in a hostile world now become part of the history of the Jews, and the many interesting vicissitudes cannot be recapitulated here. (*See* JEWS.) To the use of the Pal. Talmud by the Qaraites in their controversies with the Rabbis we owe the preservation of this recension, incomplete though it is. To the intolerance of Christians are no doubt due the rarity of old mss., and the impure state of the text of both Talmuds. At the same time, the polemics had useful results since the literary controversy in the 16th century (when Johann Reuchlin took the part of the Jews) led to the *editio princeps* of the Babylonian Talmud (Vienna, 1520–23). A change shows itself in the second edition (Basel, 1578–81), when the tractate *Abōdāh Zārāh* was omitted, and those passages which offended the Christians were cancelled or modified.

Characteristics.—Owing to the nature of its contents the Talmud stood sorely in need of aids and guides, and a vast amount of labour (of varying value) has been devoted to it by Jewish scholars.

Neither the Mishnah nor the subsequent Gemara aimed at presenting a digested corpus of law. It is really a large collection of opinions and views, a remarkably heterogeneous mixture of contents, for which the history of its growth is no doubt largely responsible. It appalls the reader with its irregularity of treatment, its variations of style, and its abrupt transitions from the spiritual to the crude and trivial, and from superstition to the purest insight. Like the Koran it is often concise to obscurity and cannot be translated literally; it presupposes a knowledge which made commentaries a necessity even, as we have seen, to the Jews themselves. The opening of Order II. 6, for example, would be unintelligible without a knowledge of the law in Levit. xxiii. 42: "A booth (the interior of which is) about 20 cubits high is disallowed. R. Judah allows it. One which is not ten hands high, one which has not three walls, or which has more sun than shade is disallowed. 'An old booth?' (marks of quotation and interrogation must be supplied). The school of Shammai disallows it; but the school of Hillel allows it," etc. In the Gemara, the decisions of the Mishnah are not only discussed, explained or developed, but all kinds of additional matter are suggested by them. Thus, in the Bab. Gem. to III. 5, the reference in the Mishnah to the Zealots (Σικάριοι) is the occasion for a long romantic account of the wars preceding the destruction of the Second Temple. In IV. 3 the incidental prohibition of the cutting up of a roll of Scripture leads to a most valuable discussion of the arrangement of the Canon of the Old Testament, and other details including some account of the character and date of Job. There are numerous haggadic interpolations, some of considerable interest. Prose mingles with poetry, wit with wisdom, the good with the bad, and as one thing goes on to suggest another, it makes the Talmud a somewhat rambling compilation. It is scarcely a law-book or a work of divinity; it is almost an encyclopaedia in its scope, a store-house reproducing the knowledge and the thought, both unconscious and speculative, of the first few centuries of the Christian era.

Estimates.—Ordinary estimates of the Talmud are often influenced by the attitude of Christianity to Judaism and Jewish legalism, and by the preponderating interest which has been taken in the religious-legal side of the Rabbinical writings. The canonization of oral tradition in the Mishnah brought the advantages and the disadvantages of a legal religion, and controversialists have usually seen only one side. The excessive legalism which pervades the Talmud was the scholarship of the age, and the Talmud suffers to a certain extent because accepted opinions and isolated views are commingled. To those who have no patience with the minutiae of legislation, the prolix discussions are as irksome as the arguments appear arbitrary. But the Talmudical discussions were often merely specialized and technical—they were academical and ecclesiastical debates which did not always touch every-day life; sometimes they were for the purpose of reconciling earlier conflicting views, or they even seem to be mere exhibitions of dialectic skill (*cf.,* perhaps, Mk. xii. 18–23). It may be supposed that this predilection for casuistry stimulated that spirit which impelled Jewish scholars of the middle ages to study or translate the learning of the Greeks. Once again it was—from a modern point of view—old-fashioned scholarship; yet one may now recognize that in the development of European science and philosophy it played a necessary part, and one can now realize that again the benefit was for common humanity rather than for the Jews alone. In any case, the Talmud must be judged, like other authoritative religious literature, by its place in history and by its survival.

Results of Criticism.—The Talmud itself is still the authoritative and practical guide of the great mass of the Jews, and is too closely connected with contemporary and earlier Palestinian history to be neglected by Christians. With the progress of modern research the value of this and of the other old Rabbinical writings is being re-estimated, and criticism has forced a modification of many old views. Thus, an early reference to the *title* of a work does not prove that it is that which is now current; this applies, for example, to the tractate *'Ēduyyōth* (see *Jew. Ency.* viii. 611), and to the Midrash *Siphrē,* which frequently differs from that as known to the Talmud (*ib.,* xi. 331). It has been found that a tradition, however tenacious or circumstantial, is not necessarily genuine, and that, too, in spite of the chain of authorities by which its antiquity or genuineness appeared to be confirmed. Implicit reliance can no longer be necessarily placed upon the reputed authorship or editorship of a work; yet, although many of the views of mediaeval Jews in this respect prove to be erroneous (*e.g.*, on the authorship of the Zōhar; *see* KABBALAH), they may sometimes preserve the recollection of a fact which only needs restatement (*e.g.*, R. Johanan as the editor of the Pal. Talmud).

Finally, the Talmud comes at the end of a very lengthy development of Palestinian thought (*see* PALESTINE: *History*). It is in the direct line of descent from the Old Testament—intervening literature having been lost—the essence of which it makes its own. Forced by the events of history, this legacy of the past was subjected to successive processes and adapted to the needs of successive generations and of widely different historical and social conditions. Legal compendiums and systems of philosophy served their age and gave place to later developments; and the elasticity of interpretation which characterizes it enabled it to outlive Karaites and Kabbalists. It also escaped the classicism of the Renaissance with its insistence upon the test—*either* fact *or* fiction. As an oriental work among an oriental people the moral and spiritual influence of the Talmud has rested upon its connection with a history which appealed to the imagination and the feelings, upon its heterogeneity of contents suitable for all moods and minds, and upon the unifying and regulative effects of its legalism. The relationship of Talmudism to the Old Testament has been likened to that of Christian theology to the Gospels; the comparison, whether fitting or not, may at least enable one to understand the varying attitudes of Jewish thinkers to their ancient sources. With closer contact to the un-oriental West and with the inevitable tendencies of modern western scholarship the Talmud has entered upon a new period, one which, though it may be said to date from the time of Moses Mendelssohn (*see* JEWS), has reached a more distinctive stage at the present day. In the weakening of that authority which had been ascribed almost unanimously to the Talmud, and invariably to the Old Testament, a new and greater strain has been laid upon Judaism to reinterpret its spirit once more to answer the diverse wants of its adherents. This is part of that larger and pressing psychological problem of adjusting the "authority" ascribed to past writings to that of the collective human experience; it does not confront Judaism alone, and it must suffice to refer to the writings of "Reformed Judaism"; see, *e.g.*, C. G. Montefiore, *Liberal Judaism* (1903); *Truth in Religion* (1906); I. Abrahams, *Judaism* (1907); *Permanent Values* (1924), and the essays of S. Schechter.

BIBLIOGRAPHY.—E. Deutsch's article on the Talmud in the *Quarterly Review*, Oct. 1867 (reprinted in his *Literary Remains*), is noteworthy for the great interest it aroused. For other introductions, *see* J. Z. Lauterbach, "Mishnah," and W. Bacher, "Talmud" in the *Jew. Ency.*; S. Schechter, "Talmud," in Hastings' *Dict. Bib., E.R.E.*; and also S. Funk, *Entstehung des Talmuds* (Leipzig, 1910). More comprehensive are the handbooks of M. Mielziner, *Introd. to the Talmud* (Cincinnati, 1894), M. L. Rodkinson, *History of the Talmud* (New York, 1903), and especially H. L. Strack, *Einleitung in den Talmud* (Leipzig, 1908, very concise, but replete with bibliographical and other information). The works already cited in this article or in the art. MIDRASH, cover the most important departments of the Rabbinical literature, and may be supplemented from the critical Jewish journals, *e.g.*, the *Jewish Quarterly Review*, *Revue des Études Juives* (Paris), and especially the *Monatsschrift f. Gesch. u. Wissenschaft des Judentums* (Breslau). (S. A. C.; X.)

TAM, JACOB BEN MEÏR (1100–1171), a grandson of Rashi (*q.v.*), was the most famous French glossator (*tosafist*) on the text of the Talmud. In 1147 he was attacked and injured by a disorderly band who had attached themselves to the Crusaders. He escaped to the neighbouring Troyes, where about 1160 was held the first of the Jewish Synods, for which the Rhinelands became celebrated. At this meeting it was laid down that disputes between Jew and Jew were not to be carried to a Christian court, but were to be settled by fraternal arbitration. New conditions of life had arisen owing to the closer terms on which Jews and Christians lived, and Jacob Tam was foremost in settling the terms which were to govern the relations, from the Jewish side. His practical ordinances (*Takkanoth*), connected with marriage and divorce, trade and proselytism, as well as with synagogue ritual, bear the stamp of enlightened independence within the limits of recognized authoritative tradition and law. Of his legal work the most important was collected in his *Sefer ha-yashar*. He was also a poet and grammarian.

See Gross, *Gallia Judaica* (index); M. Schloessinger in *Jewish Encyclopedia*, vii. 36–39. (I. A.)

TAMAI, BATTLE OF, March 13, 1884. This is memorable as the occasion on which the charge of the Sudanese tribesmen, followers of Osman Digna, broke the British "square," although eventually repulsed. For an account *see* EGYPT AND SUDAN, CAMPAIGNS IN, 1882–1899.

TAMAQUA, an anthracite-mining borough of Schuylkill county, Pennsylvania, U.S.A., 15 m. N.E. of Pottsville, on the Tamaqua (Little Schuylkill) river; served by the Central of New Jersey, the Lehigh and New England and the Reading railways. Pop. (1920) 12,363 (91% native white); 1928 local estimate over 15,000. There are many collieries in the borough and its immediate environs, and the various manufacturing industries (including foundries and machine shops, powder mills, shirt factories and knitting mills) had an aggregate output in 1925 valued at $3,796,150. Settlement here dates from 1799. Anthracite was discovered in 1817, and in 1829 a town was laid out, which in 1833 was incorporated as a borough. The name is an Indian word meaning "running water."

TAMARIND, the name popularly applied to the pods of a leguminous tree, which are hard externally, but within filled with an acid juicy pulp containing sugar and various acids, such as citric and tartaric, in combination with potash. The acid pulp is used as a laxative, the pods being largely imported both from the East and the West Indies. The tree is now widely distributed in tropical countries, but it is generally considered that its native country is in eastern tropical Africa, from Abyssinia southward to the Zambezi. The name (meaning in Arabic "Indian date") shows that it entered mediaeval commerce from India, where it is used, not only for its pulp, but for its seeds, which are astringent, its leaves, which furnish a yellow or a red dye, and its timber. The tree (*Tamarindus indica*) attains a height of 70 to 80 ft., and bears elegant pinnate foliage and purplish or orange veined flowers arranged in terminal racemes.

TAMARISK. The genus *Tamarix* gives its name to a small group of shrubs or low trees constituting the tamarisk family, Tamaricaceae. The species of tamarisk and of the very closely allied genus *Myricaria* grow in salt-deserts, by the sea-shore, or in other more or less sterile localities in warm temperate, subtropical, and tropical regions of the eastern hemisphere. Their long slender branches bear very numerous small appressed leaves, in which the transpiring surface is reduced to a minimum. The flowers are minute and numerous, in long clusters at the ends of the branches or from the trunk. Each has 4–5 free sepals, and as many petals springing with the 4–10 stamens from a fleshy disk. In *Tamarix* the stamens are free, while in *Myricaria* they are united into one parcel. The fruit is capsular, and contains numerous seeds, each usually with a long tuft of hairs at one end. The great value of these shrubs or trees lies in their ability to withstand the effects of drought and a saline soil, in consequence of which they grow where little else can flourish. On this account the common tamarisk, *T. gallica*, is planted on sea-coasts, and affords shelter where none other could be provided. *T. articulata*, native to western Asia, has been introduced as a windbreak in desert areas in southern California. Several species are cultivated as ornamentals. For tamarisk manna, *see* MANNA.

TAMATAVE (known by the natives as *Tòamàsina*) (pop. 15,022), the chief seaport of Madagascar, situated nearly on the centre of the eastern coast in 18° 10′ S., 49° 32′ E. It owes its importance to the existence of a coral reef, which forms a spacious harbour, entered by two openings but unfortunately exposed to frequent cyclonic storms and to a tidal bore. The town is built on a sandy peninsula on which are crowded numerous houses, with good shops and merchants' offices in the main thoroughfares. Tamatave is the seat of several foreign consuls, as well as of numerous French officials, and is the chief port for the capital and the interior. Imports consist principally of piece-goods, farinaceous foods, and iron and steel goods, and exports of gold dust, raffia, hides, caoutchouc and live animals. The town possesses several meat preserving factories. Communication with Europe is maintained by steamers of the Messageries Maritimes and the

Havrâise companies, and also with Mauritius, and from thence to Ceylon, by the British Union-Castle line. Of the whole foreign trade of Madagascar, 46 per cent is through Tamatave. The town is connected with the interior of the country by a network of roads and railways. Since 1895 the native population has settled in a new village to the north-west.

TAMAULIPAS, a northern Gulf-coast State of Mexico. Area 30,734 sq. miles. Pop. (1921) 286,904. The central and southern parts of the State are mountainous, but there are extensive fertile plains in the north sloping gently north-east toward the Rio Grande, and the coastal zone is sandy, much broken by lagoons and sparsely inhabited. Except in the north this coastal zone is only 5 to 7 m. wide, but the foothills region back of this is usually well wooded and fertile, and the low alluvial river valleys penetrate deeply into the sierras. There are four important rivers in the State—the Rio Grande del Norte or Rio Bravo, which forms the boundary line with the United States, the Conchas or Presas, the Soto da Marina and the Tamesi. The Pánuco forms the southern boundary for a short distance. A peculiar feature of the hydrography of Tamaulipas is the series of coastal lagoons formed by the formation of new beaches across the indentations of the coast. The climate is hot and humid on the coast, but is pleasant on the more elevated lands of the interior. The rainfall is abundant, especially on the mountain slopes of the south. The principal industry is agriculture. Sugar, cereals, tobacco, cotton and coffee are produced, and probably fruit may be raised successfully. Stock-raising receives some attention and hides and cattle are exported. The preparation of ixtle fibre for export is becoming an important industry. Copper is mined and extensive deposits of petroleum and asphalt are being exploited. Railway communication is provided by the Mexican National, two branches of which cross the northern end of the State, the line from Monterrey to Tampico, and a branch of the Mexican Central from San Luis Potosi to Tampico.

The capital of Tamaulipas is Ciudad Victoria (pop., 1921, 17,124), a small sierra town on the Monterrey and Tampico railway, about 120 m. from Tampico. Among other towns in the State may be mentioned: Matamoros (*q.v.*), Tampico (*q.v.*), Tula (3,192 in 1921), Nuevo Laredo, on the American border (14,998 in 1921), and Doña Cecilia (15,298 in 1921).

TAMAYO Y BAUS, MANUEL (1829–1898), Spanish dramatist, came of a family connected with the theatre, his mother being the eminent actress, Joaquina Baus. The earliest of his printed pieces, *Juana de Arco* (1847), is an arrangement from Schiller, as also is *Angela* (1852), while *Virginia* (1853) is a dramatic essay in Alfieri's manner. *La Locura de Amor* (1855) established Tamayo's reputation as Spain's leading playwright. *Hija y Madre* (1855) is a failure, and *La Bola de Nieve* (1856) is notable solely for its excellent workmanship. Tamayo's straitened means during the next few years forced him to put original work aside and to adapt pieces from Léon Laya, Jules Sandeau and Émile Augier. In this period he produced only one original piece, *Lances de Honor* (1863), which turned upon the immorality of duelling, and led to a warm discussion among the public.

TAMBOV, a province of the Russian S.F.S.R., surrounded by those of Voronezh, Orel, Tula, Ryazan, Penza, Saratov and Stalingrad. Area 46,742 sq.km. Pop. (1926) 2,721,173. It is much smaller than the pre-1917 province of the same name, part of which is now in Ryazan province, and is included in the recently created Black Earth area (Central) (*q.v.*). It consists of an undulating plain (450–800 ft.), intersected by deep ravines and broad valleys, the Don and its tributaries, the Voronezh, Vorona and Khoper, drain it towards the south, and the Tsna links it with the Oka on the north. Cretaceous and Jurassic deposits, thickly covered with boulder clay and loess conceal the underlying Devonian and Carboniferous strata. Phosphorite beds exist in the north-east and are used for the production of chemical manure; iron is mined in the Lipetsk district, which also has mineral springs, and limestone, clay and gypsum are worked. The soil is black earth, very fertile in the Borisoglyebsk district, but having a lower humus content towards the north, where wild cherry and almond abound. For climate, the difficulties of agriculture and general social conditions, *see* VORONEZH, noting however that Tambov has a smaller annual rainfall.

The population is mainly Great Russian in origin, settlement beginning from the principality of Moscow at a very early date, but Tatar raids prevented active colonisation until the end of the 17th century, when landowners who had received large grants of land from the tsars began to bring their serfs from central Russia. There were some Finnish tribes in occupation, and the Mordva still form an independent group in the province. After the disturbances of the 1917–20 civil war, and the retreat of Denikin's army (1920), the province was infested for some time by troops of bandits, and is only slowly recovering from the devastation and famine of that dreadful time.

TAMBOV, chief town of the above province, situated on the Tsna river (non-navigable), and at a railway junction, in 52° 45′ N., 41° 23′ E. Pop. (1926) 72,481. It has smelting works, a railway repair shop, steam flour mills, distilleries and brick works. The absence of a navigable river lessens its trading importance, though it has a grain elevator. The town was founded in 1636 as a fort against Tatar and Kalmuck raids, was a station for part of Peter the Great's army during his attack on Azov, and later was centre of Tambov province, created in 1796.

TAMERLANE: *see* TIMUR.

TAMILS, the Sanskrit generic appellation for the south Indian peoples and their languages, which passed through various stages—Dravida, Dramiḍa, Dramila, Damila. Bishop Caldwell fully explains this in his *Comparative Grammar of the Dravidian Languages* (2nd ed., 1875, p. 10 *seq.*). The term Tamulic or Tamulian has occasionally been employed as the designation of the whole class of Dravidian peoples and languages. The Tamils proper are smaller and of weaker build than Europeans, though graceful in shape. The hair is plentiful, and occasionally curly. The skin varies from brown to black. Of medium stature, they are in general long headed with medium noses. They are enterprising, and wherever money is to be earned there will Tamils be found, either as merchants or in the capacity of domestic servants and labourers. The tea and coffee districts of Ceylon are peopled by about 950,000; Tamils serve as coolies in the Mauritius and the West Indies; in Burma, the Straits, and Siam the so-called Klings are all Tamils. They have settlements in East and South Africa.

Language.—Tamil is still the principal language of the Madras Presidency; in Tanjore and Tinnevelly it is supreme. In Coimbatore it is dominant, is second in Chittoor and the Nilgiris (*Census of India* 1921, vol. xiii.). Tamil is a sister of Malayâḷam, Telugu, Kanarese, Tulu; and, as the oldest, richest, and most highly organized of the Dravidian languages, is typical of that family. The one nearest akin to it is Malayâḷam, originally a dialect of Tamil, but now differing from it in pronunciation and in idiom, in the retention of old Tamil forms obsolete in the modern language, and in having discarded all personal terminations in the verb, the person being always indicated by the pronoun. Also, the proportion of Sanskrit words in Tamil is less than in any other Dravidian tongue.

The modern Tamil characters originated "in a Brahmanical adaptation of the old Grantha letters corresponding to the so-called Vaṭṭeḷuttu," or round-hand, an alphabet once in vogue throughout the whole of the Pâṇḍyan kingdom, as well as in the South Malabar and Coimbatore districts, and still sparsely used for drawing up conveyances and other legal instruments. It is also used by the Moplahs in Tellicherry, while in Malabar it continued in general use down to the end of the 17th century. The modern Tamil characters, which have changed but little for the last 500 years, differ from all the other modern Dravidian alphabets both in shape and in their phonetic value. Their angular form is said to be due to the widespread practice of writing with the style resting on the *end* of the left thumb-nail, while the other alphabets are written with the style resting on the left side of the thumb.

The Tamil alphabet is sufficiently well adapted for the expression of the twelve vowels of the language (*a, â, i, î, u, û, e, ê, o, ô, ei, au*),—the occasional sounds of *ö* and *ü*, both short and long, being covered by the signs for *e, ê, i, î;* but it is utterly inadequate for the proper expression of the consonants, inasmuch as the one character *k* has to do duty also for *kh, g, gh,* and similarly each of the other surd consonants *ch, ṭ, t, p* represents also the remaining three letters of its respective class. The letter *k* has, besides, occasionally the sound of *h,* and *ch* that of *s.* Each of the five consonants *k, ch, ṭ, t, p* has its own nasal. In addition to the four semivowels, the Tamil possesses a cerebral *ṛ* and *ḷ* and has retained a liquid *l̤,* once peculiar to all the Dravidian languages, the sound of which varies in different districts. There is, lastly, a peculiar *n,* differing in function but not in pronunciation from the dental *n.* The three sibilants and *ḥ* of Sanskrit have no place in the Tamil alphabet; but *ch* often does duty as a sibilant in writing foreign words, and the four corresponding letters as well as *j* and *ksh* of the Grantha alphabet are now frequently called to aid. Many of the Sanskrit words imported into Tamil at various periods have therefore assumed disguises under which the original is scarcely recognizable: examples are *ulagu* (loka), *uruvam* (rûpa), *arukken* (arka), *aṛputam* (adbhutam), *naṭchattiram* (nakshatram), *iruḍi* (ṛishi), *tîrkam* (dîrgha), *arasen* (râjan).

Tamil has borrowed from Hindustani, Arabic, and Persian a large number of revenue, political, and judicial terms, and more recently a good many English words have crept in, such as *tiraṭṭi,* treaty, *paṭlar,* butler, *âkṭ,* act, *kulôb,* club, *kavarnar,* governor, *pinnalkôdu,* penal code, *sîkku,* sick, *mejastiraṭṭu,* magistrate. Of Tamil words which have found a permanent home in English may be mentioned curry (*kaṛi*), mulligatawny (*milagu,* pepper, and *taṇṇîr,* cool water), cheroot (*suruttu*), pariah (*paṛeiyan*).

The Older Literature.—The early existence, in southern India, of peoples, localities, animals and products the names of which, as mentioned in the Old Testament and in Greek and Roman writers, have been identified with corresponding Dravidian terms, goes far to prove the high antiquity, if not of the Tamil language, at least of some form of Dravidian speech (Caldwell, *loc. cit.,* Introd., pp. 81–106; *Madras District Manual,* i., Introd., pp. 134 *seq.*). But practically the earliest extant records of the Tamil language do not ascend higher than the middle of the 8th century of the Christian era, the grant in possession of the Israelites at Cochin being assigned by the late Dr. Burnell to about A.D. 750, a period when Malayâḷam did not exist yet as a separate language. There is every probability that about the same time a number of Tamil works sprung up, which are mentioned by a writer in the 11th century as representing the old literature (Burnell, *loc. cit.,* p. 127, note). The earlier of these may have been Saiva books; the more prominent of the others were decidedly Jain. Though traces of a north Indian influence are palpable in all of them that have come down to us (see *e.g.,* F. W. Ellis's notes to the *Kuṛaḷ*), we can at the same time perceive, as we must certainly appreciate, the desire of the authors to oppose the influence of Brahmanical writings, and create a literature that should rival Sanskrit books and appeal to the sentiments of the people at large. But the refinement of the poetical language, as adapted to the genius of Tamil, has been carried to greater excess than in Sanskrit; and this artificial character of the so-called Sen-Tamil is evident from a comparison with the old inscriptions, which are a reflex of the language of the people, and clearly show that Tamil has not undergone any essential change (Burnell, *loc. cit.,* p. 142).

The rules of Sen-Tamil appear to have been fixed at a very early date. The *Tolkáppiyam,* the oldest extant Tamil grammar, is assigned by Dr. Burnell (*On the Aindra School of Sanskrit Grammarians,* pp. 8, 55) to the 8th century (best edition by C. Y. Tâmodaram Pillei, Madras, 1885). The *Vîrasôḷiyam,* another grammar, is of the 11th century. Both have been superseded by the *Nannûl,* of the 15th century, which has exercised the skill of numerous commentators, and continues to be the leading native authority (English editions in Pope's *Third Tamil Grammar,* and an abridgment by Lazarus, 1884). The period of the prevalence of the Jains in the Pâṇḍya kingdom, from the 9th or 10th to the 13th century, is justly termed the Augustan age of Tamil literature. To its earlier days is assigned the *Nâlaḍiyâr,* an ethical poem on the three objects of existence, which is supposed to have preceded the *Kuṛaḷ* of Tiruvaḷḷuvan, the finest poetical production in the whole range of Tamil composition. Tradition, in keeping with the spirit of antagonism to Brahmanical influence, says that its author was a pariah. It consists of 1,330 stanzas on virtue, wealth and pleasure. It has often been edited, translated and commented upon; see the introduction to the excellent edition published by the Rev. Dr. Pope, in which also a comprehensive account of the peculiarities of Sen-Tamil will be found. To the Avvei, or Matron, a reputed sister of Tiruvaḷḷuvan, but probably of a later date, two shorter moral poems, called *Attisûḍi* and *Konṛeivêyndan,* are ascribed, which are still read in all Tamil schools. *Chintâmaṇi,* an epic of upwards of 3,000 stanzas, which celebrates the exploits of a king Jîvakan, also belongs to that early Jain period, and so does the *Divâkaram,* the oldest dictionary of classical Tamil. The former is one of the finest poems in the language; but no more than the first and part of the third of its thirteen books have been edited and translated. Kamban's *Râmâyaṇam* (about A.D. 1100) is the only other Tamil epic which comes up to the *Chintâmaṇi* in poetical beauty.

The most brilliant of the poetical productions which appeared in the period of the Saiva revival (13th and 14th centuries) are two collections of hymns addressed to Siva, the one called *Tiruvâsakam,* by Mâṇikka-Vâsakan, and a later and larger one called *Tîvâram,* by Sambandhan and two other devotees, Sundaran and Appan. Both these collections have been printed, the former in one, the latter in five volumes. They are rivalled both in religious fervour and in poetical merit by a contemporaneous collection of Vaishṇava hymns, the *Nâlâyira-prabandham* (also printed at Madras). The third section of it, called *Tiruvâymoli* or "Words of the Sacred Mouth," has been published in Telugu characters, with ample commentaries, in ten quartos (Madras, 1875–76).

After a period of literary torpor, which lasted nearly two centuries, King Vallabha Deva, better known by his assumed name Ativîrarâma Pânḍyan (second half of the 16th century), endeavoured to revive the love of poetry by compositions of his own, the most celebrated of which are the *Neiḍadam,* a somewhat extravagant imitation of Srî Harsha's Sanskrit *Naishadham,* and the *Veṛṛivêrkei,* a collection of sententious maxims. Though he had numerous followers, who made this revival the most prolific in the whole history of Tamil literature, none of the compositions of any kind, mainly translations and bombastic imitations of Sanskrit models, have attained to any fame. An exceptional place, however, is occupied by certain Tamil sectarians called *śittar* (i.e., *siddhas* or sages), whose mystical poems, especially those contained in the *Sivavâkyam,* are said to be of singular beauty. Two poems of high merit, composed at the end of the 17th century, also deserve favourable notice—the *Nîtineṛiviḷakkam,* an ethical treatise by Kumâragurupara Desikan, and the *Prabhulingalîlei,* a translation from the Kanarese of a famous text-book of the Vîra-Saiva sect. *See* the analysis in W. Taylor's *Catalogue,* vol. ii. pp. 837–47.

The Modern Period, which may be said to date from the beginning of the last century, is ushered in by two great poets, one native and the other foreign. *Tâyumânavan,* a philosopher of the pantheistic school, composed 1,453 stanzas (*pâdal*) which have a high reputation for sublimity both of sentiment and style; and the Italian Jesuit Joseph Beschi (d. 1742), under the name Vîramâmuni, elaborated, on the model of the *Chintâmaṇi,* a religious epic *Têmbâvaṇi,* which, though marred by blemishes of taste, is classed by native critics among the best productions of their literature. It treats of the history of St. Joseph, and has been printed at Pondicherry in three volumes, with a full analysis. English influence has here, as in Bengal and elsewhere in India, greatly tended to create a healthier tone in literature both as to style and sentiment. As one of the best Tamil translations of English books in respect of diction and idiom may be mentioned the *Bâlavyâpârikal,* or "Little Merchants," published by the Vernacular Text Society, Madras. P. Percival's collection of *Tamil Proverbs* (3rd ed., 1875) should also be mentioned.

The copper-plate grants, commonly called *śâsanams,* and stone inscriptions in Tamil, many of which have been copied and translated (*Archaeological Survey of Southern India,* vol. iv.; R. Sewell, *Lists of the Antiquarian Remains in the Presidency of Madras,* vols. i., ii.), are the only authentic historical records. (*See* also Sir Walter Elliot's contribution to the *International Numismata Orientalia,* vol. iii. pt. 2.) As early as the time of the Chinese traveller Hsüan Tsang, books were written in southern India on talipot leaves, and Albiruni mentions this custom as quite prevalent in his time (1031). It has not died out even at the present day, though paper imported from Portugal has, during the last three centuries, occasionally been used. Madras is now the largest depository of Tamil palm-leaf mss., which have been described in Wilson's *Catalogue of the Mackenzie Collection* (Calcutta, 1828, 2 vols.), W. Taylor's *Catalogue* (Madras, 1857, 3 vols.), and Condaswamy Iyer's *Catalogue* (vol. i., 1861).

The art of printing, however, which was introduced in southern India at an early date, while it has tended to the preservation of many valuable productions of the ancient literature, has also been the means of perpetuating and circulating a deal of literary rubbish and lasciviousness which would much better have remained in the obscurity of manuscript. Dr. Burnell has a note in his *Elements of South Indian Paleography* (2nd ed., p. 44), from which it appears that in 1578 Tamil types were cut by Father João de Faria, and that a hundred years later a Tamil and Portuguese dictionary was published at Ambalakkâḍu. At present the number of Tamil books (inclusive of newspapers) printed annually far exceeds that of all the other Dravidian vernaculars put together. The earliest Tamil version of the New Testament was commenced by the Dutch in Ceylon in 1688; Fabricius's translation appeared at Tranquebar in 1715. Since then many new translations of the whole Bible have been printed, and some of them have passed through several editions.

The German missionary B. Ziegenbalg was the first to make the study of Tamil possible in Europe by the publication of his *Grammatica Damulica,* which appeared at Halle in 1716. Some time later the Jesuit father Beschi devoted much time and labour to the composition of grammars both of the vulgar and the poetical dialect. The former is treated in his *Grammatica Latino-Tamulica,* which was written in 1728, but was not printed till eleven years later (Tranquebar, 1739). It was twice reprinted, and two English translations have been published (1831, 1848). His *Sen-Tamil Grammar,* accessible since 1822 in an English translation by Dr. Babington, was printed from his own ms. (*Clavis humaniorum literarum sublimioris Tamulici idiomatis*) at Tranquebar in 1876. This work is especially valuable, as the greater portion of it consists of a learned and exhaustive treatise on Tamil prosody and rhetoric. (*See,* on his other works, Graul's *Reise,* vol. iv. p. 327.) There are also grammars by Anderson, Rhenius, Graul (in vol. ii. of his *Bibliotheca Tamulica,* Leipzig, 1855), Lazarus (Madras, 1878), Pope (4th edition in three parts, London, 1883–85), and *Grammaire française-tamoule,* by the Abbé Dupuis (Pondicherry, 1863). The last two are by far the best. The India Office library possesses a ms. dictionary and grammar "par le Rév. Père Dominique" (Pondicherry, 1843), and a copy of a ms. Tamil-Latin dictionary by the celebrated missionary Schwarz, in which 9,000 words are explained. About the like number of words are given in the dictionary of Fabricius and Breithaupt (Madras, 1779 and 1809). Rottler's dictionary, the publication of which was commenced in 1834, is a far more ambitious work. But neither it nor Winslow's (1862) come up to the standard of Tamil scholarships; the *Dictionnaire tamoul-français,* which appeared at Pondicherry in 2 vols. (1855–62), is superior to both, just as the *Dictionarium latino-gallico-tamulicum* (*ibid,* 1846) excels the various English-Tamil dictionaries which have been published at Madras.

BIBLIOGRAPHY.—*See* A. T. Mondière and J. Vinson in *Dictionnaire des sciences anthropologiques, s.v.* "Dravidiens"; S. C. Chitty, *The Tamil Plutarch,* Jaffna, 1859; J. Murdoch, *Classified Catalogue of Tamil Printed Books,* Madras, 1865; C. E. Gover, *Folk-Songs of Southern India,* Madras, 1871; Bishop Caldwell's *Comparative Grammar of the Dravidian Languages,* 2nd ed., London, 1875; Graul's *Reise nach Ostindien,* vols. iv. and v.; the quarterly *Lists of Books* registered in the Madras Presidency; [Dr. Maclean's] *Manual of the Administration of the Madras Presidency,* vols. i. and ii., Madras, 1885, folio; F. Müller, *Grundriss der Sprachwissenschaft,* Vienna, 1884, iii. i. 162–246; G. U. Pope, *First Lessons in Tamil,* 7th ed., Oxford, 1904, and *The Nāladiyār,* Oxford, 1893; and J. Vinson, *Manuel de la langue tamoule,* Paris, 1903. (R. Rt.; X.)

TAMLUK, a subdivisional town of British India, in the Midnapore district of Bengal on the river Rupnarayan. Pop. (1921), 8,348. Under the name of Tamralipta, it was a seaport at which the Chinese Buddhist pilgrims embarked; it may also be identified with Tamalites noticed by Ptolemy as being on the river Ganges. The channel connecting the town with the sea survived till the 17th century, when the Portuguese had a settlement here, and then silted up. Tamluk is now 60 m. from the sea, and the ruins of the old city lie deep beneath river silt.

TAMMANY HALL. Quite as old as the U.S. Government, this powerful political organization in New York city has, with only occasional intermissions, not only ruled that city since the year 1800, but at times has exercised great influence in State administration and even in national affairs.

Its Origin.—Before the American Revolution groups proclaiming fealty to King George III. were organized in societies bearing the names of St. George, St. Andrew and St. David. To counter their aims the revolutionists formed associations called the Sons of Liberty or the Sons of St. Tammany. Tammany or Tammanend was an Indian chief noted for his wisdom, benevolence and love of liberty. In ridicule of the imported saints, revolutionists dubbed Tammany a saint. With the achievement of American independence the Sons of Liberty and the Sons of St. Tammany dissolved.

When the delegates of New York State met to adopt a Federal constitution, the discussions evidenced the existence of a unified aristocratic group. During the Revolution many estates owned by opponents of the American cause had been confiscated. But there remained some large estates in possession of families which either supported the Revolution or were not hostile. The proprietors of these estates, often vested with almost feudal powers, constituted the core of the aristocratic party. To resist these influences, William Mooney, an upholsterer in New York city, founded the Society of St. Tammany or Columbian Order, on May 12, 1789, a fortnight after the establishment of the National Government. His purpose was the creation of a society native in character and democratic in principle and action. Its officers were given Indian titles; the society's chief was Grand Sachem and his fellow chiefs Sachems. The democracy comprehended in Tammany's original period was not, however, that of later times. For more than three decades after its organization Tammany represented the middle-class opposed to the pretensions and power of the aristocratic party; it did not then represent the lower classes.

At first, the Society of St. Tammany was non-partisan in the sense that it had no distinct political affiliations but expressed its democratic sentiments in toasts and speeches at occasional banquets and displayed itself in parades. But when, in 1798, there was a division of conflicting forces into parties the Society of St. Tammany ardently supported the Republican (later called Democratic) Party, led by Thomas Jefferson. Realizing the effective political uses to which the society could be converted, Aaron Burr was largely instrumental in causing its change to an active political club opposed to the Federalist Party. Through various aides Burr controlled the Society of St. Tammany until his downfall after killing Alexander Hamilton in a duel in 1804. The society had an influential share in bringing about the democratic victory in the election of Thomas Jefferson as president of the U.S. in 1800. In the same year the society's leaders won election or obtained appointment to New York city municipal offices.

Tammany Hall Organized.—Caustic criticisms made by the opposition that a private society was engaging in politics resulted in a separation of social from political functions. In 1805 the Society of St. Tammany obtained from the legislature a charter incorporating it as a benevolent and charitable body to give relief to members and others. The Tammany Hall political organization was now created as an apparently distinct body. In reality the society's Sachems controlled the political mechanism; the leaders of the two organizations were either identical or the men directing the political arm had their representatives as Sachems. The explanation of the Tammany society's control of the Tammany Hall political organization lay in the fact that the society has been continuously the owner of the Tammany Hall building. In this capacity it has always had and still has the power of dispossessing any faction hostile to the Tammany Hall leaders. As the label of party regularity became binding upon a majority of voters, no faction thus evicted could properly claim to be the Tammany organization or any part of it. This happened in 1828, 1838, 1853 and 1857 when the Sachems, as trustees of the building, excluded factions from meeting in Tammany Hall.

Until 1806 Tammany Hall remained an agitational political club, the New York city representative of the Republican, later termed Democratic, Party. In that year was begun a thorough organization of Democratic voters. The main features of this comprehensive plan were general, nominating, corresponding and ward committees. In the general committee was vested the power of convening the party's meetings and of making all necessary arrangements for elections. Composed originally of 30 members, this committee was gradually expanded until it had many thousands of members penetrating every section in the city.

Tammany Hall's strength was greatly increased when, in 1820, it decided as a matter of policy to support a New York State constitutional amendment abolishing property qualifications for voting. Effective in 1822, this amendment brought a new and ever-increasing voting element into politics and generally into Tammany Hall. The change produced by manhood suffrage was not immediate. For some years more Tammany was led by bankers and merchants who used their power for self-enrichment. The Workingmen's Party, in 1829, and its successor, the Equal Rights Party, organized in 1834, so successfully warred upon banker leaders and their colleagues that the general committee rid Tammany Hall of this element.

Gang Control and "Boss" Rule.—The period especially from 1846 onward was one in which heavy immigration, notably Irish, poured into New York city. Impecunious, and objects of religious and racial prejudice, numbers of the Irish, unable to get work, banded in street gangs. Unlike other political parties, Tammany Hall welcomed immigrants, facilitated their naturalization and gave them relief. The astute, unscrupulous and engaging Fernando Wood organized the gangs as a political power within Tammany Hall, securing his own advancement as well as assuring Tammany the redoubtable support of men equally useful in overawing opposition, packing primaries or committing frauds at the polls. Wood had been a powerful but not a supreme leader. With the ascendency of William M. Tweed in 1867, Tammany Hall came under the sway of a single leader or boss. The son of a chairmaker, Tweed had won his way through ward politics, had been a member of "The Forty Thieves" board of aldermen in 1851–52, manipulating his unprincipled way to the rule of Tammany Hall. Corruption reached its climax under Tweed when New York city was plundered of an amount conservatively estimated at $45,000,000 in direct spoliation, but ranging as high as $200,000,000 when reduced taxes and fraudulent bond issues are also considered. Only $876,000 was ever recovered. Tweed died in gaol, but most of his confederates and the other looting beneficiaries retained their wealth. Tammany Hall became a world-wide object of odium.

Restored to Power.—For a time in popular disfavour, Tammany Hall, within three years after the exposures of the Tweed régime, was again in power in New York city. Succeeding Tweed as boss, John Kelly sagaciously induced Democrats who had been prominent in overthrowing Tweed to reorganize Tammany Hall. Superficial, this move in nowise affected the composition and characteristics of the Tammany organization at large. The real resuscitating factor was the attachment of New York city's tenement house masses to an organization the district leaders of which exercised a human relationship, coming into direct contact with them, treating them politically as equals, and giving a helping hand to those in want or trouble. This one large service outweighed all of the denunciations of Tammany by Republican business opponents who often had their own less spectacular but more insidious system of corruption. After Kelly's death in 1886, Richard Croker succeeded as Tammany Hall's boss, and he was followed by Charles F. Murphy in 1902. During this period many charges of Tammany corruption were made and proved. But these were perhaps no greater than the contemporary frauds and corruptions committed by financial, insurance and other corporations.

Tammany in Recent Years.—With the accession of Judge George W. Olvany to leadership of Tammany after Murphy's death in 1924, came evidence of a still more altered Tammany Hall. Differing from his predecessors, Judge Olvany was a university graduate and lawyer, having served in the court of general sessions. In contrast to former or older crude district leaders, the new district leaders were also men of varying degrees of education. The force behind this changing Tammany was generally recognized to be that of Alfred E. Smith (*q.v.*), four times governor of New York and a leading Presidential candidate. On Mar. 16, 1929, Olvany suddenly resigned his leadership. Many interpreted this as meaning a loss of Smith's power and influence after his defeat in the national election of 1928. After a month's deadlock between the factions John F. Curry, a former ward leader of the old type, was elected to head the organization. Tammany definitely decided to retrench and confine its attention to municipal politics. Although since 1898 New York city has been extended to include five boroughs, Tammany Hall's organization has been confined to Manhattan and the Bronx. The Democratic organizations of other boroughs have been allied bodies. In Dec. 1927 The Tammany Society sold the Tammany Hall building on 14th street, which it had occupied since 1868, and bought a site for a new building at Union square, E. and 17th street, which was occupied on January 1, 1929.

See Gustavus Myers, *The History of Tammany Hall;* "The New Tammany," *The Century Magazine,* Aug. 1926; Dennis Tilden Lynch, *Boss Tweed;* M. R. Werner, *Tammany Hall* (1928).

TAMMERFORS: *see* TAMPERE.

TAMMUZ, Sumerian, Babylonian and Assyrian god, who died and rose annually with dying and reviving vegetation, originally *Dumu-zi,* "the son who rises, goes forth (from the nether world)," but generally interpreted "faithful son." Philologically both interpretations are correct, and no Accadian commentary exists to explain which meaning was accepted by them. The interpretation as "the son who rises," "the resurrected child," accepted in this article, is new and differs from all views held in the standard works on this cult. It is clear, however, that the main principle of this cult is the resurrection of the dying god, and the verb *zi* stands for the root *zig* to rise up, not *zid,* to be faithful. (*See* S. Langdon, *Sumerian Liturgies and Psalms,* p. 287, 17, *ušubba-za uziga-za,* "In thy fall and in thy resurrection.")

There are many titles of the youthful god, loved by his sister, the earth and heaven goddess, Innini (Ishtar), who descends yearly into Aralû (under-world) at the time of his death to bring him back to earth in her bosom. Since he represents the mystery of life and death, as seen in the withering vegetation of the hot Mesopotamian summer, and the rapid renewal of its life at the season of the spring rains, Tammuz is the patron of flocks and irrigation as well as of vegetation. Titles such as god *Sipa,* the shepherd, *umun mirsi,* lord of the flood, god *Ab-ú,* father of vegetation, god *Zulumma,* god of the date palm, are not so old as those which reveal theological speculation concerning the brother, lover and husband of the earth mother. Theology gave rise to this, the most widely spread and profoundly religious aspect of West Asiatic and Egyptian religion (where it appears as the cult of Osiris and Isis). *Dumu-zi* appears in the oldest texts without a divine title, *c.* 3200 B.C., and in Sumerian texts of Eannatum of Lagash (*c.* 2850 B.C.), as god *Dumuzi-apsu,* "risen child of the deep," describing him as the son of the god of the nether sea of fresh waters, *Ea, Enki,* a title confined apparently to early Lagash, where he appears more often under the title Ningišzida, "Lord of the faithful tree," a title which developed into an independent deity. In the legend of Eridu, in which Adapa is sent to the gates of heaven for judgment because he had broken the wings of the south-wind, he found Tammuz and Ningišzida at the gate of heaven; they offered him bread and water of life, which he, on the advice of the water god of Eridu, refused and thus lost immortality. Tammuz and Ningišzida appear to have been identified with the stars Castor and Pollux or, perhaps, Procyon and Sirius.

The liturgical wailings for Tammuz during the period of his sojourn in Aralû are numerous and describe every aspect of the theological doctrines concerning him. They are invariably composed in Sumerian, rarely with Accadian interlinear translation. These wailings occurred at midsummer, and the sixth month of the calendar at Lagash from the 28th to the 24th centuries is named the "month of the festival of Tammuz," corresponding to September if the year began near the spring equinox. There is a variant name for this month at Nippur called, "month of the mission of Innini," referring to her descent to Aralû in search of her departed lover. The Babylonians retained the old name of the fourth month and for some reason described it as the "month Tammuz," corresponding to July, retaining the name "month of the mission of Innini" for the sixth month (Elul). In this month (fourth) Tammuz is said to have been bound, and the liturgies speak of his having been drowned among flowers which were thrown upon him as he sank beneath the waves of the Euphrates. He is described as the shepherd who left his flocks, as the shepherds sat in the fields wailing for Tammuz.

There is a strange inconsistency in the hymns of these wailings concerning the relation of the mother goddess to her lover, Tammuz. In the early Sumerian texts she is his sister, but soon the Semitic view that she is his mother prevails. The two theories appear inconsistently together throughout the entire history of the cult. He is, however, invariably the husband and lover of the otherwise consistently described virgin goddess of love, Innini, Gestinanna, *Bêlit-sêri* (queen of the field of the lower world), and the cult is particularly associated with the great city Erech, home of the cult of Anu, the heaven god, and Innini. In all ceremonies connected with his cult his mother or sister is invariably associated with him, and it is the one aspect of Sumerian and Babylonian religion which may be described as universal and not largely confined to any local tradition. Badtibira, Pantibiblas of the Greek, near Erech, seems to have been the original seat of the cult, and in the Sumerian tradition of the ten pre-diluvian kings, the name of one at Badtibira is Dumuzisipa, "Tammuz the shepherd"; one of the names of Tammuz is Tibira. No great temple was built to him, and a few casual references to a temple of Tammuz at Umma, Ur, Lagash, Agade, clearly refer to shrines in the temple of the local deity reserved for the wailings and mystic ceremonies of the cult. Worship of Tammuz spread far beyond the lands to which the Sumerian religion was principally confined. Ezekiel speaks of it as firmly installed at Jerusalem in his time; it is mentioned in the Christian era in Mandean and Syriac literature, and survived among the Ssabeans at Harran as late as the middle ages. At Byblus, in Syria, he was identified with the West Semitic Adonis.

In astrology Tammuz was identified with Aries; in the magic rituals he is symbolized by a white kid, and he is also connected with the ram, which led to this astral identification. Under the title *Sibzianna*, "faithful shepherd of heaven," he was identified with Orion. During the period of deified king worship in the Dungi period of Ur, and in the time of the Isin dynasty, the deified kings habitually identified themselves with Tammuz and were worshipped as husbands of the mother goddess. For this reason it has been argued that the cult arose in prehistoric times, when a king was put to death as a sacrifice to the earth mother in order to secure the good will of the deity of vegetation. There is, however, no evidence for this in the earlier texts, and so far as Sumerian religion is concerned, the theory must be dismissed as unproved. He was held to be a god of healing, bestower of health, and one who, like all other deities, had power over the demons.

It is obvious that a cult which is based upon the death and resurrection of a propitiating god, and upon the love of a divine mother who wails for her son, has direct connection with the facts and the theological views based upon them, which gave birth to Christianity. But the form of the cult which apparently most directly affected the origins of Christianity is that in which Marduk of Babylon was identified with Tammuz. At the Nisan or new year festival at Babylon, Bêl (Marduk) was said to have been imprisoned in the lower world, and a priestess weeps at his sepulchre. A malefactor was slain with Bêl and they descend together to the land of darkness. Beltis, his wife, descends to hell to seek him, and Bêl's garments are given Ishtar (mother of Tammuz). Bêl was laid in a sepulchre, from which he soon comes forth. This Marduk transformation of the national Tammuz cult is only another effort of the priesthood of the capital to enlarge the worship and importance of the local cult. It obtained nowhere else in Babylonia and Assyria, and may be regarded as a true interpretation of what transpired regularly in the Tammuz cult itself. That the cult had direct influence upon the origins of Christianity cannot be denied, and the Greek cult of Adonis owes its essential content to the Sumerian Tammuz.

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TAMPA, a city on the west coast of Florida, U.S.A., at the head of Tampa bay (Gulf of Mexico), 330 m. S.E. of Pensacola and 220 m. N.W. of Key West; a port of entry and the county seat of Hillsborough county. It is on Federal highways 41 and 92; has a municipal airport (240 ac.) connected with the Bay by a canal 500 ft. wide, to accommodate seaplanes; and is served by the Atlantic Coast Line and the Seaboard Air Line railways, 21 steamship lines, operating to both American coasts and foreign ports, and four motor-bus lines, covering Florida and adjacent territory and connecting with lines for New York and Chicago. Pop. 94,743 (20% negroes and about 20% foreign-born white) in 1925 (State census) and was estimated locally in 1928 (after the annexation of West Tampa and other territory) at 175,000.

The city lies at the mouth of the Hillsborough river, with the Ybor estuary on its eastern boundary, facing the islands in Hillsborough bay (the eastern arm of Tampa bay). The climate is delightful, with an average monthly mean temperature ranging from 60·6° F in January to 81·5° in August, an average annual precipitation of 53·13 in., and an average of 66% of the "possible sunshine" in the year. Tampa has been a resort since the '80s and with one exception the hotels are open the year round. It is a centre for tarpon fishing, and winter headquarters for the National Professional Polo Association. Tampa Bay hotel (the oldest one for tourists in the city) is owned and operated by the city. There is a municipal polo field, a municipal fishing pier and generous provision for all the usual sports and recreations. The Gasparilla Carnival is an annual event in February. About 100,000 visitors from the North stop in the city during the year. Between 1925 and 1928 extensive additions were made to the public school plant (according to a programme mapped out for the city by experts) bringing its total value to $12,000,000. Tampa ships more phosphate rock (1,534,266 tons in 1927) and manufactures more clear Havana cigars than any other city. Its water-borne commerce amounted to 4,170,262 tons in 1927, and customs receipts were $2,630,554. There are about 160 cigar factories. Tampa is an important distributing point for oil and gasolene, and has a large wholesale and retail trade. Bank debits in 1926 aggregated $921,229,000. The city's assessed valuation for 1927 was $139,141,000. In 1927, after seven years under a commission-manager form of government, the city modified its charter to provide for a mayor with broad authority and a council of 12 district representatives.

Tampa was the name of the Indian village which de Narváez and de Soto found here in 1528 and 1539. The harbour, according to tradition, was a favourite resort of pirates, including the picturesque Capt. José Gasparilla, whose memory is kept alive in the annual carnival. In 1823 the U.S. Government established a fort (Ft. Brooke, an important base of supplies in the Second Seminole War; abandoned in 1860) and around it grew up a civil settlement. In Nov. 1862, Tampa was taken by Federal gunboats. During the Spanish-American War (1898) it was the point of embarkation for the U.S. troops that invaded Cuba. Theodore Roosevelt and his Rough Riders were encamped here for several weeks. In 1880 the population was only 720. Between 1880 and 1890 the cigar industry was established, the first railroad reached the city, and the first hotel for tourists was built. By 1890 the city had a population of 5,532, which was shown to have increased to 15,839 in 1900, 37,782 in 1910, and 51,608 in 1920. The opening of the Panama Canal (1920) greatly enhanced the importance of the port, and within a few years its traffic was doubled. Tampa was one of the principal foci of the Florida "rush" of 1924–25. The city was incorporated in 1855.

TAMPERE, formerly Tammerfors, an industrial city of Finland in 61° 28′ N., 23° 45′ E., on the rapids connecting Lakes Näsi-järvi and Pyhä-järvi, and at a railway junction. Pop. (1925) 51,717. It manufactures textiles, paper and leather goods.

TAMPICO, a city and leading port of Mexico, in the State of Tamaulipas, on the north bank of the Pánuco river, about 6 m. from the Gulf of Mexico. In summer the climate is hot and humid, although a sea breeze modifies the temperature somewhat. In winter the temperature falls to freezing on occasional days when "northers" blow down along the Gulf coast. Tampico is almost surrounded by swampy lands and lagoons.

The eastern and poorer part of the town stands on low ground only 2 or 3 ft. above the river, and is subject to inundations. However, a modern sewer system, up-to-date street paving and a better water-supply, constructed since the beginning of the century, have greatly improved the sanitary condition and reduced the death rate from epidemics. The western part rises about 150 ft., consists largely of residential districts and is provided with still better sanitary equipment. The business section is well built, largely of stone and brick, while many of the newer structures are of reinforced concrete and rise to six and seven storeys. The city is well supplied with gas and electric light.

Tampico has excellent transportation facilities, one railway line running north-north-west to Monterrey; another westward to San Luis Potosí, connecting there with the railway to Mexico City; a third short, but important line, leads southward, through the oil fields to Túxpam. Although a bar exists at the mouth of the Pánuco river, jetties have been built and the depth has been increased by dredging so that vessels drawing up to 33 ft. can approach the water front of the city, while scows and other boats of light draught can go up the river for over 100 miles. The Chijol canal, begun in 1901, affords a waterway 6 ft. deep and 25 ft. wide for about 75 m. southward through the oil-fields to Túxpam. Modern port works, spacious enough to accommodate at the wharves 14 vessels at a time, steel sheds and warehouses, a union railway station within easy reach of the water front, and excellent equipment for loading oil tankers, make Tampico the most up-to-date harbour in Mexico.

Tampico owes its importance to the fact that four of the most productive oil-fields in the country (the Ebano, Pánuco, Huasteca and Túxpam) are situated within some 100 m. of its site. Until 1901 it was a second rate port, outlet of the fertile but relatively undeveloped hinterland, with a very bad reputation for health and sanitary conditions. The rapid exploitation of petroleum resources resulted in a marked increase of population from about 10,000 in 1900, to 16,528 in 1910 and to 24,980 in 1921 while, if the neighbouring settlements connected with the port and oil business are included, the number at this last date would approach 100,000. For some years Tampico ranked as the greatest oil port in the world. Clusters of steel petroleum storage tanks extend along the river, particularly on the southern shore, from its mouth to a few miles above the city. Pipe lines lead from the nearby fields, 68 of them centring in Tampico in 1922, while fleets of scows bring oil from farther up the river. Pipe lines and barges together are capable of transporting some 1,200,000 bbl. of oil daily from the fields to the port.

There are many foreigners (chiefly Americans) residing in the city and its suburbs and Tampico is the most Americanized of Mexican cities. It is essentially a bi-lingual port, its aspect is that of a busy American town. Up-river from the port agricultural activities have been stimulated, fruits, vegetables and grains being grown to supply the local food demands. Up-to-date commercial establishments, housed in modern structures, are stocked with American and European goods. Foreign banks afford facilities for the varied needs of the city. Hotels, clubs, restaurants and places of amusement are numerous and well served.

Besides those connected directly with the oil business, the industrial establishments of Tampico include many for the handling and repair of oil well machinery, yards for the building of river boats, an electric light and power plant, factories for making ice, clothing and fruit preserves, saw-mills, etc. In addition to petroleum, the exports include silver bullion (from San Luis Potosí, Aguascalientes, Torreón and Monterrey), ixtle fibre, sugar, hides, live cattle, cotton-seed cake, honey, fustic, sarsaparilla, coffee and copper ores.

TAMWORTH, municipality, Inglis county, New South Wales, Australia, on the Peel and Cockburn rivers, 285 m. by rail N. of Sydney. Pop. (1921) 7,150. It is the centre of several goldfields, at one of which, Bingera, diamonds are found. It is also the market of a pastoral and agricultural district. Brewing, malting, steam, saw and flour milling, coach building and the manufacture of boots and galvanized iron are its principal industries.

TAMWORTH, market town, municipal borough, Lichfield parliamentary division, Staffordshire, England, on the river Tame. The rural district of Tamworth is in the Tamworth division, Warwickshire. Pop. (1921) 8,030. It is 110 m. N.E. of London on the L.M.S. railway. The castle, situated above the Anker, is chiefly of the Jacobean period, but is enclosed by massive ancient walls. After being bestowed on the Marmions by William the Conqueror, the castle was for many years an important fortress. The town was formerly surrounded by a ditch of which traces only remain. The church of St. Editha (8th cent.) was rebuilt, after the Danes burned it, by Edgar, who made it collegiate; the existing Decorated building was erected after a fire in 1345. The free grammar school, refounded by Edward IV., was rebuilt in 1677, and again in 1867. The charities include Guy's almshouses (1678), endowed by Thomas Guy, founder of Guy's hospital, London. Coal, fireclay and blue and red brick clay are dug in the neighbourhood; and there are also market gardens. In the town are a clothing factory, paper-mills, and manufactories of small wares.

Tamworth (*Tamwurda, Thamworth, Tomworth*) is situated near the Roman Watling street. It was burned by the Danes and restored in 913 by Aethelflead, who built the fort which was the origin of the later castle. The town was again destroyed by the Danes in 943. It is mentioned in Domesday. Tamworth was incorporated by Elizabeth in 1560 by letters patent, which state that it is an "ancient mercate town," and suggest that the charters have been lost or burned. The governing charter in 1835 was that of Charles II., incorporating it under the title of the bailiffs and commonalty of the borough of Tamworth in the counties of Stafford and Warwick. Edward III. granted two fairs, still kept up in 1792, to be held respectively on St. George's day and the day of the Translation of St. Edward; another ancient fair, in honour of St. Swithin, or perhaps originally of St. Editha, is still held (July 26). Tamworth sent two members to parliament from 1562 to 1885.

TANA, a lake of North-East Africa, chief reservoir of the Abbai or Blue Nile. Tana lies between 11° 36′ and 12° 16′ N. and 37° 2′ and 37° 40′ E., 5,690 ft. above the sea, on the northern portion of the Abyssinian plateau. Its greatest length is 47 m., its greatest breadth 44 m., and it covers approximately 1,100 sq.m., having a drainage area, including the lake surface, of some 5,400 sq.m. The shores are well defined, generally flat, but at places the mountains descend somewhat abruptly into the water. Elsewhere the land rises in gentle undulations, except at the mouths of the larger tributary streams, where are alluvial plains of considerable size. At the south-east end the lake forms a bay about 11 miles long, and from three to eight miles across. From this bay the Abbai issues. The whole coast-line is considerably indented and many narrow promontories jut into the lake. The island of Dek (eight m. long by four broad) is in the south-western part of the lake. Near it is the smaller island of Dega. Numerous islets fringe the shores.

Lake Tana is fed by three large rivers and by many petty streams. The chief tributary is the Little Abbai, which enters the lake at its south-west corner. This river, and the Abbai itself or Blue Nile which issues from the lake, are regarded as one and the same stream and a current is observable from the inlet to the outlet. Next in importance of the affluents are the Reb and Gumara, which run in parallel courses and enter the lake on its eastern side. The outlet of the lake is marked by openings in a rocky ledge, through which the water pours by two or three channels, in a succession of rapids, uniting within a couple of miles into one river—the Abbai with a width of 650 ft.

The average annual rainfall in the Tana catchment area is estimated at 3¼ ft., and the volume of water received by the lake yearly from this source and from affluents at about 6,572,000,000 of cubic metres. The average seasonal alteration of the lake level is not more than about 1½ metres.

Three technical missions have been sent by the British and Egyptian Governments conducted respectively by Mr. Dupuis (1903), Mr. Buckley (1916) and Mr. Grabham (1920–1) to report on the feasibility of utilizing the lake as a reservoir with the object of regulating the supply of water (3,500 million cu.m. in a normal year) discharged from the lake into the Blue Nile for irrigation needs in the Sudan and Egypt. As a result a scheme of works has been proposed, and it is estimated that these works, in addition to securing a more even distribution of water during the year, would by storing the surplus water in years of heavy rainfall form a reserve of 8,000 million cu.m. to tide over the deficiency in years of bad supply. The Abyssinian Government, however, has consistently opposed the project.

Tana has been identified with the *Coloe Palus* of the ancients, which was described by Ptolemy as a chief reservoir of the Egyptian Nile and the source of the *Astapos*, which was certainly the Blue Nile. In 1625 it was visited by the Portuguese priest Jeronimo Lobo, and in 1771 by James Bruce. It was formerly known by the name of Dembea.

See Nile and Abyssinia, and the authorities there cited. The British Blue Book, *Egypt*, No. 2, 1904, which contains a special report (with maps) upon Lake Tana. Also the most valuable *Report of the Mission to Lake Tana (1920–21)* issued by the Egyptian Ministry of Public Works in 1925. (C. F. R.)

TANA, a river over 500 m. long, in Kenya Colony, which gives its name to the Tanaland province of that British protectorate. Its sources are along the watershed close to the eastern wall of the eastern rift-valley, and it enters the Indian Ocean in 2° 40′ S., about 110 m. north of Mombasa. One series of its numerous headstreams traverses the Kikuyu plateau north of the Athi, others flow from Mount Kenya, all following a south-easterly direction until intercepted by the main stream which flows north-east until, when nearing the equator, it turns eastward afterwards sweeping southward to the sea. It receives tributaries only along its upper course but on entering the plain it flows along a tortuous course, has low banks, is in part forested and inundated at high water, but away from the river the country appears to consist of dry plains covered with mimosa scrub. The river frequently divides in its lower course, has many backwaters and has often changed its course, especially its place of entering the sea. It is navigable for 150 m. from its mouth. North of the Tana is the Ozi, a small river connected with the Tana by the Belazoni canal.

TANAGER, the name of birds of the family *Tanagridae*, allied to the *Fringillidae* (*see* Finch), and distinguished by their feebler conformation and more exposed nostrils. They are confined to the New World, and are specially characteristic of the tropical forests of Central and South America, only in a small proportion reaching Mexico, and four species breeding in the U.S.A.

The tanagers have been examined systematically by P. L. Sclater; he admits the existence of 375 species, which he arranges in 59 genera, forming six subfamilies, *Procniatinae*, *Euphoniinae*, *Tanagrinae*, *Lamprotinae*, *Phoenicophilinae*, and *Pitylinae*. These are of very unequal extent, for, while the first of them consists of but a single species, *Procnias tersa*, the third includes more than 200.

Nearly all are birds of small size, the largest barely exceeding a song-thrush. Most of them are remarkable for their gaudy colouring, and this is especially the case in those forming the genus *Tanagra*. Generally among the tanagers, both sexes are nearly alike in plumage. Insects, especially in the larval condition, and berries afford the greater part of their food. They have a pleasing song, and build a shallow nest, in which the eggs, generally three in number, and of a greenish-blue marked with brown and purple, are laid.

The scarlet tanager (*Piranga erythromelas*) nests in the eastern U.S.A., west to the Plains and north to New Brunswick and Manitoba, wintering in South and Central America. The male is scarlet, with black wings and tail; the female is olive green, lighter below, with dusky wings and tail. The song is reminiscent of the American robin, but is inferior.

The summer tanager (*P. rubra*) does not reach farther north than New Jersey and Kansas. The male is rosy red, the female olive-yellow above, dusky saffron below. The song is superior to that of *P. erythromelas*.

The remaining species, *P. ludoviciana*, the males of which are mostly yellow and black, with the head only red, does not appear eastward of the Missouri plains, and has not so northerly a range. Another species, *P. hepatica*, has shown itself within the limits of the United States. In all these the females are plainly attired.

TANAKA, GIICHI, Baron (1863–1929), Japanese statesman and general, born in Yamaguchi, graduated at the military cadet's school in 1886, and the staff college in 1892. He was minister of war in the Hara and Takahashi cabinets in 1918–21, and 1920. He became leader of the Seiyukwai Party in 1926, and formed a government in April 1927, himself taking the ministry of foreign affairs. He died on Sept. 28, 1929.

TANAQUIL, the Etruscan name of the wife of Tarquinius Priscus, or of one of his sons. After her immigration to Rome she is said to have received the name Gaia Caecilia. She was famous for her prophetic gifts. There was a statue of her as Gaia Caecilia in the temple of Sancus, which possessed magical powers. She was celebrated as a spinner of wool, and was supposed to exercise influence over Roman brides. Tanaquil and Gaia Caecilia are, however, really distinct personalities. The anecdotes told of Gaia Caecilia are aetiological myths intended to explain certain usages at Roman marriages.

See Livy, i. 34, 41; Pliny, *Nat. Hist.*, viii. 74, xxxvi. 70; Schwegler, *Römische Geschichte*, bk. xv. 8.

TANCRED (d. 1112), nephew of Bohemund and a grandson of Robert Guiscard on the female side, was the son of a certain *Marchisus*, in whom some have seen a marquis, and some an Arab (Makrizi). He took the Cross with Bohemund in 1096, and marched with him to Constantinople. Here he refused to take an oath of Alexius, escaping across the Bosporus in the disguise of a peasant; but after the capture of Nicaea he followed the example of the other princes, and became the man of Alexius. At Heraclea, in the centre of Asia Minor, he left the main body of the Crusaders, and struck into Cilicia, closely followed by Baldwin of Lorraine. He made himself master of Tarsus, and when he was evicted from it by the superior forces of Baldwin, he pushed further onwards, and took the towns of Adana and Mamistra. He joined the main army before Antioch, and took a great part in the siege. In the beginning of 1099 he was in the ranks of Raymund's army, but he soon left the count, like so many of the other pilgrims (*see* under Raymund); and he joined himself to Godfrey of Lorraine in the final march. After the capture of Jerusalem he went to Nablous, and began to found a principality of his own. He took part in the battle of Ascalon in August; and after it he was invested by Godfrey with Tiberias and the principality of Galilee, to the north of Naplous. In 1100 he attempted, without success, to prevent Baldwin of Lorraine (his old enemy in Cilicia) from acquiring the throne of Jerusalem. Failing in this attempt, and being urgently summoned from the North to succeed Bohemund in the government of Antioch, he surrendered his smaller possessions to Baldwin. He acted as regent in Antioch until 1103, when Bohemund regained his liberty. He regained the Cilician towns for Antioch (1101), and recaptured Laodicea (1103); he imprisoned Raymund of Toulouse, and only gave him his liberty on stringent conditions; and he caused the restoration of the deposed patriarch of Jerusalem, Dagobert, if only for a brief season, by refusing to aid Baldwin I. on any other terms. When Bohemund was set free, Tancred had to surrender Antioch to him. In 1104 he joined with Bohemund and Baldwin de Burg (now count of Odessa in succession to Baldwin of Lorraine) in an expedition against Harran, in which they were heavily defeated, and Baldwin was taken prisoner. Tancred, however, profited doubly by the defeat. He took over the government of Edessa in Baldwin's place; and in 1105 Bohemund surrendered to him the government of Antioch, while he himself went to Europe to seek reinforcements. Ruler of the two northern principalities, Tancred carried on vigorous hostilities against his Mohammedan neighbours, especially Ridwan of Aleppo; and in 1106 he succeeded in capturing Apamea. In 1107, while Bohemund was beginning his last expedition against Alexius, he wrested the whole of Cilicia from the Greeks; and he steadfastly refused, after Bohemund's humiliating treaty at Durazzo in 1108, to agree to any of its stipulations with regard to Antioch and Cilicia. To the hostility of the Mohammedans and the Greeks, Tancred also added that of his own fellow Latins. When Baldwin de Burg regained his liberty in 1108, it was only with difficulty that he was induced to restore Edessa to him. But it was against the emirs of Northern Syria that his arms were chiefly directed; and he became the hammer of the Turks. He died in 1112, leaving the government to his brother-in-law, Roger de Principatu, until such time as Bohemund II. should come to his inheritance.

Bibliography.—Tancred's *Gesta* were recorded by Ralph of Caen, who drew his information from Tancred's own conversation and reminiscences. Kugler has written a work on *Bohemund und Tancred* (Tübingen, 1862); and Tancred's career is also described by Rey, in the *Revue de l'Orient Latin*, iv. 334–340.

TANCRED (d. 1194), King of Sicily, an illegitimate son of Roger the eldest son of King Roger II., was crowned in January 1190 in succession to William II. (*q.v.*). He was supported by the chancellor Matthew d'Ajello and the official class, while the rival claims of Roger II.'s daughter Constance and her husband, Henry VI., king of the Romans and emperor, were supported by most of the nobles. Tancred was a good soldier; but he was ill-supported in his task of maintaining the Norman kingdom, faced with general apathy, threatened by a baronial revolt, and menaced by Richard Coeur-de-Lion, at Messina, 1190. Henry, skilfully winning over Pisa, Genoa and the Roman Commune, isolated Tancred and intimidated Celestine III., who, on April 14, 1191, crowned him emperor at Rome. He, however, failed to capture Naples in August and retired north, leaving garrisons along the frontiers of the Regno. Tancred now sought to win over the towns by extensive grants of privileges, and at Gravina (June 1192) was recognized by the pope, whose ineffectual support he gained by surrendering the royal legateship over Sicily. In 1192 and 1193 he successfully opposed the Apulian barons, but his death at Palermo (Feb. 20, 1194) a few days after that of Roger, his son and joint-king, made Henry's path clear.

TANDY, JAMES NAPPER (1740–1803), United Irishman, born in Dublin in 1740, was a prominent reformer and supporter of Lucas and Grattan. He first won popularity by his attacks on municipal corruption and his proposal to boycott English goods in retaliation for the restrictions imposed on Irish commerce. In 1780 Tandy was expelled from the Dublin volunteers (*see* Flood, Henry); but he continued his revolutionary agitation, and in 1791 co-operated with Wolfe Tone in founding the Society of United Irishmen, of which he became the first secretary. A challenge sent to the attorney-general resulted in his imprisonment (1792), but on his release Tandy assisted in raising two battalions of a "national guard," which were suppressed. He then fled to America, and in 1798 proceeded to France, where he joined a number of Irish refugees. Having gained the ear of the French Government, Tandy was given command of a corvette, a small force of men, and a quantity of arms for distribution in Ireland. Arriving at Donegal, however, he learnt that Humbert's expedition had failed, and he thereupon fled to Hamburg. The refugees were surrendered on a peremptory demand from the British Government. Condemned to death, he was finally reprieved owing it is said to Bonaparte's intercession.

Tandy's exploits completely captured the popular imagination, and he is still remembered as the hero of the "Wearing of the Green." In France, where his release was regarded as a French diplomatic victory, he was received in March 1802, as a person of distinction; and when he died, on Aug. 24, 1803, his funeral was attended by the military and an immense number of the civil population.

See R. R. Madden, *The Lives of the United Irishmen*, 7 vols. (Dublin, 1842–46); W. J. MacNeven, *Pieces of Irish History* (New York, 1807); T. Wolfe Tone, *Autobiography*, edit. by R. Barry O'Brien, 2 vols. (London, 1893); W. J. Fitzpatrick, *Secret Service under Pitt* (London, 1892); Sir Richard Musgrave, *Memoirs of Rebellions in Ireland*, 2 vols. (Dublin, 1802); J. A. Froude, *The English in Ireland in the Eighteenth Century*, 3 vols. (London, 1872–74); *Castlereagh Correspondence*, i., ii.; *Cornwallis Correspondence*, ii., iii.

TANEGA-SHIMA, an island lying to the south of Kyushu, Japan, in 30° 50′ N. and 131° E., 36½ m. long and 7¼ m. broad at its widest part. It is a long low stretch of land, carefully cultivated, and celebrated as the place where Mendez Pinto landed when he reached Japan in 1543.

TANEIEV, SERGIUS (1856–1915), Russian composer and theorist, was born on Nov. 13, 1856, in the Vladimir government. He studied under Nicholas Rubenstein and Tschaikowsky at the Moscow conservatoire. After a short career as a concert pianist he went back to Moscow as professor of instrumentation, then first professor of pianoforte and, in 1885, director. He died at Moscow on June 15, 1915. His published works include a symphony, five string quartets, a dramatic work, *Orestes* (performed in St. Petersburg 1895), a cantata, *John of Damascus*, and choruses for male voices and for mixed voices. He also wrote a treatise on counterpoint.

TANEY, ROGER BROOKE (1777–1864), American jurist, was born in Calvert county, Md., March 17, 1777. He graduated from Dickinson college, Carlisle, Pa., in 1795, and began studying law at Annapolis in 1776. He served in the State Senate in 1816–21, was attorney general of Maryland in 1827–31; and in July 1831 entered President Jackson's cabinet as attorney general of the United States. He was the President's chief adviser in the attack on the U.S. Bank, and was transferred to the treasury department in Sept. 1833, for the special purpose of removing the Government deposits. As a result, the Senate refused to confirm his appointment as secretary of the treasury.

On Dec. 28, 1835, he was nominated chief justice of the U.S. Supreme Court. After strong opposition, the nomination was confirmed on March 15, 1836. During President Jackson's administration (1829–37), the personnel of the supreme bench was entirely changed. Five of the seven judges in 1837 were his appointees. The majority of them were Southerners who had been educated under democratic influences. As a result, the State sovereignty influence was occasionally manifest, as for example, in the opinion (written by Taney) in the *Dred Scott* case (1857, 19 Howard, 393) that Congress had no power to abolish slavery in territory acquired after the formation of the National Government. Judge Taney died Oct. 12, 1864.

An authoritative biography is Samuel Tyler's *Memoir of Roger Brooke Taney* (1872).

TANGA, a seaport of Tanganyika Territory, East Africa, lying opposite the island of Pemba in 5° 6′ S., 39° 7′ E. Population about 10,000, including (1928) 431 whites. The town is regularly laid out on elevated ground on the southern shore of Tanga bay, amid coconut groves and avenues of mango trees. The harbour, which is commodious, is entered by a broad but tortuous channel five to eight fathoms deep. Tanga is the ocean terminus of a railway to the Usumbara highlands and Kilimanjaro. A motor road (130m. long) connects it with Mombasa.

At one time part of the sultanate of Zanzibar, Tanga passed into German possession in 1888. In 1914 a British force from India landed in the bay and attempted to capture the town. It suffered heavy losses and was compelled to re-embark. It was not until July 1916 that the place was occupied by the British, the Germans having meanwhile been defeated by Gen. Smuts.

TANGANYIKA, a vast lake in East-Central Africa, the longest freshwater lake in the world, measuring about 450 m. with a general breadth varying from 30 to 45 m., and an area of about 12,700 sq.m. It lies at an altitude of about 2,536 ft., is 4,708 ft. deep, therefore its floor is 2,172 ft. below sea-level. After Lake Baikal this is the deepest freshwater lake in the world. It occupies the southern end of the great western rift-valley which terminates suddenly at its southern point, but the line of depression is continued south-eastward through Lakes Rukwa and Nyasa, from which Tanganyika is separated by the Ufipa plateau. Another branch of the rift-valley passes south-westward into the Eastern Congo, branching from the northern end of the lake. North of Tanganyika the valley is suddenly interrupted by a line of young eruptive ridges, which dam back the waters of Lake Kivu (*q.v.*) but have recently been cut through (in about the year 1906) by the outlet of that lake, the Russisi which enters Tanganyika by several mouths at its northern end. The flat plain traversed by the lower Russisi was evidently once a portion of the lake floor. Tanganyika has been formed by the subsidence of a long narrow tract of country relatively to the surrounding plateaux which fall to the lake in abrupt cliffs, some thousands of feet high in places. The geological formations thus exposed show that the plateaux are composed of a base of Archaean gneisses and schists, overlain by enormous deposits of unfossiliferous red sandstones, conglomerates and quartzites (the Tanganyika Sandstones), which reach 3,000 ft. in thickness at the south end of the lake. They are almost certainly Archaean in age. The formation of the rift-valley dates from late Tertiary times. Besides the plain to the north a considerable area near the Lukuga outlet was once covered by Tanganyika. Although drinkable, the water of the lake seems at times at least to be very slightly brackish, and it was supposed by some that no outlet existed until in 1874, Lieutenant Cameron showed that the surplus water was discharged periodically towards the Upper Congo by the Lukaga river, about the middle of the west coast. Observations during the last 50 years indicate that the level of the lake frequently changes but these alterations are probably due only to fluctuations in rainfall.

The lake is fed by a number of rivers and small streams, but is by no means the centre of a large drainage area. The Malagarasi is the largest feeder. The lake is subject to occasional storms which leave a heavy swell and impede navigation.

Vegetation is generally luxuriant, and forest clothes portions of the mountain slopes. The lake lies on the dividing line between the floral regions of East and West Africa, and the oil-palm characteristic of the latter is found on its shores. The largest timber tree is the *mvule,* which attains vast dimensions. The more level parts of the shores have a fertile soil and produce a variety of crops, including rice, maize, manioc, sweet potatoes and sugar-cane. The waters display an abundance of animal life, crocodiles and hippopotami occurring in the bays and river mouths, which are also the haunts of water-fowl of many kinds. Fish are also plentiful. Various sections of the Bantu division of the negro race dwell around the lake, those on the west and south-west showing the most pronounced negro type, while the tribes on the east exhibit some intermixture with representatives of the Hamitic stock, and (towards the south) some trace of Zulu influence. The surrounding region has been overrun by Arabs and Swahili from the East African coast.

The lake was first visited in 1858 by Burton and Speke who reached Ujiji, which was the spot where in 1871 Dr. Livingstone was found by Stanley. The southern half of the lake was first circumnavigated by Lieutenant V. L. Cameron in 1874, and the whole lake by Stanley in 1876.

In the partition of Africa among the European powers the shores of Tanganyika were shared by Belgium, Great Britain and Germany, Great Britain holding the southern extremity, Germany the east and Belgium the west. After the World War the German portion became part of the British mandated territory of Tanganyika whilst Belgium extended her boundaries to include the mountains of Urundi on the north-east of the lake shore.

The chief towns on the lake are Sumbu, Niamkolo, Kasango, Ujiji and Kigoma (all British), Usumbura, Uvira, Albertville, Vua, Baudouinville and Moliro (all Belgian). Steamers ply on the lake traversing its length in about four days, the best harbours being at Kasanga, Kigoma, Usumbura and Albertville. The East African Central railway from Dar-es-Salaam terminates at Kigoma, whilst a railway passes down the Lukuga valley from Albertville.

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TANGANYIKA TERRITORY, a country of East Central Africa. It is bounded east by the Indian ocean, south by Portuguese East Africa, south-west by Nyasaland, Northern Rhodesia, west by the Belgian Congo, north-west by Ruanda-Urundi and Uganda, north-east by Kenya Colony. It includes Mafia island. The area is about 365,000 sq.m. From 1884 to 1919 the Territory, together with the provinces of Ruanda and Urundi formed German East Africa. Since 1919 Tanganyika Territory has been administered under mandate by Great Britain. Ruanda-Urundi (*q.v.*) is under Belgian mandate.

Physical Features.—The coast extends from the mouth of the Rovuma in the south to the Umba river in the north. It is chiefly composed of coral, is little indented, and is generally low, partly sandy, partly rich alluvial soil covered with dense bush or mangroves. Where the Arabs had settlements the coco-palm and mango tree introduced by them give variety to the vegetation. The coast plain is from 10 to 30m. wide and 620m. long; it is bordered on the west by the precipitous eastern side of the interior plateau of Central Africa. This plateau, considerably tilted from its horizontal position, attains its highest elevation north of Lake Nyasa (*see* LIVINGSTONE MOUNTAINS), with heights up to 9,000 or more feet and a mean altitude of about 3,000 to 4,000 feet. From this region the country slopes towards the north-west. A deep, narrow gorge, the so-called "eastern rift-valley," traverses the middle of the plateau in a meridional direction. In the north it spreads into several side valleys, from one of which rises the extinct volcano Kilimanjaro (*q.v.*), the highest mountain in Africa (19,321ft.). Its glaciers send down a thousand rills which combine to form the Pangani river. About 40m. west of Kilimanjaro is Mount Meru (14,955ft.), another volcanic peak, with a double crater. South-east of Mount Kilimanjaro are the Pare mountains and Usambara highlands, separated from the coast by a comparatively narrow strip of plain. To the south of the Usambara hills, and on the eastern edge of the plateau, are the mountainous regions of Nguru (otherwise Unguru), Useguha and Usagara. The southern half of Victoria Nyanza and the eastern shores, in whole or in part, of Lakes Tanganyika and Nyasa, are in Tanganyika Territory. Lake Rukwa (*q.v.*), north-west of Nyasa, is presumably only the remnant of a much larger lake. Its extent varies with the rainfall of each year. North-west of Kilimanjaro is a sheet of water known as the Natron lake, from the mineral alkali it contains.

The country is well watered, but, with the exception of the Rufiji, the rivers, save for a few miles from their mouths are unnavigable. The largest streams are the Rovuma and Rufiji (*q.v.*), both rising in the central plateau and flowing to the Indian ocean. Next in importance is the Pangani river, which, as stated above, has its head springs on the slopes of Kilimanjaro. Flowing in a south-westerly direction, it reaches the sea after a course of some 250 miles. Into Victoria Nyanza are emptied, on the east, the waters of the Mori and many smaller streams; on the west, the Kagera (*q.v.*), besides smaller rivers. Into Tanganyika flows the

Malagarasi, a considerable river with many affluents, draining the west-central part of the plateau. The Kalambo is a comparatively small stream which enters the south-east end of Lake Tanganyika (marking the frontier with Northern Rhodesia). Not far from its mouth there is a magnificent fall, a large volume of water falling nearly 900ft. sheer over a rocky ledge of horse-shoe shape. So great is the height that the river only reaches the bottom of the falls in the form of spray. Of the streams entering Nyasa the chief are the Songwe and the Ruhuhu.

Mafia island lies off the coast immediately north of 8° N. It has an area of 200 sq. miles. The island is low and fertile and extensively planted with coconut palms. It is continued southwards by an extensive reef, on which stands the chief settlement, Chobe, on a shallow creek.

Geology.—The narrow foot-plateau of Kenya Colony broadens out to the south of Bagamoyo to a width of over 100 miles. This is covered to a considerable extent by rocks of recent and late Tertiary ages. Older Tertiary rocks form the bluffs of Lindi. Cretaceous marls and limestones appear at intervals, extending in places to the edge of the upper plateau, and are extensively developed on the Makonde plateau. They are underlain by Jurassic rocks, from beneath which sandstones and shales yielding *Glossopteris browniana* var. *indica,* and therefore of Lower Karroo age, appear in the south, but are overlapped on the north by Jurassic strata. The central plateau consists almost entirely of metamorphic rocks with extensive tracts of granite in Unyamwezi.

The volcanic plateau of Kenya Colony extends over the boundary in the region of Kilimanjaro. Of the sister peaks, Kibo and Mawenzi, the latter is far the oldest and has been greatly denuded, while Kibo retains its crateriform shape intact. The rift-valley faults continue down the depression, marked by numerous volcanoes, in the region of the Natron lake and Lake Manyara; while the steep walls of the deep depression of Tanganyika and Nyasa represent the western rift system at its maximum development.

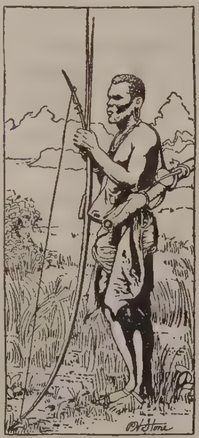
Fossil remains of saurians of gigantic size have been found in the Tendagura hills and other parts of the Lindi district; one thigh bone measures 6ft. 10 in., the same bone in the *Diplodocus Carnegii* measuring only 4ft. 11in. The examination of the sites begun by the Germans in 1909 was continued by the British, interesting discoveries being made in 1924.

Climate.—The warm currents setting landwards from the Indian ocean bring both moisture and heat, so that the coast has a higher temperature and heavier rainfall than the Atlantic seaboard under the same parallels of latitude. The mean temperature on the west and east coasts of Africa is 72° and 80° Fahr. respectively, the average rainfall in Angola 36 in., in Dar-es-Salaam 60 inches. On the Swahili coast the south-east monsoon begins in April and the north-east monsoon in November. Besides the coast lands, three other climatic zones may be distinguished, as follows, though there are many local variations: (1) a hot and moderately dry zone from 300 to 2,000 ft. high between the lowlands and the central plateau; (2) the central plateau zone, between 2,000 and 4,000 feet. Here rainfall is lower—an average of 32 inches a year at Tabora—the air dry and hot with great daily and seasonal variations; (3) a semi-temperate zone in regions over 5,000 feet. On the highest regions the climate is almost European, the nights being sometimes exceedingly cold. Two highland areas have climatic conditions permitting European settlement. The first is the Usambara hills together with the Moshi and Arusha districts of Kilimanjaro; the second, and larger, area stretches from Iringa on the central plateau south-west to Lake Nyasa. This area is known as the south-western highlands. In the country generally there are two rainy seasons, the "long rains" from February or March, and lasting two or three months, and the "lesser rains" in October and November.

Flora and Fauna.—The coast plains are covered by a rich tropical bush, in which the mangrove is very prominent. Coco-palms and mango trees have been planted in great numbers, and also many varieties of bananas. The river banks are lined with belts of dense forest, in which are useful timber trees. The *Hyphaene* palm is frequent, as well as various kinds of gum-producing mimosas. The slopes of the plateau which face the rain-bringing monsoon are in some places covered with primeval forest, in which timber is plentiful. The silk-cotton tree (*Bombax ceiba*), miomba, tamarisk, copal tree (*Hymenaea courbaril*) are frequent, besides the rubber tree (*Landolphia florida*), sycamores, banyan trees (*Ficus indica*) and the deleb palm (*Borassus aethiopium*). The plateau is partly grass land without bush or forest, partly steppe covered with mimosa bush, which sometimes is almost impenetrable.

Tanganyika is rich in all kinds of antelope, and the elephant, rhinoceros and hippopotamus are still plentiful in parts. Characteristic are the giraffe, the chimpanzee and the ostrich. Buffaloes and zebras occur in two or three varieties. Lions and leopards are found throughout the country. Crocodiles are numerous in all the larger rivers. Snakes, many venomous, abound. Of birds there are comparatively few on the steppe, but by rivers, lakes and swamps they are found in thousands. Locusts occasion much damage, and ants of various kinds are often a plague. The tsetse fly (*Glossina morsitans*) infests several districts; the sand-flea has been imported from the west coast. Land and water turtles are numerous.

Inhabitants.—There are in all some 75 distinct negro tribes in the country. Two or three tribes, such as the Wahi of Lake Eyasi, are supposed to trace descent from a pygmy-like people, who are thought to have been the earliest inhabitants of the country. But what may be called the indigenous population consists of the older or primitive Bantu races. These tribes have been subject to the intrusion from the south of more recent Bantu folk, such as the Yao, belonging to the Ama-Zulu branch of the race, while from the north there has been an immigration of Hamito-Negroid peoples. Of these the Masai and Wakuafi are found in the region between Victoria Nyanza and Kilimanjaro. The Masai (*q.v.*) and allied tribes are nomads and cattle raisers. An Hamitic race, the Bahima (Hima or Huma), form the aristocratic class in the district around the south-west shores of Victoria Nyanza, and under Bahima kings Karagwe was formerly a powerful state. The Bantu tribes are in general peaceful agriculturists, though the Bantus of recent immigration retain the warlike instincts of the Zulus. The most important group of the Bantus is the Wanyamwezi (*see* UNYAMWEZI), divided into many tribes. They are spread over the central plains, and have for neighbours on the south-east between Nyasa and the Rufiji, the Wahehe. The Wangoni (Angoni), a branch of the Ama-Zulu are widely spread over the central and Nyasa regions. The Wasambara have given their name to the Highlands between Kilimanjaro and the coast. The Swahili (*q.v.*) inhabit the seaboard. Arabs, with some Persians and Indians, have long been settled on the coast.



BY COURTESY OF THE MARTIN JOHNSON AFRICAN EXPEDITION CORP.

AN IKOMA HUNTER WITH POISONED ARROWS THAT PARALYZE THE ANIMAL BUT DO NOT MAKE THE FOOD UNFIT TO EAT

In 1928 there were some 4,500 European inhabitants, of whom more than half were British: the others were of many nationalities including a considerable Greek element and some 300 Germans. There were over 10,000 British Indians, and about 1,000 Goanese. The Arabs numbered about 4,000. The natives are estimated to number approximately 4,107,000. Of this number 1,500,000 live in the contiguous districts of Mwanza, Bukoba and Tabora, *i.e.,* the north-west part of the territory.

Many different dialects are spoken by the Bantu tribes, Kiswahili being the most widely known. (*See* BANTU LANGUAGES.) The great majority of the natives are pagans, but most of the Swahili are Mohammedans, while Protestant and Roman Catholic missions have gained a considerable number of converts.

Chief Towns.—The principal seaports are Tanga and Dar-es-Salaam. These and Bagamoyo and Kilwa are separately noticed. Pangani (pop. about 3,500), at the mouth of the river of the same name, serves a district rich in tropical products. Sadani is a smaller port midway between Pangani and Bagamoyo, Lindi (10° 0′ S., 39° 40′ E.) is 80 m. N. of Cape Delgado. Lindi (Kiswahili for The Deep Below) bay runs inland 6 m. and is 3 m. across, affording deep anchorage. Hills to the west of the bay rise over 1,000 feet.

The chief inland towns are Tabora, Korogwe, Moshi, Mrogoro, Kilossa, Dodoma and Iringa. Korogwe is in the Usambara hills, on the north bank of the Pangani river, and 52 m. by railway from Tanga. Moshi (white pop. about 300), on the south slopes of Kilimanjaro and 219 m. by rail from Tanga, is the centre of large coffee plantations. Mrogoro is 130 m. west of Dar-es-Salaam, and is the first important station on the railway to Tanganyika. Kilossa and Dodoma are farther inland on the same railway. Iringa is the centre of the southern highlands. Tabora (*q.v.*) occupies an important position on the central plateau, being the meeting place of many trade routes. It is connected by railway with Dar-es-Salaam, with Kigoma, on Lake Tanganyika, and also (since 1928) with Mwanza, the chief port on the southern shores of Victoria Nyanza. Bukoba is on the western shore, and Schirati on the eastern shore of Victoria Nyanza. On Tanganyika and near Kigoma is Ujiji (*q.v.*).

Economic Progress and Trade.—Probably no other part of Africa suffered as much as did Tanganyika Territory from the ravages of the World War, and as regards economic development almost everything had to be re-created by the British authorities, whose first task in this department was the reconditioning of the railways. It was not until 1925 that the railways paid their way. Meanwhile the sisal, coffee and cotton and rubber plantations in Usambara, Para and elsewhere, which had been owned by Germans, passed into the hands of British, Indians and Greeks. It may be noted that under the terms of the mandate no discrimination against Indians could be made in Tanganyika, which thus differed from Kenya Colony. Changed world conditions—chiefly the development of plantation rubber in the East—rendered it useless to try and revive the rubber industry, but the other products, in especial sisal hemp, yielded good returns. The European and Indian planters were not alone in cultivating coffee and cotton. The production of these crops, especially cotton, by the natives on their own account was encouraged by the Administration and by the 1924–25 season, some 75% of the cotton exported was direct native production.

Sisal hemp produced is of the highest grade; the bulk of it is grown in the drier parts of the coast belt. This industry, requiring considerable capital outlay, is in the hands of Europeans, and each factory producing hemp requires at least 2,000 acres of sisal under cultivation. The industry owed its foundation to the Germans, and they devoted great attention to it. Up to 1924 the planters were, in the main, still using pre-war German machinery. Other agricultural or sylvan crops of note are copra, groundnuts, and maize. The coconut plantations from which the copra is obtained are found chiefly on the coast and in Mafia island, and most of them are owned by the Arabs. Other products exported include ivory, beeswax, gums and resins, gum-copal, rice, ghee and mangrove poles. For all matters connected with the development of the land the Biological and Agricultural Institute at Amani, in the Usambara hills, is of great value. Founded by the Germans in 1902, it is now maintained as an institute for the whole of East Africa. Stock raising is one of the main assets of the country, and hides and skins are an important item in the exports. Unfortunately the tsetse fly has laid large areas waste. There are 4,300 sq.m. of forests. Of this area over 3,700 sq.m. are State reserves.

The minerals worked include mica—widely distributed—gold and diamonds. Cassiterite (tin-ore) is found in the Bukoba district; coal, iron, copper and lead are also found, but are not worked. The chief gold deposits are in the Mwanza district, where is also a diamondiferous area, while further south, near Shinyanga, is another diamond field. Mica and gold were mined during the German occupation: diamond mining began in 1926, and at the same time the Bukoba tinfields were being worked. It was not until 1925 that trade recovered to the level of 1913 (the last normal year under German rule). In 1922 the trade figures were: Imports £1,386,000; exports £1,300,000; re-exports £141,000 (mostly transit trade from the Belgian Congo). In 1926 domestic exports were valued at £3,025,000 and the re-exports at £235,000, while trade imports totalled £3,597,000. Cotton piece goods, the chief import, came chiefly from Great Britain, India and Japan, and those countries took the raw cotton exported (25,000 bales in 1927). In 1927 coffee exports, mostly to France and Italian East Africa, totalled 6,595 tons, and sisal (mainly to Belgium and Great Britain) 33,000 tons. The diamond production was 18,095 carats (valued at £102,000).

Communications.—One of the great handicaps to development was the lack of adequate means of communication. The Germans had built two railway lines, one from Tanga to Moshi (219 m. long) which served the important plantations in Pare, Usambara and the slopes of Kilimanjaro—and Tanga up to 1929 had a bigger trade than Dar-es-Salaam—the other 773 m. long from Dar-es-Salaam to Kigoma on Lake Tanganyika. This is known as the Central railway. It was not until 1924 that financial conditions allowed the undertaking of any new work. In that year a line was begun northward from Tabora, on the Central railway. This line, which passes through the rich Shinyanga cotton belt, reached Mwanza, on Lake Victoria, in 1928. It is 238 m. long and serves also the diamond and gold fields in the district. It also offers an alternative route (to that from Mombasa) to Uganda. Another short railway was built from Moshi to Arusha, and there is a 90 m. line in the Lindi district. Schemes were put forward in 1924 for linking the Tanga and the Central railways, and for a line from the Central railway through the south-western highlands—where European settlement had begun—to Lake Nyasa or Rhodesia. They remained in the proposal stage in 1929. Over 25,000 m. of roads were built, on which motor traffic is possible in the dry season; they are nearly all impassable in the rains. On Lake Tanganyika there are Belgian and British steamer services, the chief traffic being with the Belgian side of the lake. At Mwanza and Tabora are aerodromes, but there was up to 1928 no regular air service. The Tanga railway is linked to the Kenya and Uganda railway by the Kahe-Taveta-Voi branch; otherwise Tanganyika Territory has no railway connection with the neighbouring British lands. There is wireless communication with the Belgian Congo, telegraphic connection by land wires with South Africa, and a cable from Dar-es-Salaam to Zanzibar. Communication from Tanganyika ports is maintained by several lines. Mails from London to Dar-es-Salaam take about three weeks in transit.

Administration, Education and Revenue.—The territory is governed on the lines of a British Crown Colony. The governor, who is responsible to the Colonial Office in London, is aided by an executive council and, since 1926, by a nominated legislative council. The ancient tribal organization of the natives under chiefs of their own race—largely broken up under German rule—has been restored as far as possible under the supervision of European administrators. The chiefs, often bearing the title of sultan, are executive officers and have their own treasuries. Native courts have limited civil and criminal jurisdiction (Proclamations of 1920 and 1925). Domestic slavery had been permitted by the Germans to continue, but they had decreed the freedom of all slaves born after 1905. In 1923 the British administration abolished the status of slavery, which no longer exists in Tanganyika in any form. Neither does the administration assist in the recruitment of labour for private enterprises. From 1924 onward effective steps were taken to provide education for the natives in addition to that given by the missionary societies. In the government schools instruction is in hygiene, agriculture and industries as well as literary and moral; at Dar-es-Salaam, Tanga, Tabora, Bukoba and other places are central schools where, among other things, natives are trained for posts in an African Civil Service. There is a native teachers' training centre at Mpapua. Instruction is given in Kiswahili and English; in mission schools instruction is generally given in the vernacular. Up to 1925 there were no government schools for European or Indian children, but a grant was made to the schools of the Dutch speaking settlers at Arusha.

Revenue is obtained chiefly from import duties and the native house, hut and poll tax (6/– to 12/– a year), about half the revenue being paid by natives. The Customs tariff is similar to but not identical with that of Kenya and Uganda. Revenue which for 1919–20 was £669,000 had increased to £1,315,000 in 1923–24, the corresponding figures for expenditure being £790,000 and £1,901,000. To that time there has been a deficit of £761,000 on the working of the railways, besides £503,000 spent in capital and extraordinary expenditure upon them. Commercial depression, the forced change in the currency from rupees at 15 to the £ to florins and then shillings—the rupees (German and Indian) being redeemed at 2/– —added to the cost of restoring the devastated regions, had reacted unfavourably on revenue. But from 1923 an improvement set in and soon became marked. The revenue for 1926–27 was £1,691,000. From April 1, 1927, railway revenue was separated from the ordinary budget. For the year ended March 31, 1928, ordinary revenue was £1,904,000 and railway revenue (which showed a surplus over expenditure of £51,000) was £631,000. (E. Hea.; F. R. C.)

HISTORY

The years immediately preceding the outbreak of the World War had been a period of much administrative and commercial activity in German East Africa. There was a flourishing European settlement in the Usambara highlands and, as far as civil administration was concerned, the colony was self-supporting.

Post-war Administration.—The British and Belgians established their own administrations in the districts they conquered. It was not until March 22, 1921, that all the districts which Belgium had occupied but which fell within the British mandated area were transferred to Tanganyika Territory, the name officially given to the British area in Jan. 1920. A civil administration had been set up while the war was in progress, Mr. (afterwards Sir) Horace Byatt being the first administrator—a title changed in Aug. 1920 to that of governor. The country had suffered severely from the ravages of war and the work of reconstruction was difficult and prolonged. All the German settlers were repatriated and their estates sold. Until this process was nearing completion few new land grants were made and agriculture for a time was practically at a standstill. Moreover, both the planters and the commercial community complained, with some show of reason, that the Government was indifferent to their needs. Complaint was also made by the Europeans of the competition of the Indians. As to that the administration was tied by the terms of the mandate (which were approved by the Council of the League on July 20, 1922). The mandate enjoined equality of treatment to nationals of all members of the League in matters of "residence, trade and commerce." The administration was hampered by lack of funds and the necessity of rebuilding a large part of the central railway (the Dar-es-Salaam-Tanganyika line); and it had as its first duty the care of the natives, many of whom were restive and demoralized by the war. It had its hands full; nevertheless, it might have paid greater attention to the needs of planters—and the Amani institute for scientific research in all things connected with agriculture, which was one of the best works of the Germans, was allowed to go nearly to ruin.

In Nov. 1924 Sir Horace Byatt was transferred to Trinidad and Sir Donald Cameron succeeded him as governor of Tanganyika. Meanwhile attention had been called to the suitability of the highlands in the southwestern parts of the territory for white settlement and a number of Europeans, mostly British, obtained farms there, on long leasehold, the administration having decided against freehold sales.

Economic Development.—By the middle of 1925 the era of transition after the war may be said to have ended. In June of that year ex-enemies were allowed to re-enter the territory (a step which would in any case have been necessary when Germany entered the League of Nations in Sept. 1926). Over 200 Germans, mostly former settlers, came to Tanganyika in the next 12 months, somewhat to the alarm of the British settlers. In a couple of years it was realized, however, that the German "invasion" was of limited extent, and a degree of co-operation was established between the British and Germans. The development of the country led in 1926 to the setting up of a nominated legislative council and occasion was taken of its first meeting (Dec. 1926) for a message to be sent by the king, who expressed his "deep interest in all that concerns the welfare of the people of Tanganyika Territory." This was more than a formality, it was intended to indicate the permanent character of the ties linking Tanganyika with the British empire. Agitation had been kept up in Germany for "the return of the colonies" and was directed as far as Britain was concerned to Tanganyika. Apart from the king's message explicit declarations were made by the British Government that the mandate gave Great Britain as secure control of Tanganyika as of territories actually British. The mandate simply imposed certain "servitudes," and even permitted the administrative union of Tanganyika—if that were thought desirable—with the neighbouring British territories. (*See* British East Africa.) But economics as much as, or more than, politics engaged the attention of the administration and of the settlers. The Amani institute was reopened as a research department for the whole of East Africa; measures against the spread of the tsetse fly were taken; the rights of natives in the proprietorship of land were secured, much progress was made in education, for whites, Indians and natives alike, and particular attention was paid to improving means of transport. A line from Tabora to Mwanza on Lake Victoria, opened in July 1928, was the first addition of any considerable length to the railway system since the war.

Bibliography.—*Report on Tanganyika Territory* (Cmd. 1,428), an official publication covering the period from the Armistice to the end of 1920 (1921); the *Reports* to the Mandates Commission (London, yearly); the text of the mandate is given, with map, in *British Mandates for . . . East Africa* (Cmd. 1,794) (1923); *Report by Sir Benjamin Robertson Regarding the Proposed Settlement of Indian Agriculturists in Tanganyika Territory* (Cmd. 1,312) (1921); G. D. Hale Carpenter, *A Naturalist in East Africa* (1925). *See* also entries under British East Africa, German East Africa and Kenya Colony. For the Young Commission on East Africa *see* Uganda.

T'ANG DYNASTIES: *see* China: *History*; Chinese Painting; Chinese Sculpture.

TANGENT: *see* Geometry; Trigonometry.

TANGENTIAL CO-ORDINATES: *see* Co-ordinates.

TANGERINE (*Citrus nobilis* var. *deliciosa*), a small, thin-skinned variety of orange belonging to the Mandarin group, frequently called the "kid-glove orange," because of its loosely adhering skin, which may be removed without soiling the fingers. It has a very sweet, spicy flavour, a delicate perfume, dry pulp and a large amount of oil in the skin. It originated in south-eastern Asia. The tangerine is more quickly perishable than the orange (*q.v.*).

TANGERMÜNDE, a town in the Prussian province of Saxony, on the Elbe, 43 m. N.E. from Magdeburg by rail *via* Stendal. Pop. (1925) 13,123. It contains iron foundries, shipbuilding yards, refineries, and other industrial establishments, and enjoys a considerable river trade in grain and leather. It has numerous brick buildings of the 14th and 15th centuries. The castle, built in the 14th century, was the residence of the margraves of Brandenburg.

TANGIER (locally Tanja), a seaport of Morocco, on the Strait of Gibraltar, about 14 m. E. of Cape Spartel, nestles between two eminences at the north-west extremity of a spacious bay. The town presents a picturesque appearance from the sea, rising gradually in the form of an amphitheatre, with the citadel, the remainder of the English mole and York Castle to the right; in the central valley is the commercial quarter, while to the left along the beach runs the track to Tetuan. Several new roads have been made outside the town. In some of the older streets European shops have replaced the picturesque native cupboards; drinking dens have sprung up at many of the corners, while telephones and electric light have been introduced by private companies, and European machinery is used in many of the corn-mills, etc. The main thoroughfare leads from Báb el Marsa (Gate of the Port) to the Báb el Suk (Gate of the Market-place) known to the English as Catherine Gate.

New European quarters have been built to the north of Tangier (the Marchan quarter) and to the south (quarter of the beach and of Suani). The harbour, formed by the Bay of Tangier, is good in all weathers except during a strong east wind, but vessels of any size have to anchor a mile or so out. The work of building a deep-water harbour was begun in 1925 and will take five years. The harbour will include several basins with a depth of 7½ metres, protected on the north and north-west by a breakwater.

The population of Tangier is 56,000, of which 33,000 are Muslim, 12,000 Jews and 11,000 Europeans (9,000 Spanish, 1,500 French). The trade of Tangier has risen to 175 millions (imports 146 millions, exports 29 millions). The share of France is 87 millions, that of Spain 30 millions, that of Great Britain 20 millions. Tangier, which was formerly the first port of Morocco, has suffered a great deal during the last 20 years from the jealousies of the European Powers, which has retarded its development. Casablanca and the other ports in the French zone have taken its place. The opening of the Franco-Spanish railway from Tangier to Fez, which took place in 1928, will doubtless enable the port to draw, from its magnificent geographical situation, the advantages it has the right to expect.

The Roman Tingis, which stood in the immediate vicinity of the site of Tangier, was of great antiquity; under Augustus it became a free city, and when Otho placed the western half of Mauretania under a procurator, he called it Mauretania Tingitana, after its capital, Tingis. It was held by Vandals, Byzantines and Arabs, and when Mulai Idris passed from Tlemçen to Fez in 788, Tangier was "the oldest and most beautiful city" of the Maghrib. After many futile attempts the Portuguese obtained possession of it in 1471, but it passed to Spain in 1580, returning again to the Portuguese in 1656. In 1662, as part of the dowry of Catherine of Braganza on her marriage to Charles II., it came into the possession of the English, and they defended it against Mulai Ismail in 1680, but in 1684 it was decided, on account of expense, to abandon the place to the Moors. It was bombarded in 1844 by the French, then at war with Morocco. In the early years of the 20th century the sharīf Raisūli terrorized the district round Tangier and made captive several Europeans. As one result of the Algeçiras conference of 1906 a regular police force was organized, and the control of the customs passed into European hands.

The Franco-German treaty after the crisis of 1911 and the Franco-Spanish convention of 1912 provided a special regime for Tangier and for a zone of 15–18 km. around the town.

(A. Be.)

1912–1928

The declaration of a French protectorate over Morocco did not alter the situation at Tangier, which was understood to fall outside the effect of that declaration. The jealousies of the Powers and of their local representatives, the obstruction with which certain Governments never ceased to meet every proposition of progress, prevented Tangier from benefiting from its superb position and becoming a place of commercial and maritime importance. So loud grew the complaints of its population that the Governments of Great Britain, France and Spain decided in 1913 to draw up a convention and introduce the special regime which the treaties accorded.

After months of negotiation the representatives of the three Powers concerned were on the point of signing the convention in 1914, when the World War broke out, and the Spanish Government refused to sign. No doubt Spain preferred to await the results of the War before she definitely signed away her hope of one day possessing Tangier herself.

Tangier, like the rest of Morocco, was little affected by the War. During that whole period there was but one incident of importance, the expulsion of the German and Austrian chargés d'affaires and the personnel of their legations. The internationalisation of Tangier rendered it doubtful what steps the Allied Governments would take on this question, but the sultan of Morocco, under whose direct jurisdiction Tangier lay, was himself an Ally and the Governments interested did not hesitate to act. At the conclusion of the War Europe was too occupied to give thought to Tangier, and the policy of obstruction continued, to the lasting detriment of the place. Peace was seldom disturbed, though the fighting in the neighbouring Spanish zone impeded trade and closed the roads.

The Statute of 1923.—It was not until 1923 that the question of Tangier's future was once more taken into active consideration. The situation had now changed. France's position had become stronger since the sultan had recognized her protectorate. The British Government was, however, still determined that an international form of government must be adopted, and Spain, having failed to benefit by the War, supported this demand. A preliminary conference in London in July 1923 failed to bring about any settlement. It served, however, as a useful exchange of views, and in the following October British and Spanish delegates proceeded to Paris where the negotiations were continued. On Dec. 18, 1923, the convention was signed by the representatives of France and Great Britain, and on Feb. 7, 1924, by Spain.

The new status of Tangier is based upon a charter of permanent neutral internationalisation, under the sovereignty of the sultan of Morocco, who maintains his control over Moslem and Jewish Moroccan subjects. The sultan is represented by a high Moorish official, the mendoub. The administration of this town and its zone rests in the hands of an administrator and two assistant administrators, who carry out the decisions of the legislative assembly, subject to their ratification by the committee of control. The convention laid down that during the first six years the chief administrator should be a French subject and his assistants a British and a Spanish subject. After that period they should be chosen by the assembly. A French and a Spanish engineer superintend the public works. The committee of control, consisting of the consuls of all the Powers—except ex-enemy Powers—who signed the Algeciras Act has power, by majority decision, to veto the acts of the legislative assembly. The legislative assembly consists of 26 members, chosen from the subjects of the Powers represented in Tangier and from the Moorish and Jewish population. The number of members representing each nationality is regulated by the local importance in population, trade and influence of the nationality in question. Clauses have been introduced into the convention and in the legal codes for progressive modifications at specified periods of time should modification be deemed necessary or advisable.

Regulations were made for the formation of a force of gendarmerie but not put into practice. The special legal codes are, however, in force and justice is administered in mixed courts by judges of different nationalities. The Muslim and Jewish subjects of the sultan have their own tribunals. The status was officially introduced in June 1925 and has made very tolerable progress. Its application was rendered difficult by the fact that neither the Italian nor the American Governments had accepted its conditions, and that the subjects of those two Powers were therefore not amenable to its laws or ordinances. During the summer and autumn of 1927 the French and Spanish Governments were in negotiation for certain changes in the status, following a demand from Spain for a more prominent part in the local government.

Conference of 1928.—In 1928, the French and Spanish Governments having arrived at a compromise on the subject of the redistribution of their respective representation in the International Administration of Tangier, and Italy having meanwhile consented to recognize the convention of 1923 on certain conditions, a conference of the four Governments concerned was held at Paris. After many meetings, the conference issued "The final protocol of the conference for the Amendment of the Tangier Statute"—a name far too optimistic, as its finality was more than doubtful. With the exception of the welcome participation of Italy in Tangier's International Administration on an equality with England, the results of the conference were few and unimportant. The Belgian command of the gendarmerie, a body which had never been created, was abandoned and the appointment of a Spanish commandant, with French and Spanish subalterns, was agreed upon. In return, the Belgians were granted a judgeship in the mixed court. A "Bureau of Public Security" was introduced under a Spanish officer assisted by Spanish and French lieutenants. Their duty was "to watch over the security of Tangier and its zone." The Italians were granted the same representation as England.

These small changes in the régime were of no real importance and appear to have been accepted as a sort of compromise, no solution having been found to the more important aspects of the question—Tangier's financial burdens, or its relations with the neighbouring Spanish zone. The reorganization of the mixed court and the revision of the code, which were also advised by the conference, would have come about in the ordinary course of affairs, and were certainly advisable.

Tangier continued in a state of stagnation. Its trade showed no increase; and, except for a little more cleanliness in its streets, few changes took place. The construction of the port continued, and the railway to Rabat and Fez was opened, but there was very little amelioration to report in the situation.

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TANGO, a slow, graceful dance in $\frac{2}{4}$ time. It probably originated with the African negroes; in 1911 it became popular in a modified form in America and subsequently in Europe. It has much in common with the Cuban *Habanera.*

TANG SHAO-YI (1858–), Chinese statesman, a native of Kwantung, the first foreign-trained Chinese to rise to high office, was one of the leaders of the Chinese nationalist movement. He was educated at Columbia University, New York, and in 1898 became consul-general in Seoul in succession to Yuan Shih-kai. He organized the Tibet Convention of 1906. He was appointed special envoy to Europe and the United States (1908). He played an important part in the negotiations that followed the revolution of 1911, and in 1912, became Premier under Yuan Shih-kai. In 1919 he was one of the four directors of the Canton Government and was minister of finance at Canton 1919–22.

TANISTRY, a custom among various Celtic tribes, by which the king or chief of the clan was chosen from among the heads of the septs and elected by them in full assembly. He held office for life and was required by custom to be of full age, in possession of all his faculties and without any remarkable blemish of mind or body. At the same time, and subject to the same conditions, a *tanist* or next heir to the chieftaincy was elected, who if the king died or became disqualified, at once became king. Usually the king's son became tanist, but not because the system of primogeniture was in any way recognized; indeed, the only principle adopted was that the dignity of chieftainship should descend to the eldest and most worthy of the same blood. Tanistry was abolished by a legal decision in the reign of James I. and the English land system substituted. *See* BREHON LAWS.

TANJORE, a city and district of British India in the Madras presidency. The city is situated on the right bank of the river Cauvery, and is an important junction on the South Indian railway, 218 m. S. of Madras. Pop. (1921) 59,913. As the last capital of the ancient Hindu dynasty of the Cholas, and in all ages one of the chief political, literary and religious centres of the south, the city is full of interesting associations. It was the scene of the earliest labours of Protestant missionaries in India. The modern history of Tanjore begins with its conquest by the Mahrattas in 1674. The British first came into contact with Tanjore by their expedition in 1749 with a view to the restoration of a deposed raja. In this they failed, and a subsequent expedition was bought off. The Mahrattas practically held Tanjore until 1799, when the district was ceded to the East India Company. The raja retained only the capital and a small tract of country round. He died in 1833 and was succeeded by his son Sivaji, on whose death in 1855 without an heir the house became extinct. Among buildings may be mentioned the palace within the fort, and the great temple of the 11th century, enclosed in two courts, surmounted by a lofty tower and including the exquisitely decorated shrine of Subrahmanya. The city is famous for its silk brocade, jewelry, carpets, inlaid copper-work, modelling in pith, etc.

The DISTRICT OF TANJORE has an area of 3,727 sq.m. It is irrigated by an elaborate system of dams, cuts and canals and the soil is exceedingly productive. The delta of the Cauvery occupies the flat northern part, which is highly cultivated, dotted over with groves of coco-nut trees, and densely populated. The staple crop is rice, grown on some five-sevenths of the cultivated area, and rice-milling has developed recently. Soap and mats are made and fishing carried on. The district is traversed by the main line and several branches of the South Indian railway. The chief seaport is Negapatam. The population in 1921 was 2,326,265.

See *Tanjore District Gazetteer* (Madras, 1906).

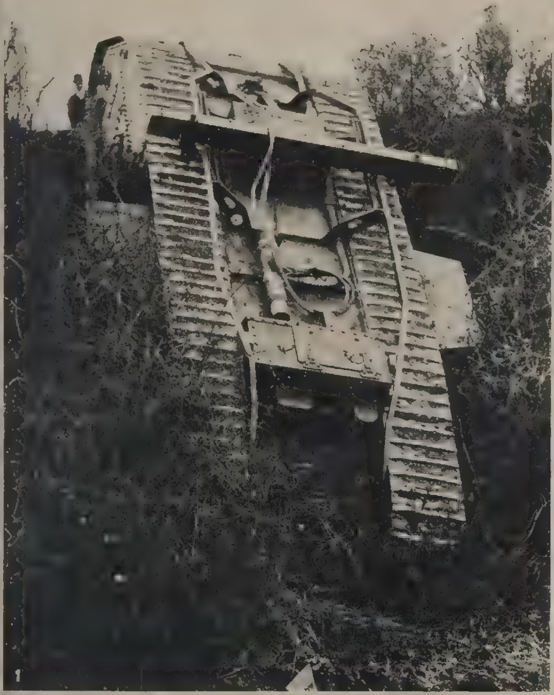
TANKARD, a type of drinking vessel. The word was formerly used loosely of many sizes, usually large, of vessels for holding liquids; thus it was applied to such as held two or more gallons and were used to carry water from the conduits in London in the 16th and early 17th centuries. The word is now generally applied to a plain, flat-bottomed drinking vessel of silver, pewter or other metal, or of glass or pottery mounted on metal, with a hinged cover and handle, holding from a pint to a quart of liquor. (*See* DRINKING VESSELS.) The derivation is obscure. It appears in O.Fr. as *tanquart.* It may have been metathesized from Gr. *κάνθαρος*, Lat. *cantharus,* a large vessel or pot.

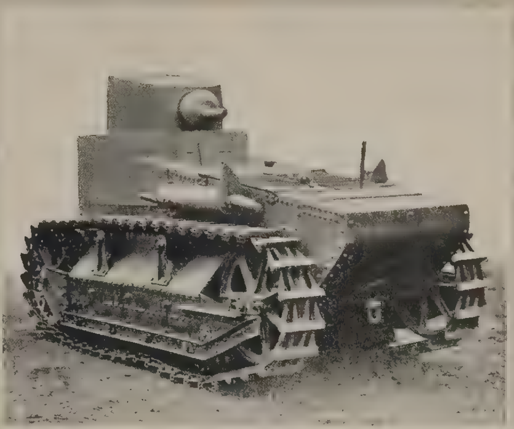
TANKS. The name tank was given during the World War to the bullet-proof, armed vehicle, driven by mechanical power and capable of crossing rough country and obstacles by the use of caterpillar tracks. The name was first used in Dec. 1915 as a blind to conceal the true nature of the experimental fighting machine then being secretly constructed in England; after the first appearance of the machine in the field the name was retained. To the British is due the credit of first conceiving and introducing this weapon which was destined to exert a decisive influence on the course of the War.

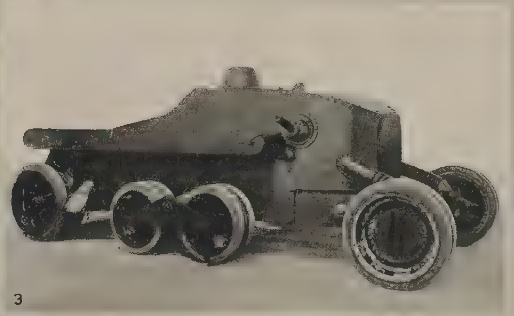
The Tank Idea in History.—From the earliest times men have attempted to find methods whereby they might move under some form of protection while they delivered blows at the enemy. Vehicles of many different types have been constructed throughout the ages with a view to solving these first principles of war and those vehicles were the forerunners of the tank. The earliest fighting vehicles of which there is a record, date back to 1200 B.C.

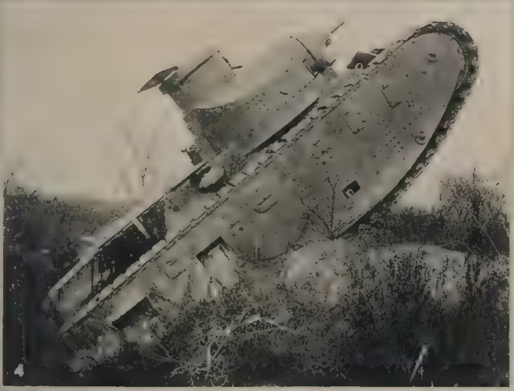
The development of firearms led to the virtual disuse of the fighting vehicle. The weight of armour which was necessary to provide protection was such that no armoured vehicle could be propelled across country by man-power or horse-power. The necessity for a fighting vehicle still existed and was in fact accentuated, especially with the introduction of the machine-gun; there was, however, at the time no apparent solution to the mechanical construction of such a vehicle. As time progressed two inventions were developed and it was the combination of these that led to the construction of the tank. The two inventions were the caterpillar track and the high-speed internal-combustion engine. The former enabled heavy vehicles to cross soft ground by the use of a track or endless belt so that the weight was distributed over a large area of ground; the latter provided a light compact power unit by means of which the vehicle could be propelled. The combination produced tractors such as the Holt, invented and in common use in America before the War. Between 1907 and 1914 several inventors suggested that tractors of this nature should be constructed and provided with armour for use as a fighting vehicle in war. No official action was, however, taken in this direction. The prevailing military opinion among all nations prior to 1914 was that any future war would be mainly a war of movement, and although it was realized that a frontal attack against a defensive position would be costly, it was considered that such an attack would be greatly assisted or even avoided entirely by envelopment or flank action.

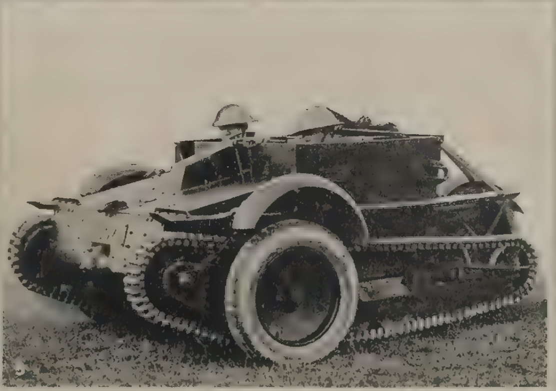
The opening phases of the World War appeared to confirm these views, but in September the Germans fell back and took up a defensive position on the Aisne and it was then that the great strength of modern field defences became apparent. The main source of strength of these defences lay in the machine-gun protected by an extensive use of barbed wire entanglements, and











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MODERN TYPES OF MILITARY TANKS

1. "Mark V." Star tank illustrating its climbing capabilities. This type tank was developed by the British army soon after the battle of Cambrai during the World War
2. Light standard tank of the T 1. type with machine gun mounted in the turret (U. S. Army)
3. Late model of fast, light tank known as the Christie wheeled caterpillar. Capable of unusual speed and easy to manoeuver
4. Heavy armoured (U. S. Army) tank in act of climbing out of a trench
5. Small, light type (Carden Loyd) of wheel-cum-track tank—or "armoured machine gun carrier" as used in the British army. This is capable of about 30 m.p.h on its wheels and 15 m.p.h. on its tracks. More recent models attain over 40 m.p.h. on tracks

they proved to be impregnable to attack by troops, equipped as they were in 1914, without the most prodigal loss of life. The efforts of the French and British troops early in October to outflank the Germans in the north, led to an extension of these defences right up to the sea. The Allies were then faced with a continuous defensive position without flanks that could be turned and they possessed no means of penetrating such defences. One solution of the difficulty appeared to be a large increase in the available artillery resources, particularly in the larger pieces and the provision of high-explosive shells. This solution was acted on at once and although no result could of course be expected for many months, it was hoped that sufficient artillery and ammunition would eventually be available to blast a way through the enemy defences and so re-establish the power of mobility.

Col. Swinton's Proposal.—Early in Oct. 1914 an officer of the Royal Engineers, Lt.-Col. (later Maj.-Gen.) E. D. Swinton, Royal Engineers, formed the opinion that a frontal assault against prepared positions, especially with limited artillery support, had become impossible, and that some form of power-driven protected machine which could traverse trenches and barbed wire was necessary to enable the attack to overcome the power of the defence. On Oct. 20, 1914, Col. Swinton saw Col. (later Sir Maurice) Hankey, secretary of the Committee of Imperial Defence, and put forward his scheme which was briefly to develop the Holt tractor and produce a mobile armoured machine which should lead the assault and act as a machine-gun destroyer.

As a result of the interview described Col. Swinton took up the question with G.H.Q. in France and Col. Hankey put the idea before Lord Kitchener; but in neither case did it lead to any result. Col. Hankey however also submitted the scheme to the prime minister as head of the Committee of Imperial Defence, and this reached Winston Churchill who was already experimenting with armoured cars for the naval detachment of the Belgian coast. On Jan. 5, 1915, Churchill wrote to the prime minister emphasizing the importance of Col. Swinton's suggestion. This letter was sent to Lord Kitchener, and at the same time Col. Swinton called at the War Office to discuss his proposals. As a result the matter received some attention and a few trials were carried out, after which the whole question was dropped. In the meantime Churchill formed a committee at the Admiralty under the chairmanship of Sir Tennyson d'Eyncourt, to investigate the problem. They carried out trials with large wheeled machines, coupled steamrollers, pedrail and caterpillar tractors, single and articulated, the underlying idea being the production of a machine for the conveyance of troops and not a machine-gun destroyer.

In the meantime Col. Swinton took his proposals to the commander-in-chief in France with the result that the specification of the type of machine required was sent to the War Office. By that time a joint naval and military committee had been formed and they were now able to work to a specification which detailed the military requirements. The result was the production—first of "Little Willie" which just failed to reach the standard required, and later of "Big Willie" or "Mother" as it was christened, which passed all tests at Hatfield on Feb. 2, 1916. The chief point in the design, and in which it differed from other caterpillar machines, was its rhomboidal shape and all round track which were the invention of Lt. (later Lt.-Col.) W. G. Wilson, working in conjunction with Sir W. Tritton. This machine, afterwards known as the Mark I. tank, was the prototype of all British machines used during the World War.

In the meantime normal trench warfare had been proceeding in France. The artillery had been considerably strengthened, but even then it was found at the battle of Loos that large numbers of enemy machine-guns would survive the heaviest bombardment and cause prohibitive casualties to the attacking infantry. G.H.Q. France therefore ordered 40 of these experimental tanks, and this number was increased by the War Office to 100 machines. A tank supply committee was formed under the Ministry of Munitions with Major (later Sir) Albert Stern as chairman. Orders were placed on Feb. 12, and production started at once with the utmost secrecy, and under great difficulties of labour and material owing to the great national effort to produce munitions of every kind.

The First British Tanks.—The Mark I. tank was built in two types, "male" and "female"; both types had "sponsons" mounted on the sides to carry the main armament. On the male tank this consisted of two 6-pdr. guns and on the female tank of four Vickers machine-guns. The idea was that the tanks would work in pairs, the male tank being more capable of dealing with defences behind brick walls or steel loophole plates and the female tank having greater man-killing fire power. The total number under construction was 150, half being males and half females. The Mark I. tank was 26 ft. long, weighed 28 tons and carried a crew of eight men. The maximum speed on the level was 4 m.p.h. and the tank could cross a trench 10 ft. wide. Reference has already been made to the track which was carried all round the tank; this track was driven from the engine through a two-speed gear box (controlled by the driver) and then through a differential which carried a second gear box at each outer end of the half shafts. These secondary gears were operated by hand levers and necessitated a gearsman on each side of the tank in addition to the driver. From these the drive was carried by chain to the driving sprockets in rear. As the original idea of the inventors had been that the tank should be used as a surprise on a large front the armour was for the most part only proof against ordinary rifle ammunition. It was realized that it might be necessary, as was indeed the case, to increase the thickness of the armour, in later models, to withstand armour-piercing bullets, when the enemy had had time to produce large quantities of these bullets. The male tank carried 324 rounds of 6-pdr. shell and 6,272 rounds of S.A.A. The female tank carried 31,232 rounds of S.A.A. Both types carried sufficient petrol for about 15 m. on a cross-country course.

A feature of this tank was the tail which consisted of a pair of steel wheels hinged on to the back of the machine and pressed down on to the ground with powerful springs. The wheels could be steered from the driver's seat and in this way the tank could negotiate easy bends; the wheels improved the balance of the machine and also slightly increased the trench crossing capacity.

In March 1916 a unit was formed to man these first tanks. For the purpose of secrecy the unit formed part of the Machine Gun Corps and was known as the Heavy Section, Machine Gun Corps. The name was later changed to Heavy Branch, Machine Gun Corps. The unit was commanded by Col. Swinton and contained sufficient personnel to man the 150 tanks under construction. The unit was organized in six companies of 25 tanks each. As soon as the tanks began to arrive from the contractors the unit encamped at a secret area near Elvedon in Suffolk and started driving and gunnery practice.

First Engagements on the Somme.—In the meantime the Somme (*q.v.*) offensive in France had come to a standstill. The right wing of the attack between the Somme and the Ancre which had met with some success at the start was definitely held up. The very heavy bombardments of the greatly increased artillery force had enabled the attackers to make some headway, but in the end the artillery fire had shelled away the barbed wire and replaced it by a worse obstacle, namely shell torn ground over which the infantry could only advance with difficulty, especially in wet weather. Moreover, this ground was quite impassable to transport. It was at this stage that it was decided to use the first two companies of tanks in an attempt to resuscitate the advance between the Somme and the Ancre. These two companies were accordingly sent to France at the end of August.

On Sept. 15, 1916, the first tank attack took place. The IV. Army was to attack and advance on the line Morval, Les Boeufs, Guendecourt and Flers and the V. Army on the left of the IV. Army was to advance on Martinpuich and Courcelette. A total of 49 tanks were to be used, the majority with the IV. Army. They were to advance in small detachments of two or three machines against the enemy strong points. The general idea was that they should advance so as to reach the objectives just before the infantry. In some cases lanes were left in the artillery barrage up which the tanks were to advance ahead of the infantry. The tanks advanced at dawn in a slight mist and came as a complete surprise to the enemy; the results were, however, disappointing. The tanks had been constructed to traverse wide trenches, banks and barbed wire obstacles, but not the shell torn ground which was the result of prolonged bombardment on a small area. Of the 49 tanks which were employed, 32 reached the front line. Of these nine went ahead of the infantry and rendered valuable assistance; nine kept up or followed just behind and helped in reducing strong points where the enemy were still holding out. The remaining 14 broke down or sank and became ditched in the soft shell torn ground shortly after the battle had commenced. One tank in front of Flers gave remarkable assistance to the infantry and caused the surrender of 300 Germans. On Sept. 25 and 26, 13 tanks were employed on the same front and a few were employed later, on Nov. 13. In each case a large proportion of the tanks were unable to negotiate the shell torn ground, but those that did rendered valuable assistance to the infantry, causing heavy casualties and the surrender of a large number of Germans.

The employment of the tanks in Sept. 1916 was contrary to the views of those who had originated the arm and were responsible for its production. They considered that the tanks should be kept as a secret and used in large numbers as a surprise on a new portion of the front so as to give a chance of achieving decisive success. It did however prove that the tank was a definite reply to the machine-gun and barbed wire and that infantry accompanied by tanks could attack defended positions with every prospect of success.

Improved Types.—As a result of these trials it was decided that the arm should be expanded to a force of 1,000 tanks. The tanks were not to be used again until the spring and the winter was to be spent in re-arming and training. The original six companies were expanded to nine battalions and the force in France was to become three brigades, of three battalions each, under the command of Lt.-Col. (afterwards Major-Gen.) H. J. Elles, R.E. Each battalion was organized in three companies and one mobile workshop, and each company was composed of four sections of four tanks each.

Although France had asked for 1,000 tanks, the design of the tanks had not been settled. There was much discussion as to whether a completely new design should not be introduced; suggestions were made that a type with much wider tracks, or possibly equipped with more than one pair of tracks, should be tried. In the meantime 100 machines were ordered which were to be similar to the Mark I. machine, but with certain minor improvements. These were known as the Mark II. and Mark III. machines. Other than the obvious fact that tanks had difficulty in crossing the pulverized ground on the Somme which was covered with craters and shell holes, the only military lesson that had been learnt as regards tank construction was the fact that it was not worth while fitting the tail to the tank; owing to its vulnerability and complications, it was constantly out of action and was of little value. The Mark II. and III. machines were therefore both very similar to the Mark I., the main differences being the provision of stronger rollers, and stronger armour to withstand the armour-piercing bullets which the Germans would be fairly certain to use in the next battle.

In the meantime the authorities in England who were responsible for the production of tanks were becoming perturbed about the delay over a decision as to the design of tanks for the order of 1,000 machines. For the original idea of fighting a surprise battle on a new front the existing design was suitable, but to produce the ideal machine for traversing the shell torn ground of an old battlefield, a new and special design was necessary and this would mean a complete new series of experimental trials involving much delay. It was not till the end of March, involving the loss of five valuable months, that a decision was reached and it was then decided that the 1,000 machines should be of a type known as the Mark IV. This type was again very similar to the Mark I., using the same engine and transmission and the same shape of hull. It included the minor improvements already incorporated in Marks II. and III. and in addition had sponsons which could swing into the body for travelling on a railway, and so saved the labour of detaching and remounting these heavy sponsons for every railway journey. Another feature of this tank was that it carried an unditching beam which could be fastened when required on to the tracks to extricate the tank from a ditch. The Mark IV. tank was the main machine used throughout 1917 and the early part of 1918.

The next action in which the tanks took part was the battle of Arras (*q.v.*) on April 9 in which the I., III. and V. Armies attacked with a view to penetrating the German defences and allowing an Army Corps and two cavalry divisions to break through. Only 60 tanks were available for this attack and they were again used in the minor rôle of assisting the infantry to "mop up" machine-gun nests and small posts that had been passed over by the artillery barrage and the assault of our leading troops. The tanks were of the Mark I., II. and III. pattern and some of them suffered heavily from armour-piercing bullets. In many cases the tanks rendered valuable assistance, overcoming enemy machine-guns and barbed wire with ease. The cavalry were prevented from breaking through owing to the usual obstacles—barbed wire and machine-guns—the tanks being far too few in numbers and too dispersed to be able to keep up the pressure and assist in further operations.

Messines.—The next attack was against the Messines-Wytschaete ridge on June 7 in which 76 Mark IV. and 12 supply tanks were used. The latter were made from old converted Mark I. or II. tanks and were used to keep the fighting tanks supplied with petrol and ammunition—a need which had been much felt in former battles. The attack was in the nature of an assault in the old form of siege warfare. The result was a complete success in which the tanks only played a small part, though in a few individual cases they rendered valuable help. The ground was completely pulverized by the preliminary bombardment but very few tanks became ditched, mainly owing to the fact that there had been no rain for many weeks and that there had been time to make a close reconnaissance of the ground and pick out the best lines of advance for the tanks. After this attack the arm was renamed as the Tank Corps.

On July 31 the battle of Ypres (*q.v.*) was launched. As the preliminary bombardment had been so successful at Messines it was decided again to use a long preliminary bombardment lasting ten days. The danger of thus rendering the ground impassable to tanks, especially if it rained, was explained by those responsible for the action of tanks, but it was considered that the value of the bombardment more than balanced the possible loss of the use of tanks; this did not prove to be the case as the Germans adopted a defence distributed in depth which did much to discount the value of the bombardment. Unfortunately it rained on the first day of the battle and although the tanks rendered much assistance in individual cases during the early stages of the attack, the ground soon became quite impassable to tanks, and later it became impassable to infantry as well.

Success at Cambrai.—Although the failure of the tanks at the third battle of Ypres was through no fault of the officers and men and those who commanded them, it lead to much discussion as to whether tanks should be retained at all. The Germans formed the opinion that the tank was practically useless, and many British officers held the same view. Fortunately this view was not unanimous and on Nov. 20 permission was obtained to launch an attack at Cambrai, in which the tanks were to be used in the way in which their originators had intended that they should be used. This was the turning point in the history of the Tank Corps. The action as fought was in almost every detail the execution of the plan put forward officially for the employment of the tanks by Col. Swinton in Feb. 1916, seven months before the first tank action. The attack was to be a complete surprise and no preliminary bombardment was to be used. Three brigades of tanks (nine battalions) were to take part with a total of 378 Mark IV. tanks and 98 administrative machines (*see* CAMBRAI).

The attack was launched at 6.20 A.M. in a slight fog, Maj.-Gen. Elles leading the attack in a vanguard tank with the centre division. The operation was a complete success; the enemy were taken absolutely by surprise and most of the infantry bolted or surrendered. Within 12 hours the infantry had advanced 12,000 yd. on a front of 13,000 with only 4,000 casualties. A similar penetration at Ypres had taken three months, with enormous loss of life and morale. The preliminary bombardment which had cost some £22,000,000 at Ypres was dispensed with and a further advantage was gained in that the roads had not been torn up with shell fire and were available for use almost at once. And this had been achieved by the Tank Corps using great mechanical power, but numbering only 4,000 of all ranks.

As regards tank design three main lessons were learnt from the battle of Cambrai. First of all the tanks required to be handier, and controlled by one man, without the assistance of any gearsmen, and to meet this requirement the Mark V. tank was produced. This design had been suggested but not accepted almost a year previously. Outwardly the tank had the same appearance as Marks I. to IV., but the engine and transmission were much improved. The engine developed more power and the steering was effected by using epicyclic gears on the transmission to each track; this was the best tank produced during the War. Then the difficulty of crossing the wide trenches of the Hindenburg line had been considerable, and a certain number of special long tanks were ordered for this purpose. These were made from Mark V. tanks by adding a section in the centre to obtain the required length, and were known as Mark V.* tanks. Later an improved type was made with a more powerful engine known as the Mark V.** The third lesson was the necessity at times for a much more mobile tank for use beyond the main trench systems. These tanks would not need to cross wide trenches and hence they could be shorter and lighter and more mobile. One type, known as the whippet, had already been constructed experimentally. These lighter tanks became known as "medium" tanks, and the whippet was named the Medium Mark A.

German Offensive of March 1918.—The Tank Corps was now expanded to five brigades of 13 battalions with 320 Mark IV. machines and 50 Medium A. machines. During the winter of 1917–18 all units were training and being equipped with new tanks. No further offensive operations were in view and there ensued a period of preparation for the expected German attack in the spring of 1918. To assist in repelling such an attack the Tank Corps was distributed in detachments on a front of some 60 miles.

The attack was launched on March 21 (*see* St. Quentin, Battle of), and the Germans advanced rapidly. The tanks took part in many improvised attacks in attempting to stem the German advance. Some of these met with fair success and caused heavy casualties but the tanks were too few and too dispersed to make their real weight felt. It was during this retreat that the Medium A. tanks were first engaged in action and they met with considerable success, their additional mobility being of great assistance in this type of warfare. The attack fought itself to a standstill within a month, immobility being caused more by the difficulties of transport than by the resistance offered by the Allies. The supply of ammunition and food to the advanced German troops, especially where the lines of supply crossed the old battlefields, became exceedingly difficult, and it was at this stage that the necessity for some form of cross-country transport to enable an army to pursue across the devastated country left behind by the opposing force, began to be realized. The Tank Corps had already foreseen its own requirements by the provision of supply tanks and sledges drawn by tanks, and later by moving signalling equipment in special signal tanks.

In the meantime a reaction had set in as regards the estimated value of fighting tanks. The critics asserted that the battle of Cambrai could never be repeated and pointed to the lack of decisive results achieved by the tanks during the German advance. The proposed expansion of the Tank Corps was postponed and the existence of the corps seriously threatened. Fortunately the Mark V. tanks were now arriving at the rate of about 60 machines per week, and on July 4 one brigade of tanks equipped with these machines carried out a surprise attack on the Germans at Hamel in conjunction with the Australians. The attack was a complete success. The extra handiness and mobility of this machine enabled it to be used very effectively against machine-guns, many of which were crushed and rolled into the ground.

The Triumph of the Tank.—The great French victory of Soissons on July 18, 1918 (*see* Marne, Second Battle of the), marked the turning point of the War; the victory was largely due to the use of French tanks employed in much the same way as the British had used their tanks at Cambrai. This was followed by the opening of the British strategic offensive on Aug. 8 with the battle of Amiens (*q.v.*). In this attack the tank tactics were those of Cambrai modified by recent experience and adapted to the improved machines available. The attack was carried out by three army corps, a cavalry corps and 11 tank battalions; nine battalions were equipped with Mark V. tanks and the remainder with Medium A. tanks. For the first time since tanks had been used for an offensive it was possible to keep some in reserve and 42 tanks were kept in hand. The attack was a complete success, the greatest penetration of the tanks being 7½ miles. The tanks continued in action till Aug. 11.

From that date until the Armistice tanks took part in every main attack and in no case, where tanks were properly employed in conjunction with the other arms, did the attack fail. During this period the tanks co-operated in the battles of Bapaume, Epehy, Cambrai, St. Quentin, the Selle and Maubeuge. Tanks came to be looked upon as essential to the success of any attack, and in his final dispatch the commander-in-chief stated that the successful attacks which won great victories at Amiens and afterwards would have been impossible without tanks. The Germans also confessed that it was the tanks that had caused the downfall of their armies in the field. An expansion of the Tank Corps to 34 battalions had been sanctioned if the War continued into 1919, and the Ministry of Munitions in England had hoped to produce a total of 6,000 machines in 1919.

FRENCH AND AMERICAN TANKS

Independent Invention by the French.—The French were faced with the same difficulty as the British in the early stages of the War, and their attacks were held up by machine-guns and barbed wire although they were often well supported by artillery using high-explosive shells. It was Col. (later Gen.) J. B. E. Estienne of the artillery who first perceived the necessity for some mechanical machine which could cross the trenches and barbed wire in the face of machine-gun fire, and when this officer saw the Holt caterpillar tractors at work behind the British front for hauling guns, it occurred to him that the solution might be found in an armoured caterpillar machine. On Dec. 1, 1915, Col. Estienne put forward his idea officially to the French commander-in-chief and asked for an interview. Thus the ideas which had been thought out by the British originators in 1914 were re-invented separately and independently by the French in 1915. As the result of Col. Estienne's interview, 400 tanks were asked for and the design was to be prepared jointly between Col. Estienne and M. Brille of the Schneider Works. Later a further order for another 400 machines was placed with the St. Chamond Works.

In June 1916 French Headquarters received information from British G.H.Q. as to what was being done in England. Col. Estienne visited England and saw the Mark I. tanks in training. He expressed the view that the two countries should collaborate as regards the production of tanks and that as the British had progressed with the design of a large heavy machine, the French might specialize with a light machine for more mobile warfare. Col. Estienne was specially insistent in the view that neither country should forestall the other in the use of tanks, but that they should co-operate and launch a great offensive in which both British and French tanks might obtain full value from surprise.

French Light and Medium Tanks.—The first light tank was produced by the Renault firm in November but the production of these small machines did not receive official support. The French classified their tanks or "chars d'assaut," as they were called, in three categories, and this classification was generally accepted. The light tanks were under 10 tons in weight and were to be transported over long distances in lorries. The medium tanks (St. Chamond and Schneider) weighed between 10 and 30 tons and could be transported by rail on ordinary trucks. The heavy tanks, of which the British Mark I. formed the only example at the time, were machines weighing over 30 tons and required special railway trucks for transport.

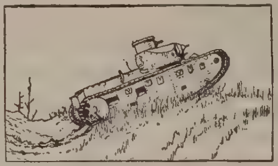
A training centre was now formed at Marly-le-Roi and later an additional centre was started at Champlieu. On Sept. 30, the artillerie d'assaut, which was the counterpart to the British Tank Corps, was formed under the command of Col. Estienne. The French medium tanks now began to arrive. The Schneider tank was six metres in length and driven by a 60 h.p. engine. It was armed with a short 75 mm. gun and two machine-guns. The St. Chamond tank was somewhat larger and heavier, being 8 metres in length and driven by an 80 h.p. engine through a petrol-electric transmission. The armament was one 75 mm. gun and four machine-guns. Both machines differed radically from the British tank in that the track was not carried round the machine but consisted of the ordinary short type used on tractors. This resulted in the machines having very limited climbing power out of shell holes or craters. The artillerie d'assaut was organized in "groupes"; each "groupe" had four batteries of four tanks each. The light Renault tank was used as a "command" tank and one was allotted to each "groupe."

The delivery of both types of tank was very slow and instead of 800 tanks being ready for the spring offensive in 1917 only 250 had been received. The result was that only 10 "groupes" were able to take part in Gen. Nivelle's offensive. The French high command had grave doubts whether to make use of so small a number of tanks, but eventually decided to do so. The offensive was unsuccessful and although the tanks did good work in isolated cases, the result was disappointing. The employment of tanks in this manner was a repetition of the mistakes made by the British.

Success of the Renault Type.—Between this date and the end of the year 1917, the French tanks were again used on several occasions with similar results. On Oct. 23, five "groupes" took part in the battle of La Malmaison and met with much success though the battle was not launched as a surprise and was preceded by an artillery bombardment. During this period much discussion took place and designs were prepared for improved medium tanks and for heavy tanks. Finally in Dec. 1917 it was decided to concentrate on the Renault light type; this was the machine that Col. Estienne had asked for in 1916. Some of these tanks were already on order but production had been very slow. In Jan. 1918 it was decided to increase the orders to a total of 4.000 light tanks, of which 1,000 were to be ready by the end of March. The Renault tank was a small machine weighing 6½ tons. The length was four metres and in addition there was a short skid tail in rear to assist in trench crossing. It was driven by a 35 h.p. engine. There were two types, one being armed with a 37 mm. gun and the other with one machine-gun. The crew consisted only of two men, one driver and one gunner.

The French had hoped to use their tanks in mass in a great offensive in the spring or summer of 1918, but the German advance on March 21 upset all these plans. Instead the tanks were used piecemeal and in local counter-attacks to stem the German advance. In May and June tanks were used on occasions and the Renault tank made its first appearance in battle on the east of the Forest of Retz. During this time the artillerie d'assaut was reorganizing and rearming. On July 18, the second battle of the Marne took place and the French tanks came into their own. It was in many ways a repetition of the battle of Cambrai, but as the warfare had been of a semi-mobile nature for some months, the wide trenches of static warfare were nonexistent. This suited the Renault tanks. The attack was launched as a surprise using a total of 120 medium tanks and 700 Renault tanks. The attack was a complete success and definitely established the value of the tank in the French army. From that date until the Armistice, the French tanks—mainly Renault tanks—took part in practically every attack and contributed largely to the success of the final French offensive.

American Tanks.—The Americans were quick to grasp the great possibilities of tank action on the Western Front and this form of mechanical warfare appealed to their national characteristics. Officers were sent to study the employment of tanks and questions relating to their construction and design. As a result the Americans decided to adopt the British heavy type of tank and the French light type known as the Renault tank. In Dec. 1917 an allied commission was formed and it was decided to construct a tank known as the Allied tank; this was a heavy tank similar to the latest British type and was to be the Mark VIII. tank for the British Army. It was designed to use the Liberty aero engine and was known in America as the Liberty tank. A factory was erected at Neuvy Pailleux which was eventually to be capable of constructing and assembling these tanks at the rate of 1,200 a month and the first 600 were to be used for equipping the first American tank units. A large constructional programme was also started in America to produce both this type and the French Renault tank. The first tanks of this type were not constructed until just after the end of the War, but several American tank units equipped with British and French tanks took part in the latter phases of the War and met with marked success. If the War had continued the American tanks would have come in with an overwhelming effect in 1919.



BY COURTESY OF THE ARMY ORDNANCE ASSOCIATION

U.S.A. 1921 MEDIUM TANK (22½ TONS)

Anti-tank Defence.—The Germans never made an attempt to construct tanks in large numbers, partly owing to the restricted manufacturing power possessed by Germany compared with the Allies, and partly to the comparative failure of the British tanks at Ypres in 1917. A rather clumsy type of heavy tank known as the A.Y.V. was constructed in small numbers. These and a number of captured machines were formed into units and used in small numbers in a few isolated cases during 1918, but owing to the way in which they were employed and handled they met with little success.

On the other hand the Germans made continual attempts to introduce some form of anti-tank defence, but as the British tanks met with comparatively small success in the early stages, these measures were only developed half-heartedly. The first step was the introduction of armour-piercing bullets which was countered by the use of thicker armour on the Mark IV. tank. Next the Germans turned their attention to the employment of field guns specially allocated for anti-tank defence and often dug in or concealed in the forward areas. The employment of field guns in this way seriously depleted the power of the German artillery for other purposes, but they were meeting with considerable success until the introduction of the Mark V. tank, which, with its increasing mobility was able to reduce very largely the value of this field gun defence.

In addition the Germans often employed obstacles such as pits and barricades or mines. The former required a large amount of material and labour in construction, and could usually only be made in isolated places or in defiles, and did not seriously trouble the Allied tanks. The latter were a source of danger to friend and foe, and required much time and material before a continuous line of minefield could be constructed. Although tanks were blown up in isolated cases by German mines the danger was never serious. The Allies made preparations to meet enemy tank attacks with field gun fire and in some cases by the use of male tanks kept in hand for this purpose. The latter is the most certain method of secure defence against tanks but was never adopted by the Germans. In 1918 the Germans evolved a heavy anti-tank rifle which was capable of penetrating the armour plates of the tanks, but the rifle had a heavy recoil and was difficult to handle and did not prove successful as an anti-tank measure.

After the success of the Allies at the battles of Soissons and Amiens in July and Aug. 1918 the Germans were awakened to the great danger in which they stood from tank attacks. They then constructed a heavy machine-gun firing a 13 mm. bullet and capable of penetrating 30 mm. of armour. The gun was known as the Tuf, and great efforts were made to construct it rapidly and secretly, but none was ready till after the Armistice.

PROGRESS IN TANK DESIGN

With the exception of the Germans, who are prohibited by the Peace Treaty from doing so, all great nations now employ tanks as part of their military force. The French have retained the Renault tank as the main armament of their tank corps and although they have carried out much experimental work, no models have been considered sufficiently advanced to standardize and construct in any large numbers. The Americans have also constructed many experimental patterns, and after for long retaining the Mark VIII. or Allied tank as the heavy tank with which their tank units are equipped, are now superseding it by a 23 ton tank with a crew of four, a speed of 12 m.p.h., a protection of an inch of armour and an armament of one 6-pounder and two machine-guns. The Renault has also been replaced by a light tank with a speed of 18 m.p.h. and a cruising radius of 80 miles. It has a crew of two and an armament of one 37 mm. gun and one machine-gun.

The British, as the originators of the tank, have sought to maintain their lead. Some months before the conclusion of the World War, when preparations were being considered for a great offensive in 1919, the specification was drawn up for a tank which was to be a great advance on the existing patterns. It was to have a speed of 20 m.p.h. and be capable of floating and propelling itself across water. Enough petrol was to be carried to travel 200 m. cross country, and the tank was to be long enough to cross a trench 12 ft. wide. This tank was to be used for attacking the enemy communications and headquarters while the more conventional tanks were attacking the main armies in front. The first experimental model was actually completed just after the Armistice. The tank used a system of spring suspension on a cable and hydraulic power for control. Although the machine attained a speed of 28 m.p.h. and swam successfully across a narrow river on several occasions, it proved to be unreliable owing to the many new devices which it contained and which required further development. The problem of steering has been found to present many mechanical difficulties and, although much work has been done, no satisfactory solution has yet been found.

The Vickers Tank.—In the meantime the British Tank Corps which was reduced to four battalions after the War, was armed with the Mark V. tank and the Medium C. The Medium B. replaced the Medium A. at the end of the War, but very few of this model were made and the units were equipped with an improved type in the Medium C. This machine had a maximum speed of 12 m.p.h. and a radius of action of 70 m. and would have been a very useful tank in France. But by 1920–21 these machines were becoming worn out, and, although much knowledge had been gained, the experimental machines aiming at far higher achievements, and which have already been referred to, were not yet in a satisfactory state for production. A tank was therefore designed which was constructed on conventional lines and aimed at obtaining a high degree of mobility, if necessary at the expense of trench spanning capacity. The machine was known as the Vickers light tank. It is 18 ft. in length and weighs 10 tons and is armed with one 3-pdr. gun and two machine-guns. It can attain a speed of over 20 m.p.h. and travel 150 m. on the petrol that it carries.

One Man Tanks.—In 1925 a new line of development was started by the British and the first one man tank[1] was constructed. The essence of the idea was to produce a small cheap fighting machine which could be used in large numbers, either instead of or in addition to the much larger and more expensive fighting tanks. The anti-tank weapons have become a serious threat to the large tanks used in the small numbers that peace time financial stringency dictates, but if they can be split up into 20 times as many small tanks, the casualties can be reduced by the use of dispersion. Furthermore, small cheap tanks provide a means of sending out scouts and a protective screen which the tanks did not formerly possess. It was with these ideas in mind that the first of these small tanks was made. The original idea was that one man should both drive and fight the machine, and practical trials showed that this was not impossible. The advantage of having only one man was that for the same charge on army funds, a larger number of machines could be manned and maintained than if two men were used in each machine. After due consideration it was, however, decided that these small tanks should be made to take two men each, the one to drive and the other to fire the machine gun.

As a result of demonstrations given with the first experimental model, the firm of Morris Commercial Cars were asked to make a number of these small tanks which were later christened tankettes. The main idea was to endeavour to use commercial components as far as possible so as to reduce the cost and thus enable large numbers to be used. The first models had many defects but they served to launch the idea and to raise interest in this new development. A little later the firm of Carden Loyd Tractors came forward with proposals which they had had in mind for some time. Their original idea was a low unarmoured one man machine but this proved to be impracticable and they then developed an armoured two man tankette. Their early models had many mechanical defects but these were gradually overcome and later models were very successful. At the end of 1927 the term tankette was replaced by light tank and the Vickers tank was renamed as a medium tank. In their present form these light tanks weigh about 2 tons and cost about £500. They can travel 20 m.p.h. on good going, can cross most small ditches and natural obstacles, can move along tracks and pass between trees in some woods.

Mechanized Warfare.—From the moment that tanks arrived in France during the World War there arose a demand from other arms for assistance from vehicles of this nature with track transmission. Artillerymen required track vehicles for the forward transport of some of their guns, the administrative services required track vehicles to enable them to maintain supplies across shell stricken areas, and the whole subject was grouped rather loosely under the name of mechanical warfare. The various ways in which mechanically propelled vehicles can be used to assist an army can be divided, for the sake of clearness in discussion, into strategical, tactical and administrative mechanization.

Strategical mechanization is used to enable a commander to move troops over long distances with great rapidity, *e.g.*, if the necessary vehicles are available, a complete Division can be moved 100 m. in 24 hours, and if the vehicles are of a cross country type, the move may be carried out across country where the enemy has endeavoured to impede progress by the use of extensive demolitions.

Tactical mechanization is used to enable the men to fight on the move and behind armour on the battle field, *e.g.*, the tank, the armoured car, and the gun on a self-propelled mounting.

Administrative mechanization is used to assist the administrative services in several ways, *e.g.*, mechanized artillery need far less weight and bulk in petrol than a corresponding unit in forage, and this greatly aids administration by reducing the demands on shipping. Vehicles with a cross country capacity may enable the Staff to feed troops over an area in which ordinary lorries and horses would be quite unable to cope with the work.

Considerable progress has already been made with strategical mechanization. For a long time attempts were made to use track vehicles for this purpose, and considerable difficulties were encountered, but more recently the six-wheel lorry was invented, and the development of this vehicle has overcome nearly all the troubles. In the British army a start has already been made in mechanizing the first line transport of infantry battalions with these vehicles, and there is every chance of their commercial employment, which means that the army will be able to draw on civilian resources for mobilization. This would pave the way for a considerable extension in mechanizing first line transport, and thus overcome the main objection to strategical mechanization, for although there has never been any great difficulty in collecting buses and lorries for the rapid transport of dismounted men, the movement of their first line transport has represented a serious difficulty in the past. By the use of six-wheel lorries, the first line transport can travel with the buses, and the whole unit can move considerable distances at high speed. There are, of course, some forms of tactical mechanization which bring with them strategical mobility, but the necessity of carrying armour reduces this mobility in a large degree. Strategical mechanization offers very considerable advantages to the commander of a force. It renders no actual assistance to the infantryman in an attack on the battlefield, but it may enable a commander to move one or more infantry divisions with great rapidity to the flank or rear of the enemy position and so achieve his object without the use of any armoured fighting vehicles at all.

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[1] The idea was initiated and the first tank constructed as a private experiment by Major G. le Q. Martel, D.S.O., M.C., R.E.

Administrative mechanization is closely wrapped up with the progress that is being made with strategical mechanization. The six-wheel lorry brings with it a great saving in financial expenditure in peace time, and in war it would enable a large reduction to be made in the tonnage which has to be transported by rail or sea to maintain a force, compared with the amount that would be required for a similar force using horse transport, because the necessary quantities of petrol and oil would be far smaller in both weight and bulk than the corresponding amounts in forage. In addition, a commander with an adequate number of six-wheel lorries at his disposal can face an advance through an area over which an enemy has retreated and demolished all communication, with the knowledge that he will be able to maintain his troops with the necessary supplies and munitions.

It is concerning tactical mechanization, however, that there is so much difference of opinion and discussion. Here the six-wheeler is of little value. It is true that six-wheel armoured cars will be useful for long distance reconnaissance, but their fighting value may not be great. Their mobility is entirely dependent on the pneumatic tyre, which is at present very vulnerable though recent developments may give it greater immunity. These tyres can be replaced by semi-solid tyres of various types which are unaffected by bullets, but this reduces the cross country capacity of the vehicle and the speed on roads to a considerable extent. The six-wheeler is therefore at present mainly limited to armoured reconnaissance and armoured mounts for officers and staff, and although these duties are important, they represent only a small part of the work of armoured fighting vehicles.

The present trend of thought is to divide the use of tactical mechanization into two branches—the employment of armoured fighting vehicles with normal formations such as an infantry division, and their employment in an independent mechanized force whose rôle would be to carry out turning movements and attack the enemy in flank or rear or to attack his communications.

Tanks are likely to be employed for many years to come in co-operation with infantry skirmishers in any carefully staged attack against a defensive position. The smaller tanks will in addition be used for scouting and reconnaissance work, while the larger tanks are kept for the decisive attack where trenches and obstacles may have to be surmounted which would be impassable to the lighter tanks. It is the employment of an independent mechanized force, however, that presents such difficulties and yet holds out great possibilities. This is in reality the modern form of independent cavalry, and just as the horseman was supreme on the battlefield in the early middle ages, so the advocates of an independent mechanized force consider that in this, their latest and most modern form, they will again reign supreme.

An Experimental Mechanized Force.—All the views that have been expressed have been based on theory, and as no one is going to re-organize an army on theory alone, the British army formed an experimental mechanized force. In this force the tanks and the necessary supplementary arms and weapons are being tested out, and facts will be gained which will supplement or replace theories. There are many lessons which can never be learnt except on the battlefield, but there are others, such as the fatigue of tank crews and the capabilities of the machines, which can be determined exactly, and in many ways the manoeuvres with this force will provide a valuable guide as to the capabilities of an independent force of this nature. In 1928 the American army also formed a mechanized force.

The British mechanized force was formed in July 1927, and consisted of one battalion of Vickers tanks (48 tanks), two companies of armoured cars, a company of 16 light tanks, one mechanized brigade of field artillery and one light battery, one machine-gun battalion carried in half-track vehicles, one mechanized company of Royal Engineers, and a specially equipped company of the Royal Corps of Signals. It was realized that there were too few light tanks and armoured cars. The vehicles with which this force was equipped were by no means ideal, but it was thought better to carry out tactical trials and gain some information in this way with vehicles that were available at the time, rather than await the development of more perfect machines. If the trials developed successfully, it was intended that the force should travel entirely in armoured vehicles so that the whole force should be proof against small arm fire.

A series of trials were carried out on Salisbury plain. It may be argued that these rolling plains were unduly favourable for the mechanized force, and that much greater difficulties would have been encountered in almost any other part of England when the force moved across country. This is true, but on the other hand the enclosed country which is so common in England is not found to any great extent elsewhere, and Salisbury plain is much more typical of Europe. In these trials the plan was evolved of using a light group ahead, consisting of armoured cars, light tanks and light guns, and following up with a heavy group of Vickers tanks and mechanized artillery. It was the duty of the light group to carry out long distance reconnaissance with armoured cars, and close reconnaissance with light tanks; they were responsible for gaining and keeping touch with the enemy and holding important points. The heavy group followed close up, and when the enemy main body had been located, they were used to strike a decisive blow. At the end of 1927 the name of the force was changed to the Experimental Armoured Force.

These trials are, however, in an elementary stage; as the equipment of the force improves, the anti-tank weapons of the opposing side will be developed. There are those who argue that the tanks will be developed with much heavier armour and a higher speed, and will be capable of resisting the smaller calibres of anti-tank weapons, and that development will be on naval lines up to huge battle tanks. There is, however, this fundamental difference between the army and navy, that whereas a battleship on the open sea is all powerful and can destroy in a few moments any inferior surface craft that appears within range, a battle tank would be in no such position. A single gun concealed in a wood may be within a few hundred yards of a big powerful tank and yet quite unseen, and it could destroy the tank before a shot could be fired in return. It is possible that development will be in the other direction, *i.e.*, towards smaller and more numerous tanks which can avoid casualties by dispersion.

The present attitude of nearly all armies towards tactical mechanization is to watch developments. It is possible that the progress in design of anti-tank weapons may render the supremacy of fighting vehicles short-lived. On the other hand the development of these vehicles may surpass that of anti-tank weapons. Much will be learnt from the trials with the armoured force on Salisbury plain. The formation of this force was a most progressive step; just as the British were the first to conceive and use an armoured fighting vehicle—the tank—on the battlefield, so they have been the first to extend the idea to the use of a self-contained armoured force. The future progress will be watched with interest.

(G. LE Q. M.)

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TANNA: *see* GAON.

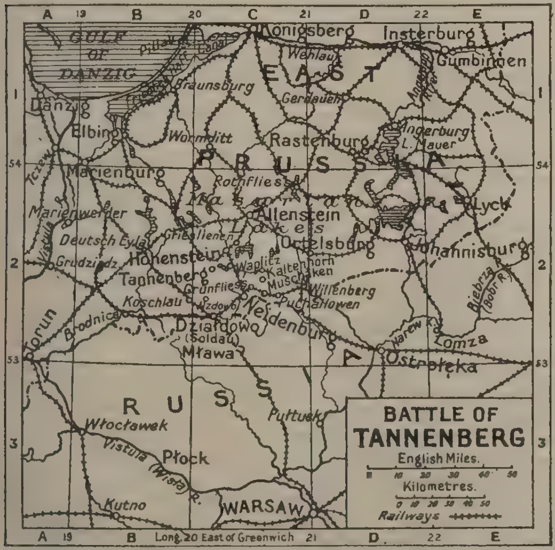
TANNAHILL, ROBERT (1774–1810), Scottish song-writer, son of a Paisley silk-weaver, was born on June 3, 1774. He was apprenticed to his father's trade at the age of 12, and, inspired by the poetry of Robert Burns, he wrote verses as he drove the shuttle to and fro. He began in 1805 to contribute verses to Glasgow and Paisley periodicals, and published an edition of his poems by subscription in 1807. Three years later, on May 17, 1810, he committed suicide. Tannahill wrote some charming songs. "Loudon's Bonnie Woods and Braes," "Jessie, the Flower o' Dunblane," and "Gloomy Winter's Noo Awa" are the best.

Tannahill's centenary was celebrated at Paisley in 1874. *See* edition by D. Semple (1876) for details of his life; also Brown's *Paisley Poets* (vol. i., 1889).

TANNENBERG, BATTLE OF. No portion of the earth's surface has been more fought over than East Prussia. It was in 1410, on the field of Tannenberg, that the Teutonic knights were utterly routed by their enemies the Poles and Lithuanians, and the German victory of 500 years later was in some degree the reversal of this defeat.

The Tannenberg of 1914 was the greatest victory achieved by any of the combatants at the commencement of the World War, and its strategic and moral effect upon the struggle were far-reaching. France and Russia had been joined by military convention since 1892 and their chiefs of staff had made careful arrangements for concerted action. In case of war with the Central Powers it had been agreed that Germany was the main enemy and that the principal military effort must be made against her.

Owing to the vastness of her territory and to the comparatively undeveloped state of her railways, Russia's rate of concentration was considerably slower than that of France, so much so that there was a danger of the latter being crushed before the attack on Germany in the East could begin to exert its effect. Unfortunately, under the pressure of French insistence, the good will and optimism of Russia's military leaders exceeded practical possibilities and the outbreak of war found her military plans in some disorder. All their initial operations in East Prussia were in fact hasty improvisations.


BATTLE OF TANNENBERG

Geographically, East Prussia points forward into the heart of Slavdom and constituted a difficult problem of defence for Germany. True to her policy of concentration of force at the decisive point, she had decided to advance against France with her main forces whilst maintaining only a minimum of strength in the East. Not wishing to abandon national territory without a blow, she had decided to concentrate this minimum strength in East Prussia, despite the dangers involved in such action. Germany's strength in the East was to consist of 11 divisions, six first-line and five second-line, with but a single cavalry division.

Taking the East Prussian front as it appeared to the Russians, we can divide it militarily as follows:

(*a*) *Königsberg Area.*—A more or less fortified area extending over the Königsberg peninsula, of a depth of 19 m. from north to south. In the centre lay the obsolete fortress, strong against anything but heavy artillery. The area could be reinforced by sea through the canal from Pillau. It formed a strong flanking position from which to attack any force to the south.

(*b*) *Insterburg Gap.*—A gap of 43 m. of open country, down which ran the main Insterburg-Allenstein railway. The River Angerapp running north and south blocks this gap. It formed an excellent line of defence with the right flank resting against the impassable Lake Mauer.

(*c*) *Masurian Lakes.*—A line of continuous lakes from Angerburg to the Russian frontier at Johannisburg, a distance of 50 miles. The narrow gaps between the lakes could be held with few troops, and the whole line presented an almost impregnable front behind which the Germans could operate to either flank.

(*d*) *Johannisburg-Dzialdowo* (*Soldau*) *Front.*—A distance of 75 m. running east and west. On the Russian side the country had been left a desert as a defence against Germany.

The Russian Plan of Invasion.—The Russian plan for the invasion of East Prussia was to advance with two armies north and south of the line of lakes, with the object of enveloping the German forces supposedly concentrating behind this line. The northern army under Rennenkampf was to advance first, towards the Insterburg gap, with the object of drawing the Germans as far to the east as possible. The southern army under Samsonov was to advance to the line Rastenburg-Allenstein, with the object of striking the rear of the Germans opposing Rennenkampf.

Rennenkampf's army crossed the frontier on Aug. 17 with a strength of 6½ divisions and 5½ cavalry divisions. On the 20th an action was fought with the German VIII. Army at Gumbinnen. Prittwitz, the German commander in the East, had concentrated his main strength to meet Rennenkampf, six divisions and a cavalry division, whilst leaving some two divisions to face Samsonov's army, which was concentrating on the River Narew.

Rennenkampf had moved off without a great portion of his transport and found himself forced to halt on the 20th. Prittwitz advanced to attack him. There were serious miscalculations in the German movements, with the result that the action was indecisive, both sides suffering heavy losses. That evening the news arrived that Samsonov had not only started to advance, but that two of his corps were already close to the frontier and that he had at least five corps with him. The German commander abandoned all hope of defeating Rennenkampf on the 21st and contemplated a withdrawal to the Vistula. On communicating this on the telephone to the supreme command, he and his chief of staff were at once superseded.

The new commander, Hindenburg, had not yet been employed in the War. His chief of staff, Ludendorff, reached supreme headquarters at Coblenz on the 22nd and the situation in the East was explained to him. He immediately ordered the troops retreating in front of Rennenkampf to halt at once and to prevent him from pursuing, and issued instructions for a concentration against Samsonov. General Hindenburg joined Ludendorff's train at Hanover and took over the command at Marienburg on the 23rd.

Luckily for the new command, Hoffmann, the chief of the operations section under Prittwitz, had already carried out many steps facilitating the concentration desired by Ludendorff, and the situation, though alarming, had not grown worse since the supersession of Prittwitz. Samsonov's right was indeed well over the frontier near Ortelsburg and his left between Neidenburg and Działdowo (Soldau) but the Russian advance appeared to be slowing up. The German XX. Corps had taken up a position north of Neidenburg and was awaiting attack. The leading units of the I. Corps were detraining south of Deutsch Eylau and were moving up on the right of the XX. Corps. The 3rd Res. division had detrained at Allenstein and was moving up on the left of the XX. Corps. A Landwehr division and units from the Vistula garrison troops were also coming up. Thus, a strength of about six or seven divisions had been collected to oppose ten divisions and three cavalry divisions of Samsonov's army.

No decisive results could be expected from such strength, and decisive operations were the Germans' only hope. The most important feature of the situation, however, was that Rennenkampf had made no forward move since Gumbinnen and had lost all touch with the enemy in front of him. Ludendorff therefore conceived the idea of withdrawing all the troops from Rennenkampf's front, with the exception of the cavalry division, and of directing them against the right flank of Samsonov's army. Another four divisions thus obtained would give him an actual superiority over Samsonov and the direction of their attack might indeed be decisive.

An Account of the Battle.—Samsonov, who in peace time was the governor-general of Turkistan, had arrived from sick-leave in the Caucasus on Aug. 12. He had seen neither his subordinate generals nor his staff before, and his immediate superior Jilinsky, commander of the north-western front, was urging him forward to cross the frontier on the 19th. The original concentration areas of his army behind the Bobr and the Narew had been considered to be too far to the east and a general move of all corps to the west was in progress. By the 20th, the right wing (VI. and XIII. Corps) had reached the frontier, with the 4th Cav. Div. well behind on the right. The left wing (XV. and I. Corps) was just short of the frontier, with the 6th and 15th Cav. Divs. covering it. Of the XXIII. Corps, one division was two days' march behind the left wing and the other had not yet detrained at Warsaw. The troops had been marching for a week across the desert area north of Ostrołeka, over execrable roads in very hot weather. Much of the transport had been left behind, the men were tired and unfed and numbers had been much reduced by sickness. No contact had been gained with the enemy and the army was already more than 24 hours late in crossing the frontier. Reports from Rennenkampf of his victory at Gumbinnen and, during his advance westwards on the 24th and 25th, of the signs of a hurried retreat on the part of the Germans, brought further urgings from Jilinsky to Samsonov to hurry. Samsonov obeyed to the best of his ability, and by the morning of the 26th his position was as follows:—

His centre of two corps (XIII. and XV.) was advancing north-west and was close on the line Allenstein-Hohenstein. On his right was one corps (VI.) and the 4th Cav. Div. at Rothfliess, at two days' march from the centre. On his left was a corps (I.) and the 6th and 15th Cav. Divs. near Koschlau, at one day's march from his centre. The XXIII. Corps troops which were up were moving into the gap between the centre and the left. His forces were thus much dispersed.

Reconnaissance had been bad and he had little information as to the enemy's dispositions. He seems to have thought that the Germans flying in front of Rennenkampf had already crossed his front in their march to the Vistula and that he was too late to cut them off. He had deviated from his instructions to advance with his left on Allenstein and now had practically the whole of his force to the west of that town. He had no knowledge of the whereabouts of Rennenkampf's army and did not realize that he was increasing the space between the two Russian armies and thereby facilitating the German operations. His supply system had broken down utterly and his men were half-famished and worn out with the fatigue of excessive marching. The signal service had also broken down and orders had been sent out to corps by wireless. The Russian signals were easily read by the Germans, who thus had absolutely accurate information as to their opponents' dispositions and intentions.

Germans Attack Samsonov.—The new German Command had galvanized the dispirited VIII. Army from the first and hope of success ran high. The attacks on Samsonov's two flanks were to be launched simultaneously on the 26th. On the right, the German I. Corps, strengthened by the Vistula garrisons, attacked only half-heartedly. François, the commander of the I. Corps, was short of some of his heavy artillery and he contented himself with driving in some of the Russian outposts. On the 27th, however, he launched his attack in earnest. At dawn a hurricane bombardment was opened on the Russian I. Corps' positions on either side of Uzdowo. The famished Russians did not wait for the infantry attack but broke and ran. By 10 P.M. that night there was nothing left of the Russian left wing except a small rear-guard just north of Działdowo; and that too had disappeared before the next morning.

The rear of the Russian centre was now completely exposed and François directed his march on Neidenburg. Opposition there was none, and by the night of the 28th his leading troops had reached Muschaken, 8 m. E. of Neidenburg. By the night of the 29th the whole length of the road from Neidenburg to Willenberg was held by a line of entrenched pickets. The Russian retreat to the south was completely blocked. During the 30th François was attacked at Neidenburg by fresh Russian troops coming up from Mława and actually lost the town for a time. He held stoutly on to the line of his pickets, however, and on the 31st Neidenburg was reoccupied.

On the left, the German XVII. and I. Res. Corps, having turned their backs on Rennenkampf and marched due south, had arrived within striking distance of the Russian right at Rothfliess on the night of the 25th. Their attack on the morning of the 26th came as a complete surprise. The Russian VI. Corps withdrew in confusion, losing 6,000 men and 16 guns. By the night of the 27th the Russian right was 32 m. S. of Rothfliess and in a state of hopeless demoralization. The rear of the Russian centre was now exposed on its other flank. The German XVII. Corps continued its march to the south, whilst the I. Res. Corps moved in closer towards Allenstein. The story of the fighting in the Russian centre is not so inglorious as that on the two flanks. In accordance with Samsonov's plan the centre (XIII. and XV. Corps) continued their advance on the 26th towards the line Allenstein-Hohenstein. The XIII. Corps encountered no opposition, but the XV. had to fight its way steadily forward. For the 27th, the advance was to be continued.

Second German Blow.—Ludendorff, with his accurate information of the events on either flank, now decided that the German centre had retired enough. The reinforced XX. Corps was therefore ordered to attack on the 27th. The battle which ensued between the Russian XV. Corps and the German XX. Corps was particularly fierce, the Russians holding their own and even advancing a little on their left. The Russian XIII. Corps rendered no help to its neighbour. On the 28th the Germans renewed their attacks and this time the hardly-tried Russian XV. Corps commenced to break. The XIII. Corps, moving down to assist, found itself assailed in rear by troops arriving from Allenstein and for the second time brought no help.

When night fell the two Russian Corps were on a line from Grieslienen to Waplitz and in close touch with the Germans. Hoping to escape from pursuit, they commenced to withdraw during the night. The withdrawal soon became a rout, and a mass of troops and transport, both unfed and unwatered, became inextricably mixed in the depth of the Forest of Grünfliess. Determined attempts were made during the 29th to break through to the south of Muschaken and to the north at Kaltenborn, but the German ring held fast. Only some 2,000 men effected their escape. The greater portion of these two corps surrendered to the German parties clearing the forest during the 30th and 31st.

Samsonov himself had moved up to Neidenburg on the 27th in order better to control the battle. He was greeted with the news of the disaster to both his flanks and met streams of stragglers coming into the town. He decided to go to the headquarters of the XV. Corps and take personal charge, and left Neidenburg on the morning of the 28th with a small staff, all mounted on horses.

At once he became mixed in the mass of transport in the forest and could exercise no effective command. He then decided to ride to the south, but during the night of the 28th–29th he became exhausted after having walked for some distance. He drew aside in the darkness and his staff heard a single shot. A careful search brought no result and the staff continued their way, certain that their unfortunate commander had taken his own life in his despair at the turn which events had taken.

Results.—The practical result of the fighting from Aug. 26–30 was the total annihilation of two Russian corps and the reduction of three other corps to half their strength in numbers. The whole Russian II. Army was so demoralized and was so deficient in essential material, such as artillery and transport, that it was no longer of any fighting value. The Germans claimed 125,000 prisoners and 500 guns. It is certain that their booty was very great, for 60 train loads of captured material left Puchallowen after the battle and the captured horses were driven in herds to improvised camps at Neidenburg. Although greatly inferior in the whole eastern theatre, the Germans had yet managed to concentrate a superiority on the field of battle. The Russians had 132 battalions, 96 squadrons and 620 guns, including 12 heavy, whilst the Germans had 155 battalions, 48 squadrons and 818 guns, including 128 heavy.

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(W. E. I.)

TANNER, HENRY OSSAWA (1859–), American artist, of Negro descent, was born at Pittsburgh, Pa., on June 21, 1859. He was the son of Benjamin Tucker Tanner (born 1835), who became bishop of the African Methodist Episcopal Church in 1888. Henry Tanner was a pupil of Thomas Eakins, in Philadelphia, and of J. P. Laurens and Benjamin Constant in Paris. He first exhibited at the Salon in 1895. Examples of his work are in the galleries of the Luxembourg, Chicago, Des Moines, Los Angeles, etc. His "The Destruction of Sodom and Gomorrah" (1925) is in the Metropolitan museum, New York. He is a knight of the Legion of Honour, a member of the Paris Society of American Painters, of the American Art Association in Paris and of the National Academy of Design, New York.

TANNHÄUSER or TANHUSER, German Minnesinger of the 13th century, who lived for a time at the court of Frederick II., duke of Austria. After Duke Frederick's death he was received at the court of Otto II., duke of Bavaria; but he spent much time in wandering about Germany. He also went as a Crusader to the Holy Land. His poems belong to the decadence of the Minnesang, and combine a didactic display of learning with descriptions of peasant-life. His adventurous life led him to be identified, in the popular imagination, with the knight Tannhäuser who, after many wanderings, comes to the Venusberg, or Hörselberg, near Eisenach. He enters the cave where the Lady Venus—the Frau Hulda of German folk-lore—holds her court, and abandons himself to a life of sensual pleasure. By and by he is overcome by remorse, and, invoking the aid of the Virgin Mary, he obtains permission to return for a while to the outer world. He then goes as a pilgrim to Rome, and entreats Pope Urban to secure for him the forgiveness of his sins. The pope declares it is as impossible for him to be pardoned as for the staff he has in his hand to blossom. Tannhäuser departs in despair, and returns to the Venusberg. In three days the staff begins to put forth green leaves, and the pope sends messengers in all directions in search of the penitent, but he is never seen again. The legend has been reproduced by several modern German poets, and by Richard Wagner in the famous music drama.

For Tannhäuser's lyric poetry, *see* F. H. von der Hagen's *Minnesinger,* ii. (1838); K. Bartsch, *Deutsche Liederdichter des 12. bis 14. Jahrhunderts* (3rd ed. 1893), No. 47. *See* also F. Zander, *Die Tannhäusersage und der Minnesinger Tannhäuser* (1858); J. G. T. Grässe, *Die Sage von Tannhäuser* (1846; 2nd ed. 1861); A. Öhlke, *Zu Tannhäusers Leben und Dichten* (1890); J. Siebert, *Tannhäuser, Inhalt und Form seiner Gedichte* (1894).

TANNIN or **TANNIC ACID,** the generic name for a widely disseminated group of vegetable products, so named from their property of converting raw hide into leather (*q.v.*). They are soluble in water, and their solutions which have an acid reaction and an astringent taste, are coloured dark blue or green by ferrous salts, a property utilized in the manufacture of ink (*q.v.*). Some tannins appear to be glucosides of gallic acid, since they yield this acid and a sugar on hydrolysis, *e.g.*, oak tannin, whilst others yield protocatechuic acid and phloroglucinol, *e.g.*, moringa-tannin; common tannin, however, is a digallic acid.

Common tannin, or tannic acid, $C_{14}H_{10}O_9{\cdot}2H_2O$, occurs to the extent of 50% in gall-nuts, and also in tea, sumach and in other plants. It may be obtained by extracting powdered gall-nuts with a mixture of ether and alcohol. When pure the acid forms a colourless, amorphous mass, very soluble in water, less so in alcohol, and practically insoluble in ether. It may be obtained artificially by heating gallic acid with phosphorus oxychloride or dilute arsenic acid; and conversely on boiling with dilute acids or alkalis it takes up a molecule of water and yields two molecules of gallic acid $(HO)_3C_6H_2{\cdot}CO_2H$.

The tannin of oak, $C_{19}H_{16}O_{10}$, which is found, mixed with gallic acid, ellagic acid and quercite, in oak bark, is a red powder; its aqueous solution is coloured dark blue by ferric chloride. The tannin of coffee, $C_{30}H_{18}O_{16}$, found in coffee beans, is not precipitated from its solutions by gelatin. Hydrolysis by alkaline solutions gives a sugar and caffeic acid; whilst fusion with potassium hydroxide gives protocatechuic acid. Moringa-tannin or maclurin, $C_{13}H_{10}O_6{\cdot}H_2O$, found in *chlorophora tinctoria,* hydrolyses on fusion with caustic potash to phloroglucinol and protocatechuic acid. Catechu-tannin occurs in the extract of *Mimosa catechu;* and kino-tannin is the chief ingredient of kino (*q.v.*). Tannic acid is employed either alone or in conjunction with antimony salts as mordant in dyeing cotton with basic colouring matter.

Medicine.—Tannic acid is officinal in both the British and United States pharmacopoeias. It is incompatible with mineral acids, alkalis, salts of iron, antimony, lead and silver, alkaloids and gelatin. The British pharmacopoeial preparations are (1) *glycerinum acidi tannici;* (2) *suppositoria acidi tannici;* (3) *trochiscus acidi tannici.* The United States also has a *collodium stypticum* and an ointment. The intestine tannic acid controls intestinal bleeding, acting as a powerful astringent and causing constipation; it has been recommended to check diarrhoea.

Tannic acid is used in the treatment of various ulcers, sores and moist eruptions. The glycerin solution is used in tonsilitis and the lozenges in pharyngitis. For bleeding haemorrhoids tannic acid suppositories are useful, or tannic acid can be dusted on directly. The collodium stypticum is a valuable external remedy. Tannic acid is absorbed as gallic acid into the blood and eliminated as gallic and pyrogallic acids, darkening the urine.

TANNING, a term describing the conversion of natural skins into leather. The word *tan* means the bark of the oak, which contains tannin or tannic acid; this has the power to combine with skin-fibre and render it imputrescible. Modern tannage may be (1) vegetable tanning, *i.e.*, performed with the water extract of barks, woods, nuts, etc., containing tannin; (2) mineral tanning, principally with compounds of chromium or aluminium; (3) combination mineral and vegetable tanning; (4) oil tanning, *i.e.*, chamois leather. (*See* LEATHER.)

TANTA, a town of Lower Egypt, in a central position nearly midway between the two main branches of the Nile, and converging-point of several railways traversing the Delta in all directions. It has a population of 57,000, is the capital of the rich province of Gharbia, and is noted for its fairs and Muslim festivals, which are held three times a year and are sometimes attended by 200,000 pilgrims and traders.

TANTALUM, a metallic chemical element belonging to a family of three metals which includes vanadium (*q.v.*) and columbium (*q.v.*). It occurs in certain rare but widely distributed minerals usually associated with columbium. Columbite (Massachusetts), the native ferrous columbate, $Fe(CbO_3)_2$, and tantalite, ferrous tantalate, $Fe(TaO_3)_2$, frequently contain both columbium and tantalum with manganese partially replacing iron. Fergusonite is a complex columbo-tantalate of iron and the rare earth metals, samarskite has an even more complicated composition since it also contains uranium. It is accordingly not surprising that the history of tantalum is closely intermingled with that of columbium, some confusion having arisen formerly in regard to the separate identities of these closely allied metals. Struverite, a titaniferous tantalum ore ($TiO_2$46·0%, Ta_2O_5 36·0%) found extensively in Malaya, is a valuable source of both tantalum and titanium.

The first successful application of tantalum was as a filament for the incandescent electric lamp, but for this purpose it has now been superseded by tungsten.

Separation and Extraction.—Tantalum is extracted from the foregoing minerals by one of the following processes:—(i.) Fusion with potassium fluoride and extraction of the melt with dilute hydrofluoric acid. On evaporating the solution, potassium tantalifluoride, K_2TaF_7, separates first, as one part of this salt is soluble only in 155 parts of cold water, whereas potassium columbium oxyfluoride, K_2CbOF_5, H_2O, being soluble in 12–13 parts of water, is obtained on further concentration. (ii.) Alkali fusion with sodium peroxide, caustic potash or potassium carbonate and acidification of the melt with dilute hydrochloric acid, when on boiling, the oxides Cb_2O_5 and Ta_2O_5 are precipitated. (iii.) Fusion with potassium bisulphate, and extraction with acidified water, removal of tin and tungsten with ammonium sulphide and of silica and titania with hydrofluoric and sulphuric acids. Final neutralisation with ammonia and boiling with salicylic acid leads to precipitation of the two pentoxides.

Metallic tantalum was first obtained by Berzelius (1820) on heating potassium tantalifluoride with potassium; a more modern procedure is to reduce it in an evacuated electric furnace with either potassium or sodium. The product compressed and fused in the electric furnace with exclusion of air led to the pure metal (W. von Bolton, 1905). Moissan reduced the pentoxide with carbon in the electric furnace (1902). Other methods of obtaining the metal include electrolysis of the fused K_2TaF_7 or of tantalum compounds in dilute sulphuric acid.

Tantalum (symbol Ta, atomic number 73, atomic weight 181·5) is a white metal; its melting point is 2,850° C and its specific gravity 16·6. It is very ductile and malleable with considerable toughness. It may be drawn into very thin wires. Its tensile strength is greater than that of steel or platinum; its coefficient of expansion is less than that of the latter metal so that it may be sealed into glass. On heating, it absorbs large volumes of hydrogen or nitrogen and these gases are only removed by heating to fusion in a vacuum. It resists all single acids except hydrofluoric and hot concentrated sulphuric acids.

Applications.—Because of its resistance to corrosive agents tantalum may be used instead of platinum in standard weights and crucibles. Chemical apparatus in ductile tantalum, which is much cheaper than platinum, excels in its degree of resistance to acid corrosion. Metals may be deposited electrolytically on tantalum cathodes and since tantalum is not attacked by aqua regia the metallic deposit may be removed completely. Tantalum is claimed to surpass steel for surgical instruments and special tools, since these do not rust. It is used extensively as an electrolytic valve since it has the property shared with certain other metals of allowing electric current to pass in one direction only when immersed in acid. But unlike most metals, it is not subject to acid corrosion and hence it makes an ideal material for rectifiers and under the trade name of "Balkite" it forms the essential constituent of many rectifying units.

Compounds of Tantalum.—The pentoxide, Ta_2O_5, is a white infusible mass obtained by heating the metal in oxygen or by igniting tantalic acid.

Tantalic acid, $HTaO_3$, is a gelatinous precipitate obtained on adding water to tantalum pentachloride; it dissolves in aqueous alkalis to yield solutions of alkali tantalates, and is soluble in hydrofluoric acid to form tantalum pentafluoride (colourless prisms, m.p. 97°, b.p. 229° C). Addition of potassium fluoride to the pentafluoride solution gives potassium tantalifluoride which crystallises in needles. Solutions of tantalates furnish insoluble yellow tantalum ferrocyanide. Tantalum pentachloride, white hygroscopic needles melting at 211° C, and boiling at 241·6° C, is produced by heating the pentoxide to redness in a stream of chlorine and carbon tetrachloride. A suboxide (hypotantalic oxide) $(TaO_2)_x$, is a grey mass produced by heating the pentoxide with carbon, or magnesium; the corresponding sulphide, TaS_2, results from the action of hydrogen sulphide and carbon disulphide on the heated pentoxide.

Tritantalum hexachloride ("tantalum dichloride") Ta_3Cl_6, formed by heating the pentachloride with lead at 600° C, is extracted with hydrochloric acid and left as a green precipitate on evaporating *in vacuo*. Saturation of the extract with hydrogen chloride yields the green crystalline tritantalochloric acid $[Ta_3Cl_7,H_2O]H,3H_2O$. Acids of mixed type

$$[Ta_3Cl_6Br,H_2O]H,3H_2O \text{ and } [Ta_3Cl_6SO_4]H_2,$$

are obtained by the use of hydrogen bromide and dilute sulphuric acid respectively. In these compounds tantalum is bivalent, and analogous substances have been prepared containing bivalent molybdenum and tungsten (K. Lindner and others, 1924).

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(G. T. M.)

TANTALUS, in Greek legend, son of Zeus or Tmolus and Pluto (Wealth), daughter of Himantes, the father of Pelops and Niobe. He was the traditional king of Sipylus in Lydia (or of Phrygia), and was the intimate friend of Zeus and the other gods, to whose table he was admitted. But he abused the divine favour by revealing to mankind the secrets he had learned in heaven (Diod. Sic. iv. 74), or by killing his son Pelops (*q.v.*) and serving him up to the gods at table, in order to test their power of observation (Ovid, *Metam.* vi. 401); another story was that he stole nectar and ambrosia from heaven and gave them to men (Pindar, *Ol.* i. 60); a fourth that he was guilty of perjury (Antoninus Liberalis, 36). The punishment of Tantalus in the lower world was famous. He stood up to his neck in water, which flowed from him when he tried to drink of it; and over his head hung fruits which the wind wafted away whenever he tried to grasp them (*Odyssey,* xi. 582). This myth is the origin of the English word "tantalize." Another story is that a rock hung over his head ready to fall and crush him (Euripides, *Orestes,* 5). The sins of Tantalus were visited upon his descendants, the Pelopidae. Ancient historical reminiscences and natural phenomena, especially volcanic catastrophes, are at the bottom of the legend. The tomb of Tantalus on Mt. Sipylus was pointed out in antiquity, and has been in modern times identified by C. F. Texier with the great cairn beneath Old Magnesia; but Sir W. M. Ramsay inclines to a remarkable rock-cut tomb beside Magnesia.

The story of Tantalus is an echo of a semi-Greek kingdom, which had its seat at Sipylus, the oldest and holiest city of Lydia, the remains of which are still visible. There was a tradition in antiquity that the city of Tantalus had been swallowed up in a lake on the mountain; but the legend may, as Ramsay thinks, have been suggested by the vast ravine which yawns beneath the acropolis.

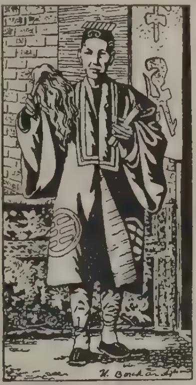
See PELOPS, PHRYGIA; Sir W. M. Ramsay in *Journal of Hellenic Studies,* iii.; Frazer's *Pausanias,* iii. p. 555; v., p. 392; J. Hylen, *De Tantalo* (Uppsala, 1896).

TANTIA TOPI (*c.* 1819–1859), rebel leader during the Indian Mutiny, was a Mahratta Brahman in the service of Nana Sahib. He instigated the massacre of Cawnpore, and commanded at the battle of Bithur, where he was defeated by General Havelock. With the aid of the Gwalior contingent he pressed General Windham hard at Cawnpore on Nov. 27–28, 1857, but was defeated by Sir Colin Campbell on Dec. 6. Together with the Rani of Jhansi he was besieged by Sir Hugh Rose in the Jhansi fort, but escaped and collected a force of 20,000 men which Sir Hugh defeated without relaxing the siege. This was the decisive action of the campaign in Central India, and Tantia Topi was obliged to seek refuge in the jungles of Rajputana and Bundelkhand, where he was taken by Major Meade, condemned and executed on April 18, 1859. He was the only rebel leader in the Mutiny who showed any conspicuous military ability. (*See* INDIAN MUTINY.)

TAOISM. The term Taoism has two meanings: (1) the philosophical system attributed to Lao Tzu (b. 604 B.C.) and Chuang Tzu (b. 330 B.C.); (2) the popular religion of the Chinese.

Taoism as a Philosophical System.—The term Tao originally meant the revolution or the way of the heavens about the earth. This movement of the heavens was regarded as the cause of the phenomena on earth. The Tao was located about the celestial pole, which was considered to be the seat of power because all revolves about it. In the course of time this concrete expression became abstract, and the Tao was viewed as the universal cosmic energy behind the visible order of nature. This cosmic energy regarded as *being* is impersonal, omnipresent and eternal; viewed as *becoming* it works spontaneously, orderly, unselfishly and continuously for the highest good of all beings.

The Tao produced the *yin* and the *yang*, the negative and the positive, female and male principles of nature. These by their interaction brought forth heaven and earth. Heaven and earth gave birth to all beings. The human order is the product of the eternal energy.



TAOIST PRIEST IN FULL COSTUME, CANTON, CHINA

Philosophic Aspect.—Taoism has usually been regarded as a mystic religion, but it was also an economic and political philosophy. It advocated frugality, simplicity and the joys of the peasant life in contact with the soil. It opposed the educational programme of the Confucianists, and advocated the theory that the people should be kept in innocence (not in ignorance). The Taoist philosophy is responsible for that remarkable trait of the Chinese, namely, their contentment in situations which offer a minimum of comfort and their prizing of culture above possession.

Political Aspect.—In politics Taoism opposed a highly centralized government and favoured the maximum autonomy for the people. Lao Tzu and his successors promoted the small village state which enjoyed full autonomy and lived in harmony with its neighbours. All forms of bondage and legal restraints were opposed. Non-resistance was exalted and militarism was condemned.

The ethics of Confucianism met with the strongest opposition on the part of the Taoists. Such virtues as love, justice, reverence, wisdom and sincerity were regarded as the first steps departing from the harmony of the simple life in the Tao, and producing the distracting contraries which marred the purity of life.

The Taoists were mystics, but they were practical mystics, who hoped to realise the best social order through a harmonious relationship with the Tao. Their ideal was "this worldly." Their mysticism had three stages: (1) the purgation, casting out selfishness and self-seeking; (2) union with the Tao, by which the individual lost his individuality with the distraction of the contraries; (3) power, which enabled the individual merged with the Tao to escape the limitations of time and space.

Taoism as a Religion.—Taoism as a religion is inherent in Taoism as a philosophy. The early mystics practised breathing and abstaining from food, and sought longevity and a future life in the Taoist paradise. The religious aspect did not become prominent, however, until the Han dynasty (206 B.C–A.D. 221), when the Taoists occupied themselves in compounding the elixir of life and in making journeys to the Isles of the Immortals. They also developed several sects which practised exorcism and fortunetelling and exercised considerable political power.

The rise of Taoism as a church is attributed to Chang Tao-Ling (b. A.D. 34), who developed a high degree of magic power which he transmitted to his heirs, together with the political prestige which reputation for such power brought. These took part in a successful rebellion in the latter part of the 2nd century, and established a state in Szechuan based on Taoist principles. The descendants of Chang Tao-Ling were recognized by the Government and in 1016 were given a fief at Lung Hu Shan in Kiangsi Their function consisted of a general oversight of the Taoist priests and monks and the rule over the world of the gods. The system developed a hierarchy among the gods which corresponded to that of the government of China. At the head was Yü Huang Shangti, the Pearly emperor, who presided over an elaborate pantheon.

Buddhist Influence.—Through contact with Buddhism in the first six centuries of our era the Taoists appropriated the Buddhist world view, adopted the monastic system and imitated the Buddhist pantheon. Lao Tzu was deified and was associated with Pan Ku and Yü Huang Shangti in the Taoist Trinity patterned after the Three Jewels of Buddhism. Present-day Taoism is a conglomeration of animism, polytheism and magic.

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(L. H.)

TAORMINA, a town on the east coast of Sicily (ancient *Tauromenium*), in the province of Messina, from which town it is 30 m. S.S.W. by rail. Pop. (1921) 4,980. It is a favourite winter resort, chiefly on account of its fine situation and beautiful views. It lies on an abrupt hill 650 ft. above the railway station, and was occupied at least as early as the 8th cent. B.C. (as the discovery of a Sicel cemetery of that period shows). It was refounded by the Carthaginian Himilco in 397 B.C., after the destruction, by Dionysius the Elder of Syracuse, of the neighbouring city of Naxos. In 392 Dionysius occupied it and settled his mercenaries there. In 358 the exiles from Naxos at last found a home there. It was the city at which both Timoleon and Pyrrhus first landed. During the First Punic War it belonged to the kingdom of Hiero, and after his death it was allied to Rome. During the first Servile War it was occupied by Eunous and some of his followers, but was at length taken by the consul Publius Rupilius in 132. It was one of the strongholds of Sextus Pompeius, and after defeating him Augustus made it into a *colonia.* In the time of Strabo it was inferior in population to Messana and Catana; its marble, wine and mullets were highly esteemed. In A.D. 902 it was taken and burnt by the Saracens; it was retaken in 962, and in 1078 fell to the Normans.

The ancient town perhaps had two citadels; one the hill above the town to the W., now crowned by a mediaeval castle, the other the hill upon which the theatre was afterwards constructed. There are some remains of the city walls. The church of San Pancrazio, just outside the modern town, is built into a temple of the 3rd century B.C., dedicated to Serapis, the south wall of the cella of which is alone preserved. The other ruins belong in the main to the Roman period. The theatre, largely hewn in the rock, is of Greek origin, but entirely reconstructed. The stage and its adjacent buildings, especially the wall, in two storeys, at the back, are preserved. The view is of exceptional beauty, Mount Etna being seen from the summit to the base on the south-west, while to the north the rugged outlines of the coast and the mountains of Calabria across the sea to the north-east make up one of the most famous views in the world. There are also remains of a much smaller theatre (the so-called Odeum), and some large cisterns; a large bath or tank which was apparently open, known as the Naumachia, measures 426½ ft. in length and 39½ in width. There are remains of houses, tombs, etc., of the Roman period, and fine specimens of Romanesque and Gothic architecture (notably the Palazzo Corvaia) in the modern town.

See Rizzo, *Guida di Taormina e dintorni*, Catania, 1902.

TAPACULO, the name given in Chile to a bird (*Pteroptochus albicollis*) and applied in an extended sense to its allied forms, which constitute a small Passerine family, *Pteroptochidae*, peculiar to South America. About 20 species are known.

The true tapaculo (*P. albicollis*) has a resemblance to the females of some of the smaller shrikes (*Lanius*), but differs in its shortened wings and powerful feet. It rarely flies, hops actively on the ground or among bushes with its tail erect, and continually utters various and strange notes—some, says Darwin, are "like the cooing of doves, others like the bubbling of water, and many defy all similes." The Turco, *Hylactes megapodius*, is larger, with greatly developed feet and claws, but is very similar in colour and habits. The Turco is distributed through central and northern Chile.

TAPANULI, a residency on the west coast of Sumatra, D. E. Indies, area, 38,227 sq.km., bounded north by Achin, east by the government of the East Coast of Sumatra, south by the residency of Sumatra West Coast, and west by the Indian Ocean. It is very mountainous, but has flat stretches of alluvial land on the coast between spurs of the great central range of mountains which traverses the length of the residency from north to south and forms a great massif from the centre of the residency to its eastern border which includes the mountain lake Toba, along the eastern shore of which the Tapanuli boundary runs. This lake, regarded as holy, was not seen by a European until 1863 (van der Tuuk). Previous attempts to reach it met with disaster, three Frenchmen and two Americans being murdered on their way to it, in 1835, while, in 1850, Ada Pfeiffer was obliged to turn back on account of native hostility. The lake, which is 3,000 ft. above sea level, is 56 m. long, with an area of 23 sq.m. and a greatest depth of 1,500 feet. It has a large hilly island, Samosir, in the centre, divided from the mainland on the west by a narrow channel. It is bordered on all sides by steep rocks, overhung with vegetation, and surrounded by mountains, and affords magnificent views. A good motor road runs to it from the coast, and there is a road around the lake from Balige to Prapat. There is also a motor boat service.

The mountains of Tapanuli include Malea, in the south, 6,545 ft., Ulu Darat, in the centre, 7,010 ft., and Sibutan, on the northeastern border, 7,972 ft. Small rivers flow westwards from the mountains to the sea, the Gadis, Turu and Sibundong, but they are almost useless for navigation. The coast is either rocky or marshy, but in Tapanuli Bay, which is surrounded by mountains and shut off from the effects of the south-west monsoon by Morsala Island, there is a good harbour with secure anchorage. Cultivation is confined to the valleys and the flat coastal strips, where maize, rice, coco-nuts, coffee, nutmegs and rubber are grown. Gold and silver are known in close association. Pop. (1927) 895,416, largely Batak. The inhabitants consist of Mohammedans and Christians, whilst many remain pagans, with traces of Hinduistic practices mingled with their animism. (*See* SUMATRA.) They grow rice, coffee, tobacco and maize, also fruit and vegetables, and keep horses, cattle, pigs and buffaloes, build picturesque houses, are patriarchal in society, and are good craftsmen in wood, ivory and copper, whilst the women weave their own clothes. Cannibalism has been shed, and as the country becomes more opened up the Bataks become more amenable to outside civilizing influences. They have many languages.

The capital and chief port of Tapanuli is Sibolga, pop. 5,822, the headquarters of the Resident, which is connected by road with Lake Toba and the interior generally, and, by the road round the southern end of Lake Toba, with Pematang Siatar, the terminus of the Sumatra West Coast railway, giving access to Medan and Belawan on the coast. A road through the Padang Highlands connects Sibolga with Padang, and a branch from this leads to Natal, a small port on the coast, in the south, whilst there is road connection between Sibolga and Barus, a small port in the north, connected by cable and overhead telegraph with Padang, and, by vessels of the Royal Packet Navigation Company between Barus, Sibolga, Natal and Padang, Bencoolen and Batavia. Exports (1926), were 14,899,537 and imports 5,072,923 guilders. Tapanuli was annexed piecemeal by the Dutch during the nineteenth century.

TAPE MACHINE: *see* TICKER.

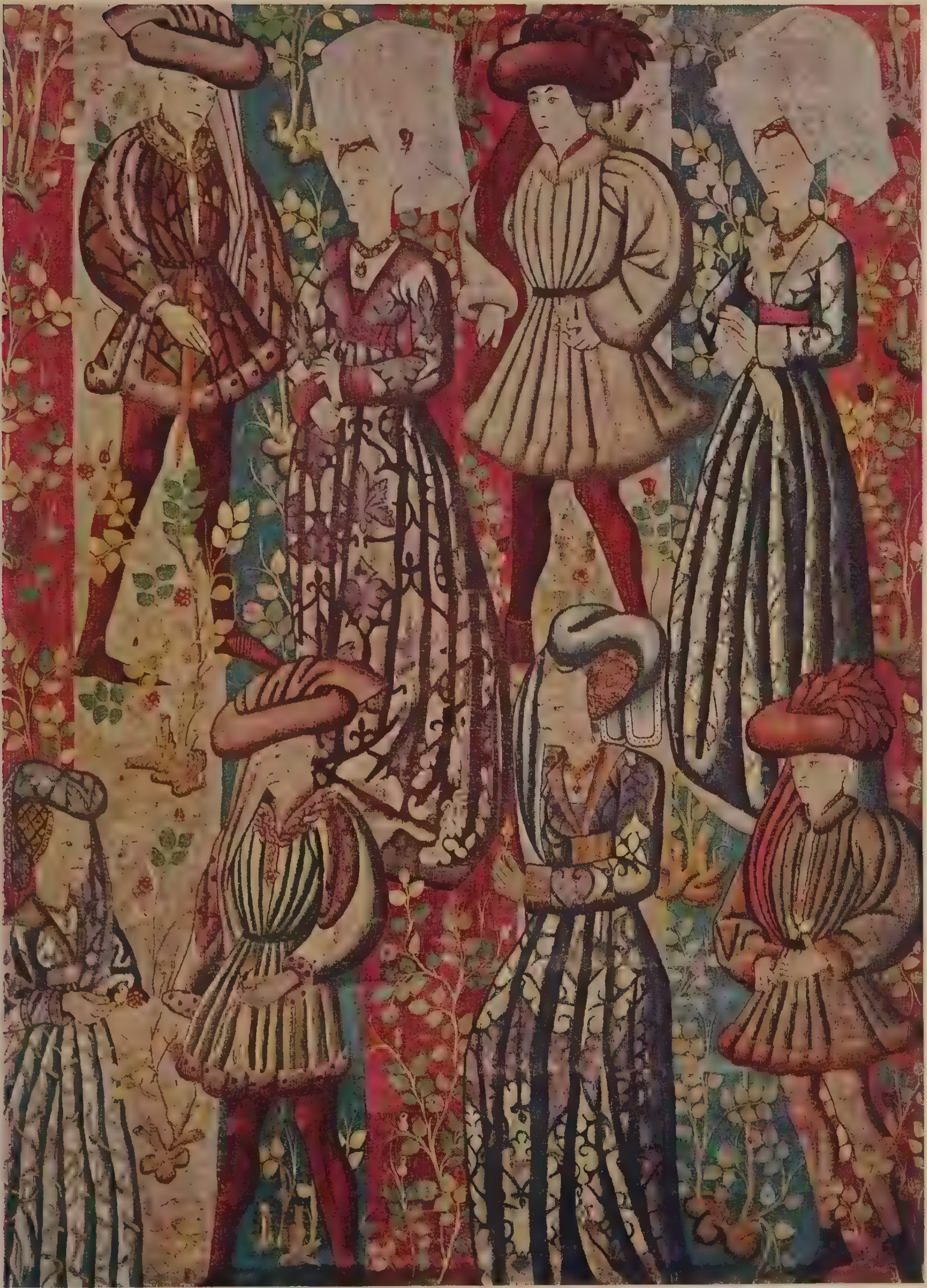
TAPESTRY, a term that came to be applied, in English, to stout woven materials of various kinds for hangings, curtains, coverings and upholstery. The word is also heir of the term "arras," so called from the city in Flanders, but has gained a technical meaning of its own. It is in this latter sense that the word is to be used in this article. Much that used to be called tapestry is not included, while everything that was formerly called arras comes within its scope. The differentiation between tapestry and arras continued into the 17th century. George Herbert, in *The Temple* (1633), writes of "the cloth of State . . . not of rich arras, but mean tapestrie." The elimination of the word "arras" and the assumption of its meaning by "tapestry" was accomplished gradually during the 18th century.

Origin and Method.—Tapestry is a fabric woven by a primitive and very simple method. Whether the invention took place in one locality, thence becoming known throughout the world, cannot be decided from existing evidence. It is found in early times in places so far apart as Peru, Egypt and China and this is a good reason for the assumption that so obvious a method of weaving threads into a texture came naturally, wherever primitive mankind took to weaving at all. There is no simpler way of passing threads across one another, over and under, so as to form a coherent texture. It is really on account of this essential simplicity that it came to be used for the large and elaborate pictorial hangings which come first to the mind when the word "tapestry" is mentioned. The method is pliable in the hands of the worker, who is freed from the limitations of the power-loom. In the latter, the exact repetition of the design follows as naturally as the multiplication of copies of a printed book, while there is no more reason why tapestries should be alike than why paintings should be.

Like other woven fabrics, tapestry consists of warp and weft threads. The warp is the series of parallel threads set out on the loom to the width of the fabric. In some forms of primitive weaving, not yet entirely out of use in remote districts, these warps were hung from a beam, with a weight attached to the lower end of each separate thread to keep it relatively taut during the weaving process. A well-known representation of this form of loom is on a Greek vase from Chiusi, painted with a scene from the *Odyssey* in which Penelope delays her suitors by working at the loom, during the absence of Ulysses. The first step forward in method was that of securing both ends of the warp by stretching them across a rectangular frame. With the subsequent addition of a simple contrivance for pulling forward the threads in succession in order to pass the weft through behind, the tapestry-loom was perfected for its work. This frame or loom, with its parallel row of warp threads, is placed for weaving either upright, when it is known as "high-warp," or horizontally (low-warp) with the threads running directly away from the weaver. The former is the better method though the results in each case are approximately the same. Low-warp weaving is about one-third quicker, and the cost is usually about one-half that of high-warp tapestry.

The weft threads, which form the pattern, are inserted by hand, alternately over and under the warps, generally with the aid of a wooden bobbin, a pointed peg-like implement round which the thread is wound. This is the special feature of tapestry-weaving; there is no shuttle passing backwards and forwards right across the fabric, but the threads are only inserted to cover the particular space for each colour as required by the design. Thus a tapestry may be compared to a mosaic. In the large tapestry hangings of Europe the warps may be as few as ten to the inch, or as many as 30; in the majority of cases there are less than 20. The higher figure is often exceeded in the fine work such as the Chinese and the Egyptian.

Materials and Colours.—The high-warp weaver sits at the back of his loom, with the cartoon to be copied placed conveniently near him. A mirror hung before the warp on the other side enables him to gauge the effect as the work goes forward. The loose ends of the warp at the start and finish of each patch of colour are pulled through to the side at which he works, and are thus left to hang at the back of the finished fabric; otherwise back and



BY COURTESY OF THE METROPOLITAN MUSEUM OF ART, NEW YORK

FRANCO-FLEMISH TAPESTRY

"Courtiers with Roses," the second of a set of three tapestries made towards the middle of the 15th century, perhaps at the order of Charles VII. It is woven of wool in a coarse texture of about 12 warps to the inch. The tapestry, which recalls the paintings of Jean Foucquet, has great decorative qualities. Since its exhibition at the Louvre in 1904 it has been recognized as one of the most important tapestries of its period. It was purchased in 1909 by the Metropolitan Museum of Art, New York.

front are approximately alike. The wefts are inserted loosely and afterwards pressed down by an instrument like a comb, the teeth of which are thrust between the warps and beaten down until those threads are entirely covered by the wefts. The bobbins on which the threads for the weft are wound are usually pointed at one end, to serve on occasion the same purpose as the comb. The warp is a strong thread, generally of wool, linen or cotton. The weft is mostly of wool, silk or metal threads, and in elaborate work it is often of all three. The weaver does much, almost everything, to make or mar the beauty of a tapestry, but the cartoon he copies is seldom his own work. At Brussels a regulation in the 15th century debarred the weaver from designing anything more than accessory details. The cartoon is usually prepared by an artist specially qualified by training and experience. He may, and often does, base his work on a design by another artist. Quite frequently paintings, illuminations, drawings or engravings not originally intended for reproduction in tapestry are used as the basis of the cartoon. Whatever may be the size of these models the cartoon is approximately of the size the tapestry is to be; it is generally painted on paper, though linen appears to have been more usual in the middle ages. The main outlines of the design are traced upon the warps, but the weaver must constantly refer to the cartoon for guidance as he proceeds. It was not at all unusual for weavers to duplicate their work, or to copy existing sets of tapestries made by others. Among the weavers of Brussels in the 16th century copying each other's work was forbidden, but any restriction of this kind was local and exceptional.

The colours used for a simple pictorial subject may be as few as 12, and mediaeval tapestries seldom have more than 40. In early tapestries, gradation of tints was rendered by running one into another in projections like the teeth of a comb, or in cruder fashion by rings of colour comparable to the colouring of a contour-map. The method, introduced at a later time, of imitating the fusion of tones in a picture has led to the use of a large number of intermediary tints. The employment of a large or small number of tints, or of a fine or coarse texture does not necessarily affect the beauty, but only the character, of the finished fabric. When the painter Oudry, as inspector of the Gobelins factory in the 18th century, insisted on the imitation of the oil-colours of the painter's palette, in place of the *coloris de tapisserie* proper to the method, the number of tints had to be multiplied enormously, until the weaver had more than 10,000 different tints at his disposal. The increase in the number of tints employed has not been the only change brought about with the lapse of time. At first each colour was shaded with deeper tones of its own colour, and high lights were white. This simple method, resembling that of book-illumination, is productive of the most beautiful effects. At a later time yellow becomes the dominant colour, giving a unity recalling that often provided by the varnish on a picture. When gold and silver thread are freely used for salient points the limit of splendour is reached, but not without some sacrifice of true tapestry-effect.

Almost incredible pains were sometimes taken to see that materials and workmanship were of the best. Regulations were framed to this end, and the penalties for infringement were severe. Distinguished artists were engaged to watch the progress of the work. In the case of a set of tapestries woven at Brussels to commemorate the conquest of Tunis by the emperor Charles V. there were stipulations controlling the kind of thread to be used, and the proportion of metal thread to wool and silk. The emperor provided the gold and silk threads, and his agent spent more than two years at Granada supervising the preparation and dyeing of the silk. Eighty-four weavers were to be continually employed on the 12 panels, and a commission was appointed to superintend the work.

Early Examples.—The earliest specimens of tapestry-work which can be accurately dated were found in the year 1903 in the tomb of Thutmosis IV. (1420–1411 B.C.) at Thebes. They are now in the Cairo museum. There are three small examples, woven in coloured linen threads. One has the cartouche of Amenhotep II. (*c.* 1450 B.C.), and another that of Thutmosis III. (*c.* 1500 B.C.) inwoven in colours.

The skill shown in these very remarkable weavings points to a far older tradition, and though at present no other examples are known for 1,000 years after, there can be no reasonable doubt of continuity in the process of tapestry-weaving. The next examples about which we have certain knowledge are some fragments of garments found about 1872 in some Greek graves near Kertch in the Crimea, and now in the Hermitage museum at Leningrad. They are woven in coloured wools. One has a pattern of stags' heads and ducks, and another has rows of blossoms; the rest are mostly striped or plain. Two of the graves in which these specimens were found are of the 4th or 3rd centuries B.C.

Reverting to Egypt, after a gap of fifteen or sixteen hundred years from the date of the examples already mentioned, tapestry-weavings became abundant. Indeed there is much to confirm the theory that in the Graeco-Roman period, during the first few centuries of the Christian era, this was the principal method employed to produce a pattern in woven stuffs. Some examples are woven entirely by the tapestry-process, and among these a few are of a size and scale which warrant comparison with the tapestry-hangings of later days. One hanging found in a burying ground at Akhmîm on the Nile, and now in the Victoria and Albert Museum, has a pattern of birds and foliage on a red ground. The majority of the specimens from Egypt are panels and bands of ornament forming a continuous texture with the linen stuffs which provide the warps for the woollen tapestry-weaving. Examples preserved in the museums of Europe and America show a wide range of patterns of classical and early Christian origin. The method of weaving was continued in the Mohammedan period, from the 7th century onwards, when silk came into common use for the tapestry patterns, which are often of great fineness and elaboration.

It is beyond doubt that tapestry-work was done by the Romans, though no specimens have been found on Italian soil. In fact, but for those from Egypt, practically nothing of ancient Roman textile art has come down to our times. The Byzantines, too, were acquainted with it. A fine silk tapestry-hanging with an equestrian portrait of an emperor of the East was found in the tomb of Bishop Gunther, who died in the year 1064 on his way home from an embassy to Constantinople and was buried, enwrapped in this hanging, in Bamberg cathedral.

The Low Countries.—Tapestry weaving enters on a new phase, and one which reduces all others to relative insignificance, in the work of the Low Countries. How this great industry first arose there we do not precisely know, but it has been conjectured that the election of Baldwin of Flanders as emperor of the East in the year 1204, may have familiarized the Flemings with Byzantine work like that brought home by Bishop Gunther. However this may be, little more than the bare idea can have been derived from any outside source. The industry as it developed was characteristically Flemish, and in its turn it exerted a very wide influence upon the rest of Europe. The distinction between high-warp and low-warp tapestry-work, which now becomes significant, is first met with in the Low Countries at the beginning of the 14th century. To that time, or perhaps a little earlier, may be traced the origin of those large pictorial tapestries which soon brought the weaver into successful rivalry with the painter in the decoration of churches, halls, palaces and dwelling-houses. In the dukes of Burgundy, who acquired the Flemish provinces by marriage in the 14th century, the weavers found patrons of almost unlimited wealth and luxury. Arras was the first place to rise to fame. Its high-warp tapestry is mentioned in the early years of the 14th century, and the city gave its name to tapestry-work in England, as we have seen, as well as in other countries whither the tapestries of Arras were sent. By about the middle of the 15th century the pre-eminence of Arras was disputed by Tournai, but it is significant that the series of tapestries with scenes in the lives of SS. Piat and Eleutherius were woven at Arras for the cathedral of Tournai in the year 1402. During the course of the century the dukes of Burgundy gave large commissions to the weavers of Tournai, and near its close Pasquier and John Grenier obtained permission to import tapestries into England.

In the year 1477 Arras was captured by Louis XI. of France, and the industry which had brought the city so much fame suffered a check from which it never recovered. Among other centres of tapestry-weaving were Audenarde, Bruges, Douai, Enghien, Ghent, Lille and Valenciennes, but Brussels began to take the place that Arras had lost, and from the early years of the 16th century until the end of the 18th it was the leading tapestry-weaving centre in the Low Countries. In the year 1528 an enactment required that all tapestries above a very moderate size woven at Brussels should bear the distinctive mark of the town as well as that of the maker. The former was a shield with a B on either side. The maker's mark was generally a monogrammatic device not easy to decipher and often impossible to identify, as the local records have perished. In later times the separate initials or the full name are often given. In the absence of definite records it is not easy, and often impossible, to distinguish the work of one factory from another, but as the example of Brussels in the use of a distinctive mark was shortly followed by all other factories of the Low Countries, clues to a classification were provided. Difficulties do not end entirely at this stage, since the selvedges, where the marks were placed invariably at first, and usually at a later time, are not often intact in tapestries of the 16th century.

The best known and the most frequently repeated of the tapestries woven at Brussels was the famous set of the "Acts of the Apostles," designed by Raphael for Pope Leo X., and woven at Brussels by Peter van Aelst during the second decade of the 16th century. When hung in their destined position round the walls of the Sistine chapel of the Vatican, they evoked the greatest enthusiasm. Another set woven shortly afterwards and now in the Berlin museum is believed to be the set given by the pope to Henry VIII. of England, and sold with the effects of Charles I. Numerous other repetitions were woven at Brussels, and afterwards they were copied at Paris and Beauvais. There were originally ten subjects. In the year 1630 seven of the cartoons (presumably three had perished) were bought by Charles I. of England, on the advice of Rubens, to be reproduced in tapestry at the factory at Mortlake established not long before, and many sets were woven there in subsequent years.

Bernard van Orley, the follower and imitator of Raphael, also designed subjects for the weavers of Brussels. He was succeeded by a number of lesser-known artists of the Netherlands. In the 17th century, Rubens was engaged to make numerous cartoons, and his example was followed by Jacob Jordaens and other contemporaries. A little later the works of Teniers were very frequently copied. During the 17th century the factories of Brussels were busily occupied, but towards the end of that period the rise of the Gobelins factory at Paris, and in the 18th century the growing use of wall papers, exerted a pressure which was severely felt. It is said that early in the 18th century the number of weavers was hardly more than one-tenth of those employed a century before, and during the course of the century there was a further decrease until at the last one atelier alone remained, that of Jan van der Borght. In the year 1794 this too was closed, and the industry which had given distinction to Brussels for three centuries came to an end. During the greater part of this time its prestige in the Netherlands was hardly disputed, yet other factories had a career of fluctuating prosperity. An edict of the Emperor Charles V. in the year 1544 shows that tapestries were then being woven at Brussels, Louvain, Bruges, Audenarde, Alost, Enghien, Binche, Ath, Lille, Tournai and a few other places. Antwerp is also mentioned, but the extent to which tapestries were actually made there is uncertain. The city had then taken the place of Bruges as the chief *entrepôt* of commerce in the Netherlands, and a gallery was provided for the display of tapestries on sale. Henry VIII. of England had his agents there, ostensibly for the purchase of tapestries, but actually in search of political intelligence. English agents were again there at the end of Elizabeth's reign. Large numbers of tapestries were sent from Antwerp to Spain, where Flemish tapestries were much in demand. In the collections of the Spanish Crown at the present time there are 422 of them.

The range of subjects covered by the tapestries of the Low Countries can only be indicated here in the briefest outline—legends of antiquity (*e.g.*, the Trojan war; the adventures of Ulysses; Romulus and Remus); scenes from ancient history (the life of Alexander; Julius Caesar); stories of the gods (Apollo, Diana, Vulcan, Venus, Hercules); the Old and New Testament (from Genesis to Revelation); the lives of saints (innumerable); the legends of chivalry (Charlemagne); mediaeval histories and allegories (the story of Herkinbald; Petrarch's *Triumphs;* the months; the seasons); contemporary history (Charles V.'s conquest of Tunis; adventures of João de Castro, viceroy of the Portuguese Indies); scenes of peasant life (Gombaut and Macée; subjects after Teniers); sport (hunting, archery); heraldry, landscapes, verdures and decorative panels. Some of these were newly designed from time to time (for example, the life of Alexander is found in the 14th, 15th, 16th, 17th and 18th centuries), but many were reproduced again and again from old cartoons or tapestries. In instances of the latter kind, the borders are more characteristic of the period of production.

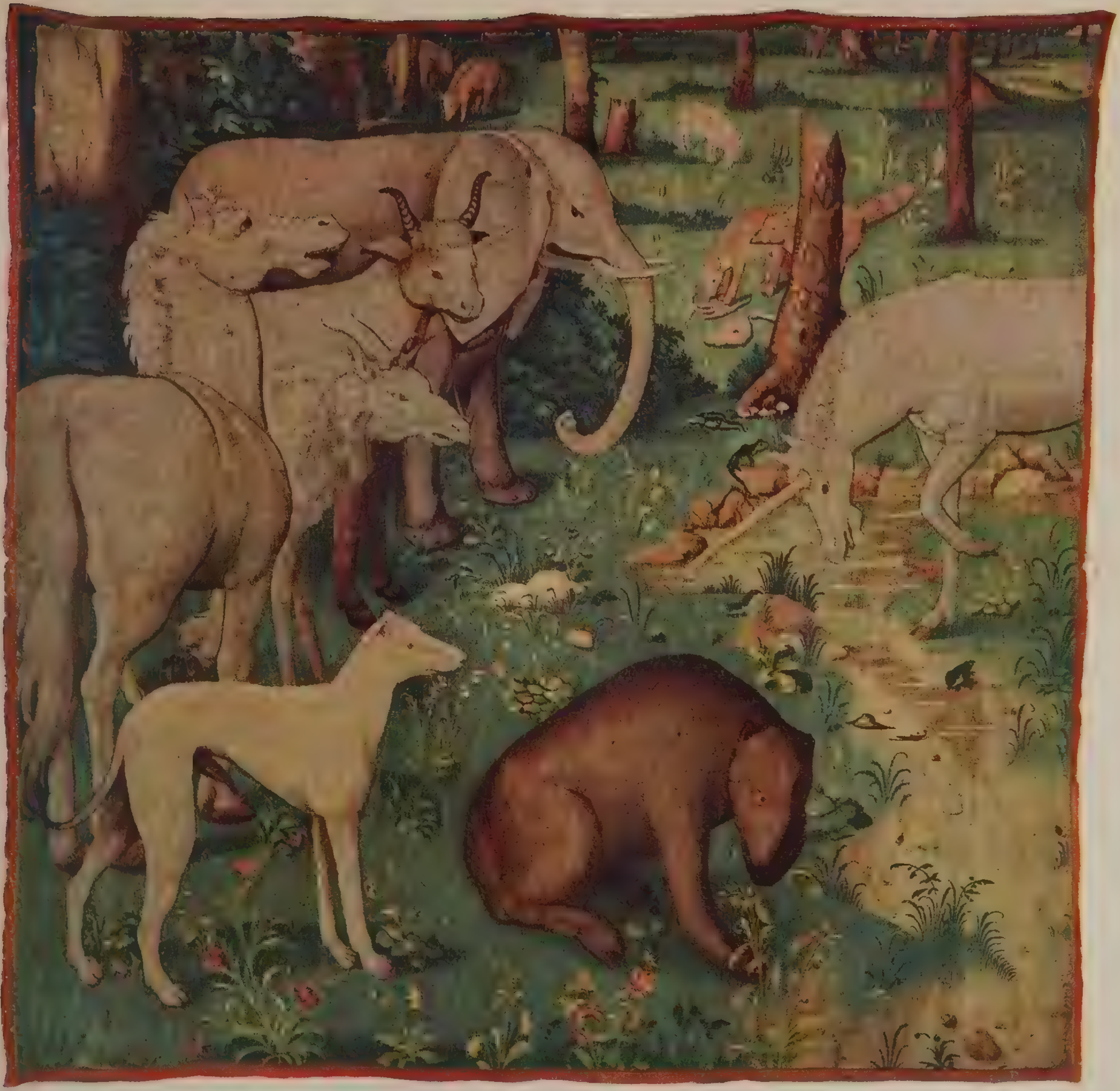
It is not uncommon for early tapestries to be divided up by Gothic pillars and arches after the fashion of a mediaeval folding altar-piece. Sometimes scrolls with explanatory inscriptions run along above and below the scenes. In the latter part of the 15th century a narrow band filled with sprays of flowers began to be used. As the 16th century advanced this inconspicuous border was first elaborated by the addition of ribbons, masks and similar accessories, and then it was widened to include canopies, figures, animals and birds. By the 17th century the border sometimes comes near to being the dominant feature, with historical and emblematical themes, landscapes, heraldry and drapery, or it is architectonic, with base, supporting columns and entablature, enriched with sculpture. In the 18th century the borders tend, as a general rule, to become narrower again; the imitation of oil-paintings imposed upon the weavers by Oudry and his school led to the representation of moulded and gilt picture-frames as borders. Occasionally there was no border except the plain narrow selvedge, the place of the border being supplied by wood panelling, or other architectural framework.

Tapestries were freely displayed indoors and out of doors at coronations, church festivals, pageants and processions, and on all occasions of ceremony. For domestic purposes they were often carried with the movable household goods as the family migrated during the course of the year from one habitation to another, to enliven the walls, or to be hung on tenter hooks left permanently in the rafters of large halls to facilitate convenient division into smaller apartments when occasion required.

Flemish weavers early took to wandering abroad to places where special inducements were offered for earning a living, and few countries in Europe where tapestry weaving was carried on were able to claim that they owed nothing to such immigrants. Several arrived in England as early as the 14th century, and a high-warp weaver of Arras was met with even in Hungary by a traveller in 1432.

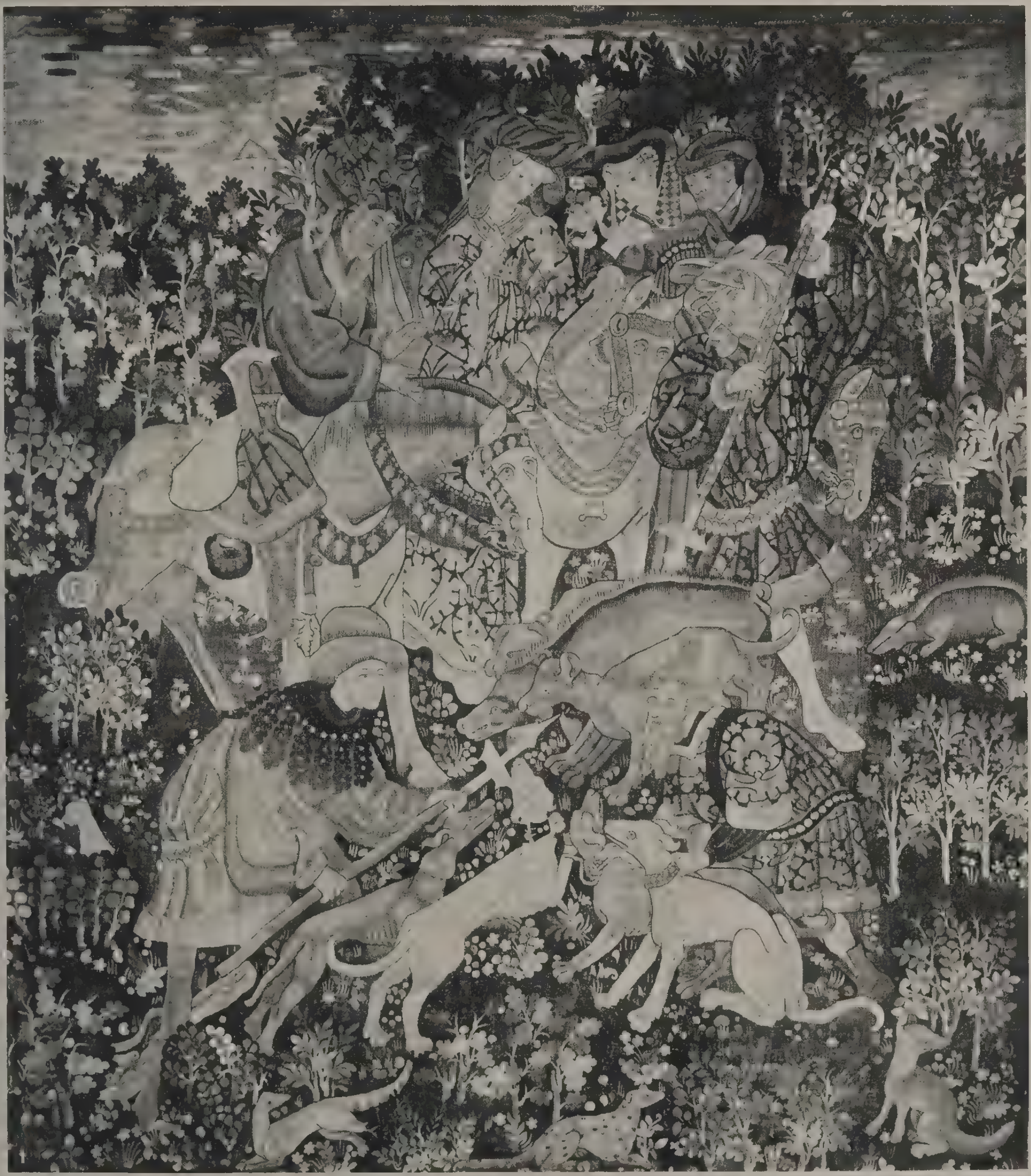
France.—France is linked closely with Flanders in the beginnings of its tapestry-weaving industry. The associations of the two countries were intimate, both geographically and politically. Arras, the most famous tapestry-weaving centre of all, passed from one country to the other in the 15th century. Moreover the dukes of Burgundy, who ruled Flanders with such splendour from 1363 to 1477, were members of the royal house of France. High-warp weaving is numbered among the crafts followed in Paris as early as the year 1302, but it is unsafe to assume without question that tapestries ordered or obtained through an agent in Paris were necessarily made there, or even in France.

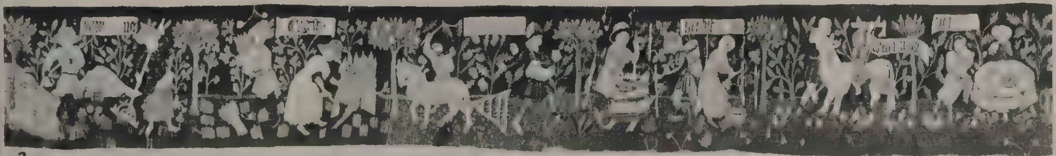
The known facts concerning the famous tapestries of the Apocalypse in the cathedral of Angers throw light on this problem. The series was begun in the year 1376 for Louis, duke of Anjou, and the panels ultimately passed by bequest to the cathedral of Angers in 1480. The cartoons were prepared by Hennequin de Bruges, and the weaving was started under the supervision of Colin Bataille, citizen, weaver and tapestry-merchant of Paris. Guidance in delineating the scenes was obtained from an illuminated ms. of the Apocalypse in the library of King Charles V. of



GOTHIC TAPESTRY OF THE LATE 15TH CENTURY

This tapestry of *mille fleurs* design, in the M. Hawley MacLanahan collection, was woven in Arras about 1490, when that city still occupied an eminent position as a centre of Flemish tapestry-weaving. The subject is mythical, representing a unicorn purifying the waters of a spring with his horn while other animals wait to drink. The tapestry has been cut down somewhat from the original





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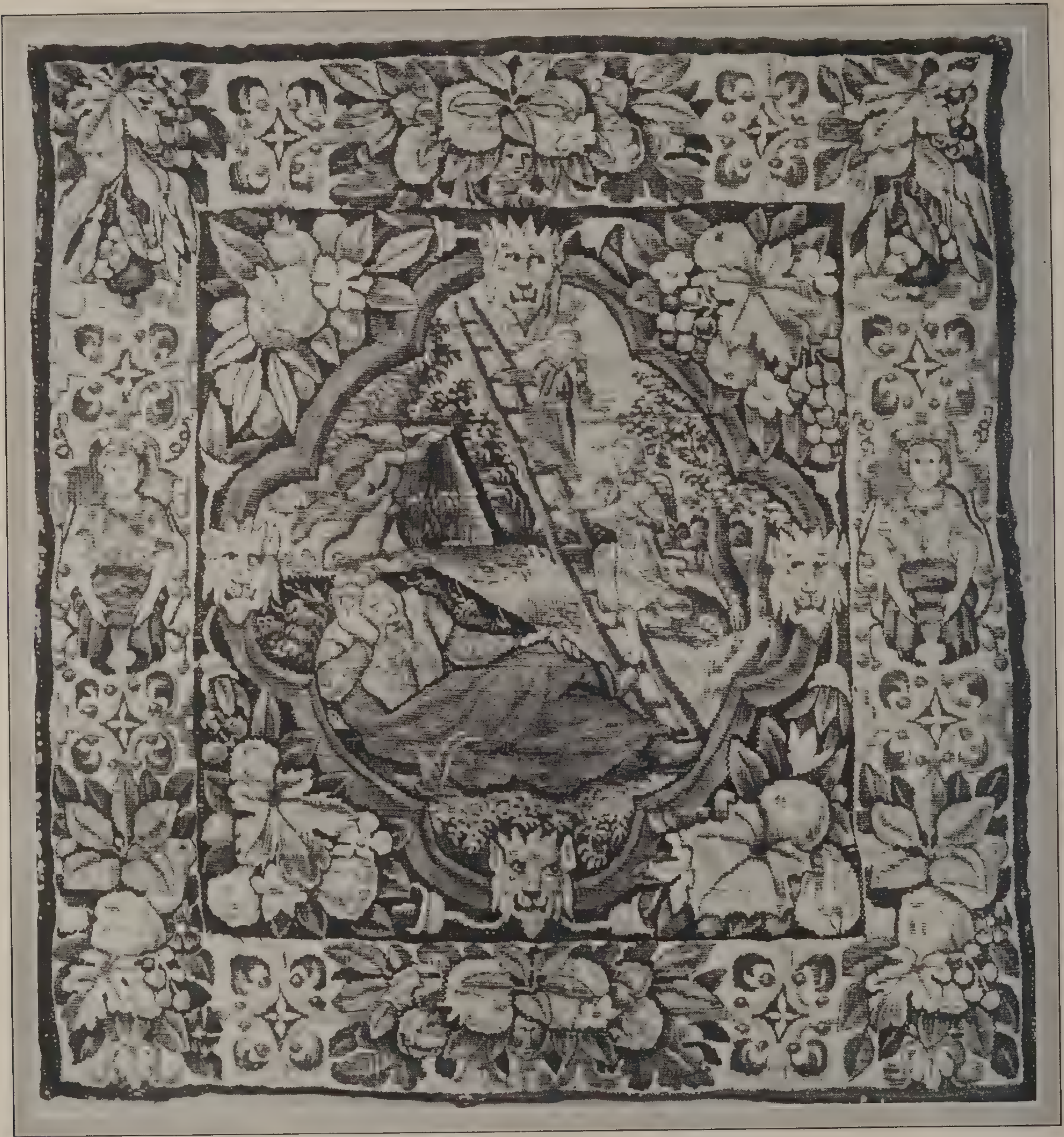
BY COURTESY OF (1) THE ART INSTITUTE OF CHICAGO, (2) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM

FRENCH AND GERMAN TAPESTRIES OF THE 15TH CENTURY

1. "The Boar Hunt in the Forest," a French tapestry of the second quarter of the 15th century. One of a series illustrating mediaeval field sports. Size 9 feet by 11 feet
2. "The Occupations of the last six months of the year," a German tapestry of the early 15th century illustrating field labours and fruit gathering. Size 15¼ inches by 8 feet 11½ inches

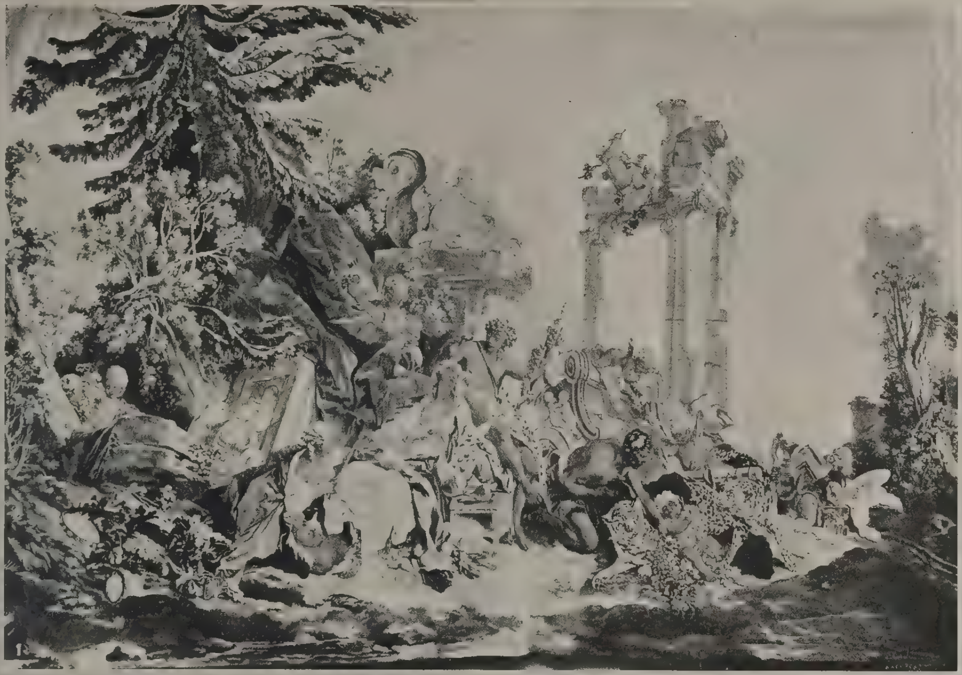
TAPESTRY



BY COURTESY OF THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM, LONDON

AN ENGLISH TAPESTRY BY SHELDON

Jacob's dream, one of the series of tapestry cushion-covers, depicting incidents in the life of Jacob. William Sheldon, who died in the year 1570, was the first Englishman who established a tapestry factory. His looms were set up at Barcheston in Warwickshire, and weaving was continued for two generations after his death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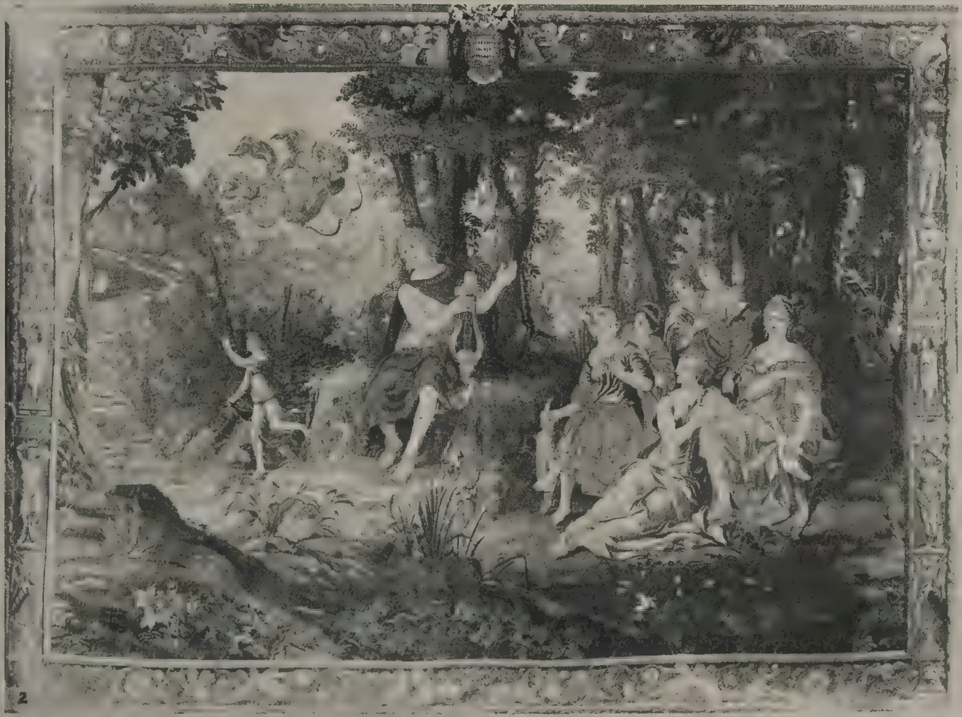
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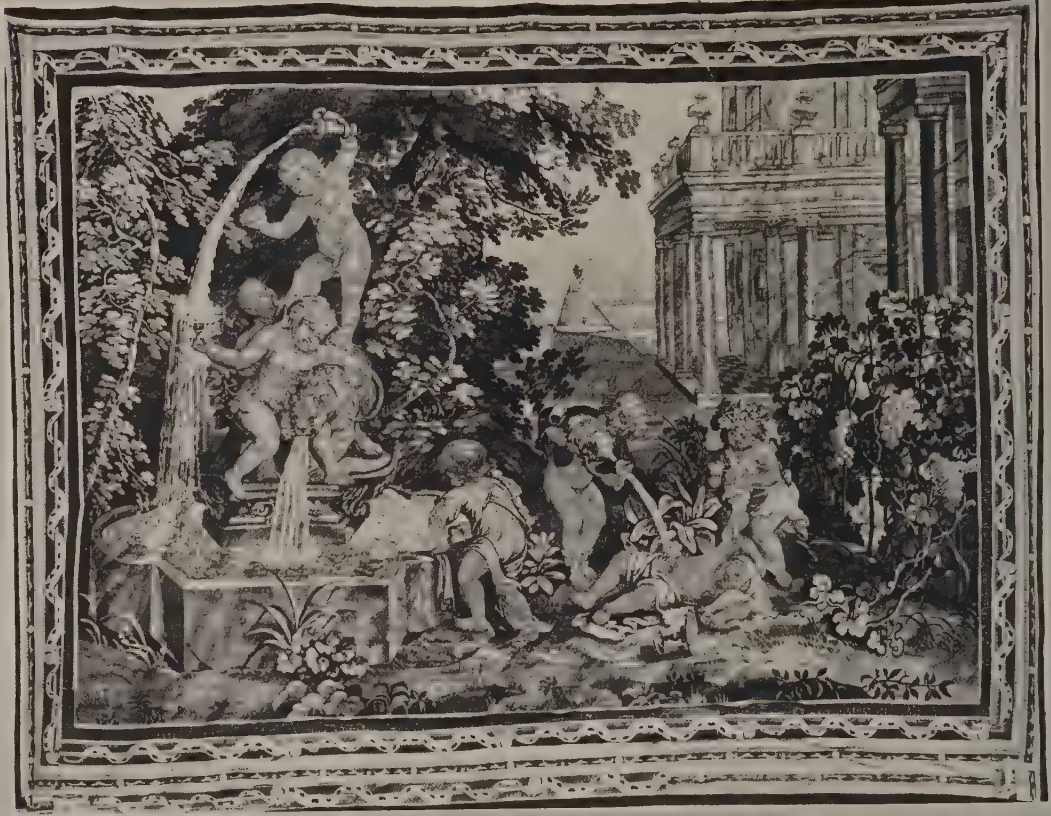
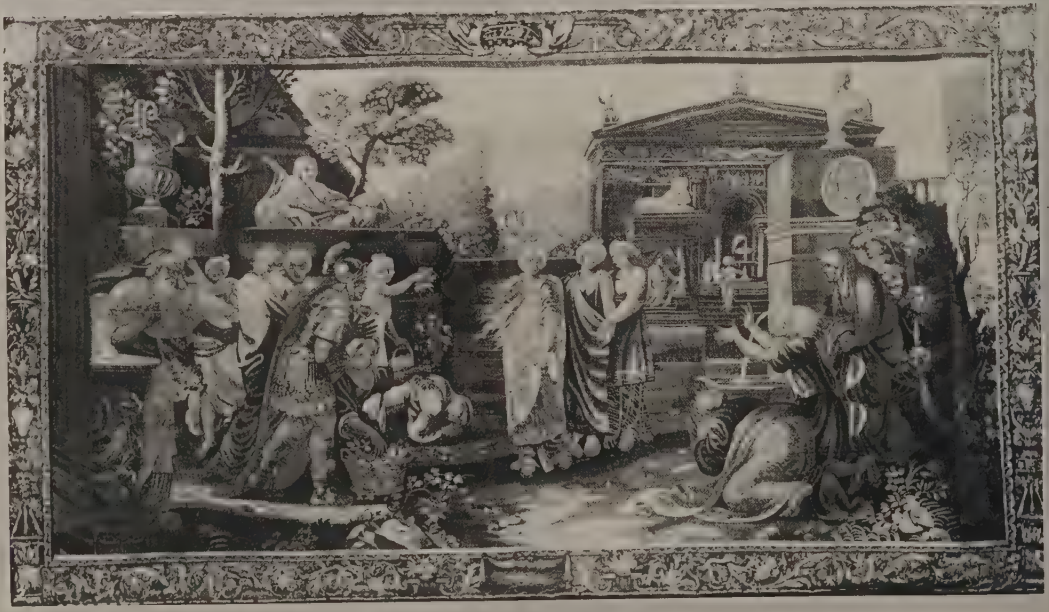
BY COURTESY OF (1) THE METROPOLITAN MUSEUM OF ART, NEW YORK, (2) THE TRUSTEES OF THE BOWES MUSEUM, BARNARD CASTLE

EUROPEAN TAPESTRIES OF THE 17TH AND 18TH CENTURIES

1. "Bacchus and Ariadne," woven of wool and silk at Beauvais, 1754, under Oudry and A. C. Charron, after a design by François Boucher
2. "Apollo and the Muses," a 17th century French tapestry bearing the arms of the Grimaldi family princes of Monaco

TAPESTRY





BY COURTESY OF (1) HIS GRACE THE DUKE OF BUCCLEUCH (2) THE TRUSTEES OF THE BOWES MUSEUM, BARNARD CASTLE

MORTLAKE AND BEAUVAIS TAPESTRIES

1. "Children Playing," one of a set woven in coloured wools and silks at Mortlake, England, in the second half of the 17th century after a 16th century Italian design. Height, 9 ft. 6 in.; length, 11 ft. 2 inches

2. "Psyche Going to the Sacrifice"; one of a series representing the story of Psyche. Woven at the Beauvais factory, after engravings attributed to Mark Antonio and from designs of the school of Raphael

France. The ms. (Bibl. nat., Paris, franç. 403) was written at the end of the 12th century, but the scenes were based on an earlier tradition, originating (according to some authorities) as early as the 8th century. The series was added to from time to time until its completion in the 15th century.

The first tapestry factory in France about the origin of which there is definite information was established at Fontainebleau by Francis I. in the year 1535. Its work reflects the Italianate leanings of French art under that monarch. It is supposed that the weavers of Fontainebleau were transferred to the Hôpital de la Trinité at Paris, where tapestry-work was begun under Henry II. Other factories were set up at Paris in the following years, and some outlasted the foundation of the Gobelins factory.

In the provinces, the factory at Aubusson seems to have begun work with the aid of immigrant weavers from Flanders, though at what time is not exactly known. There are records of weaving there from the beginning of the 16th century, but there is no clue to the identification of the tapestries of Aubusson at that time. It is thought possible that the famous tapestries of the "Lady of the Unicorn" from Boussac, now in the Cluny museum at Paris, were woven there. If so, it began well. In the year 1665 the factory at Aubusson was placed under royal patronage, but the standard of craftsmanship there never rivalled that of the royal tapestry factories of Paris, though its work has often shown good decorative qualities. The tapestries of Aubusson at the present day are worthy of the long record of the factory. The tapestry-works of Felletin and Bellegarde were largely auxiliary to those of the neighbouring town of Aubusson, and they followed the same tradition. Tapestries were also woven at Reims, Tours, Nancy and Maincy. "Les amours de Gombaut et de Macée," a rhymed story of peasant life of the end of the 15th century, was reproduced several times in tapestry during the two following centuries. Sets are stated to have been woven at Aubusson, Tours and Paris, as well as at Brussels.

The most renowned of all French tapestry-factories, that of the Gobelins, united several of the Parisian factories existing in 1662, the year in which it was inaugurated by Louis XIV. Weavers of Flemish origin, already employed in Paris, were transferred to the new works. It was the choice of Charles Le Brun, whose decorative instinct was quite remarkable, as director of the works, which enabled the new works to interpret so well the tastes and artistic aspirations of the time. Among the first undertakings was a set of tapestries from Raphael's frescoes in the Stanze of the Vatican, after copies made by the students of the French Academy in Rome, then newly founded. Other sets, among them the famous "Chasses de Maximilien" were copied, in accordance with the fashion of the time, from older Flemish tapestries in the royal *garde-meuble*. Many sets were designed to reflect the luxury and achievements of Louis XIV.—the "Histoire du Roi," his victories, the capture of cities, the royal residences. Under the succeeding kings, decoration was the chief aim, and such subjects as Don Quixote, fortune tellers and children at play were the vehicle of decorative schemes of much refinement. The work of the Gobelins has always been characterized by the excellence of the materials, by the range and high quality of the dyes, and by extraordinary manipulative skill. All the resources of the king and his ministers were freely used to render the factory worthy of the age which brought it into being. The upheaval of the Revolution left the Gobelins undisturbed, and to-day it still enjoys its ancient privileges.

The royal factory at Beauvais was set up about the same time as the Gobelins. Under Philippe Béhagle, a weaver from Tournai, it earned a great reputation. Among the greatest works produced at Beauvais were those from the designs of François Boucher, who was also employed for the Gobelins. At the present time, Beauvais uses only the low-warp loom and the Gobelins the high-warp. These two factories eclipsed all others in France, but a factory at Caen was busy in the latter half of the 17th century, that at Tours continued down to the 18th, and in the first half of that century some good work was done at Nancy.

Italy.—Tapestry weaving in Italy has been carried on, at one place or another, practically without intermission from the 15th century; but in spite of the real beauty of much Italian work, the craft has never become entirely acclimatized in a country where fresco-painting is more suited to the climate and the national genius. At first, tapestry-weavers from the Low Countries and France were induced to migrate to Italy, for the purpose of carrying out special local commissions. Tapestries were thus made in Florence, Siena, Rome, Urbino, Milan, Genoa, Venice, Ferrara, Bologna and elsewhere.

In spite of the artistic activity in Rome and Florence under Pope Leo X. in the earlier years of the 16th century, it is significant that the reproduction of Raphael's cartoons for the Sistine chapel was entrusted to a weaver at Brussels. Other cartoons by Italian artists were sent by the Medici to be woven at Bruges. We also learn, from Vasari, that Leonardo's lost cartoon of the Temptation in the Garden of Eden was to have been copied in Flanders. The Italian historian also mentions two immigrant weavers of the 16th century, Nicholas Karcher and J. B. Rost, who worked at Ferrara. Karcher wove the series of the history of SS. George and Maurelius in Ferrara cathedral, and those of the history of the Virgin and the Old Testament in the cathedral of Como. Both weavers also worked at Florence, where the duke of Tuscany founded a factory which continued until the 18th century.

In Rome, after an attempt in the 15th century, and again in the 17th, to start tapestry-weaving under papal patronage, a factory was inaugurated by Clement XI. in the year 1710 which is still at work under the Government of Italy. Factories were founded in the 18th century at Turin and Naples. Most of the tapestries woven in Italy have been designed by Italian artists.

Spain and Portugal.—In Spain, as in Italy, Flemish weavers were induced to settle when tapestry-work was to be done. After a few scattered efforts, the factory of Santa Isabel at Madrid gained some celebrity in the 17th century; the workroom is seen in Velasquez's picture "Las Hilanderas" in the Prado. In the early years of the 18th century Van der Goten of Antwerp was employed in Madrid. A factory at Seville did not last more than a few years. The most famous of all Spanish tapestries are those woven in the factory of Santa Bárbara at Madrid after the designs of Goya. Altogether this celebrated artist painted 45 subjects, taken from the peasant life of Spain, between the years 1776 and 1791. Thirty-six of these designs and most of the tapestries are still preserved in the Escorial and in the royal residences. There are scattered records of tapestry-weaving in Portugal from the 15th century onwards, but little is known of any work done except that at Tavira in the 18th century.

England.—Tapestries were widely used in England before any regular factory was founded for meeting the needs of the country. The dukes of Burgundy, from the last years of the 14th century onwards, made gifts of many tapestries to members of the English royal family. Well-to-do subjects followed the royal example in their use. One of the most beautiful sets of tapestries of the first half of the 15th century in existence, with hunting scenes, in the possession of the duke of Devonshire, probably came direct from the looms of Tournai or Arras. In the latter part of that century a weaver of Tournai was licensed to import tapestries into England. A little later Cardinal Wolsey's agents in the Low Countries spent large sums on his behalf. In one year alone (1522) 21 sets, numbering 132 pieces altogether, were bought for him. At the death of Henry VIII. the inventory of the royal possessions enumerated over 2,000 tapestries. Yet up to this time no tapestry-factory existed in England, and when at last one was founded it came into being through the initiative of a country squire. There are records of arras-weavers operating in England from time to time before that event, but no factory-tradition was established: and it is even probable that these weavers, immigrants or others, were chiefly engaged in repairs. A tapestry at Winchester college, with the mythical arms of King Arthur of Britain, and large red and white roses, on a "paned" ground in stripes alternately red and blue, belongs to the reign of Henry VII. There are strong arguments tending to show that this panel commemorates the birth of Prince Arthur (so named after the British king), eldest son of Henry VII., at Winchester in the year 1486;

the design is unusual, and as the workmanship does not show the accomplishment of Flemish weaving at the time, the panel may have been woven in England. On the other hand the tapestries made about the year 1511 for William Warham, archbishop of Canterbury, and now at Aix in Provence, are Flemish work.

William Sheldon, to whom the honour is due (as indeed he claims in his will) of having been the first to establish tapestry-weaving in England, set up looms at Barcheston and Baddesley Clinton in Warwickshire not long after the middle of the 16th century. Although his chief weaver, Richard Hyckes, had been sent to the Netherlands to learn the craft, these English tapestries have a character of their own. The tapestries which, above all, have preserved Sheldon's name from unmerited oblivion are the maps of English counties belonging to the Bodleian library at Oxford and the Yorkshire Philosophical Society. Such evidence as can be gleaned about the Barcheston work tends to show that it went on, for a short time at any rate, after the foundation of the factory at Mortlake in the year 1619, though the possibility that it was absorbed into the royal factory should not be lost sight of. The promoters of that factory, in a petition to King James I., instanced the example of the French king, whose factories at Paris had brought him so much honour. Weavers from the Netherlands were engaged, and effective steps were taken to secure a standard of craftsmanship equal to that of any contemporary work. At first, the subjects of older Flemish tapestries were copied, after the fashion of the time, and this procedure was largely followed throughout the career of the factory, which lasted, with varying fortunes, till the end of the century. With its decline, ateliers were set up in the neighbourhood of London by weavers who had been employed at Mortlake, and there can be no doubt that this rivalry hastened the decline of the parent factory, which finally closed its doors in the year 1703. William Benood worked at Lambeth and Francis Poyntz at Hatton Garden, but the most eminent and perhaps the greatest, of all these weavers was John Vanderbank of Great Queen street, Soho, whither the Great Wardrobe was removed from Hatton Garden towards the end of the 17th century. Vanderbank held the office of Yeoman arras-worker in the reigns of William III., Anne and George I. Looms were set up at Chelsea about the year 1723 by James Christopher Le Blon. He wove two or three small panels of the Head of Christ, after the Vatican emerald, but nothing else by him is known. Parisot, a Frenchman, wove small tapestry panels at Paddington and Fulham towards the middle of the 18th century. A few years later, Paul Saunders, a capable and original weaver, was at work in London. After his time there is little to be said about tapestry-weaving in England for another 100 years. The revival in the latter part of the 19th century will be referred to later.

Germany and Switzerland.—In its earlier stages, tapestry-weaving in Germany and Switzerland held aloof from the Flemish tradition. Work seems to have been done chiefly in convents and private houses. In the border of a tapestry in Bamberg cathedral, two Dominican nuns are seen at work at the loom—no doubt the weavers of the panel itself. Most of these tapestries are small. Long narrow panels, illustrating scriptural subjects, rhymed romances, allegories and fanciful or purely decorative themes were woven in Switzerland, principally in Basel and the neighbourhood, in the 15th and 16th centuries. There is a remarkable collection in the Basel museum. It is not unusual in mediaeval German work to find small details done in knotted pile after the manner of carpet-weaving, and occasionally whole tapestries were woven in pile. An example of the 12th century is in the cathedral of Quedlinburg, and another, of the early years of the 16th, is in the Victoria and Albert Museum.

In the 16th century, factory-work was organized after the example of the Low Countries at Lauingen in Swabia. At the end of the century a factory was started at Munich under Flemish direction. A fresh start was made in the year 1718, and weaving continued for another 80 years. Works were set up at Berlin and Würzburg towards the end of the 17th century, and at Dresden early in the 18th century.

Other Countries.—As in Germany, tapestry-weaving in Scandinavia was a domestic craft in the middle ages, and such it has always continued to be. A few early specimens have been preserved; among them is the panel attributed to the 12th century, with figures symbolical of the months of April and May, from Baldishol church, and now in the Museum at Oslo. They bear witness to the early origin of tapestry-weaving in Scandinavia, and also to its continuity with little change down to recent times. Few colours are used and the designs are extremely simple. The traditional character of much Scandinavian work often renders the age of a specimen a matter of considerable doubt. In Sweden and Norway the weaving of relatively large panels, with subjects taken from the Bible or from the legends of heroes, was carried on down to the later years of the 18th century, to be revived in recent times. Many pieces are squares, often double, for cushion-covers. It is significant that ordinary pattern-weaving for curtains and hangings has been carried on contemporaneously with the work more usually associated with the tapestry-process. In this and other respects Scandinavian work throws light on the practice of tapestry-weaving in primitive times.

In Denmark, Flemish weavers were established before the end of the 16th century. A series of tapestries at Rosenborg castle, Copenhagen, was woven by command of King Christian V. to commemorate events in the war between Sweden and Denmark in the years 1675 to 1679.

In Holland, tapestry-weaving was closely associated with Flanders and it followed the same tradition. Weaving was done at Middelburg as early as the 15th century. In the 17th century Delft and Amsterdam were the chief centres.

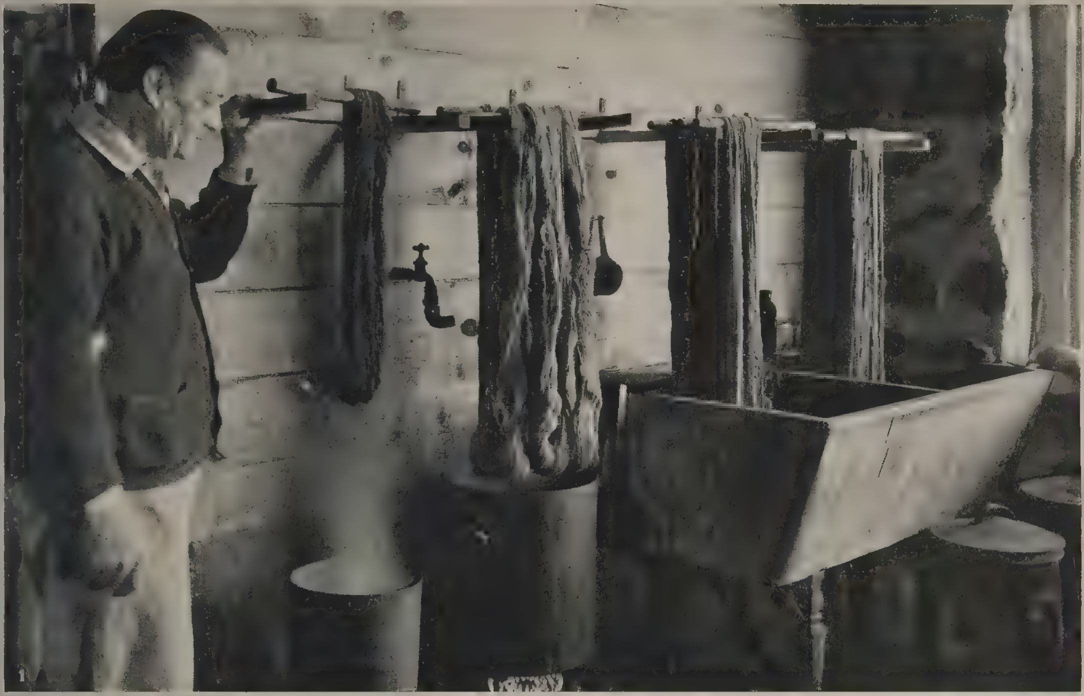
In Russia, tapestries were woven at Moscow in the early years of the 17th century by a weaver from Antwerp. At Leningrad, weavers from the Gobelins were established under Peter the Great early in the 18th century, and portraits of members of the royal family were woven. Flemish weavers arrived in the latter half of the century, and domestic scenes after the fashion of the Low Countries were woven. Tapestry-weaving was carried on well into the 19th century.

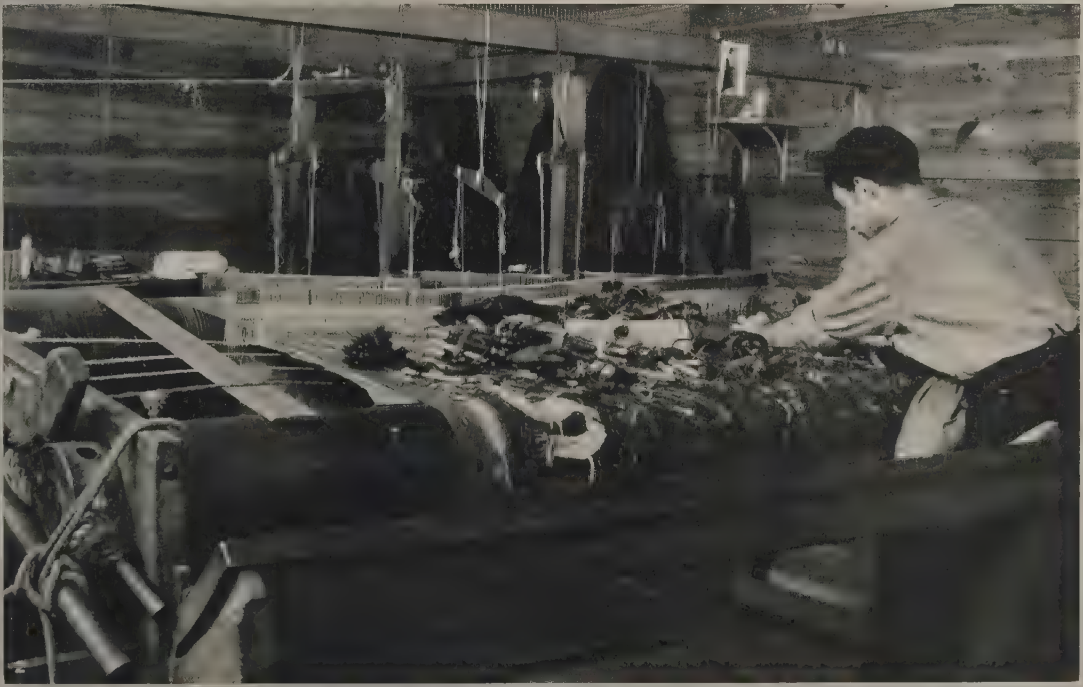
Present Day.—Throughout Europe the spacious dwellings of even half-a-century ago are rapidly being replaced by smaller apartments, for which some slighter form of ornament is regarded as equally appropriate, while it is often less costly. Since the War, the relatively high cost of tapestry-work, and the straitened circumstances of many to whom the weavers would naturally look for employment, has contributed still further to give a temporary setback to the industry.

The great exhibition of modern industrial art held in Paris during the summer of 1925 showed that there is still a healthy vitality from the workers' point of view. Sound work was shown by several European countries. The panels exhibited by the Gobelins and Beauvais factories were unsurpassed in scope, as well as in technical mastery. Indeed they were worthy of a tradition of two centuries during which these factories have been maintained by the State. Themes of national interest were set in hand upon the restoration of peace. The subject of one large panel was the Entry of the Americans into the war, and another was entitled "Verdun and Victory." Furniture-upholstery showed ships, aeroplanes, infantrymen leaving the plough, cannon and military trophies. The Aubusson factories exhibited a panel showing an ironclad steaming into an African port. A panel woven at Felletin, "the Garden of Eden," was a sort of "verdure" in vivid modern colours. These panels can only be regarded as exceptional products of the industry, rendered possible by State subvention or brought about by the special circumstances of a great exhibition.

In Austria tapestry-weaving is taught in the school of arts applied to industry at Vienna, and tapestries woven by pupils were shown at Paris. A remarkable series of panels, entitled allegories of the arts and crafts, has been woven in Czechoslovakia for the palace of the president of the republic. In Scandinavia and Finland panels of a formal and decorative type, mostly of moderate size, continue the tradition of earlier times.

A factory was inaugurated at Heverlé near Louvain in Belgium, with the concurrence of the minister of industry and labour, early



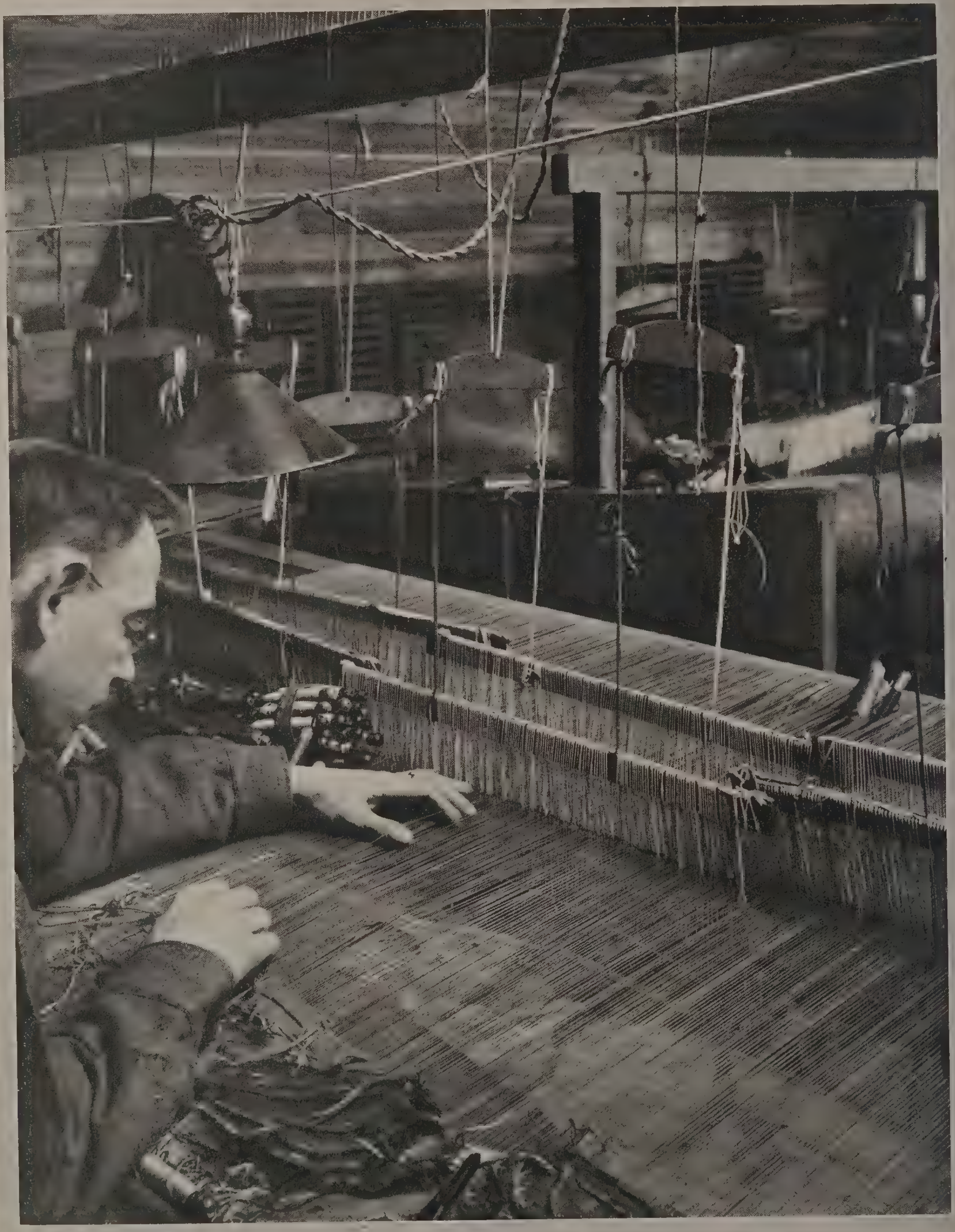


BY COURTESY OF THE EDGEWATER TAPESTRY LOOMS

STAGES IN THE PROCESS OF MODERN TAPESTRY WEAVING

1. The dyer with his vats. This stage is extremely important as weak colours or cheap dyes will ruin a well-designed tapestry. Master chemists have laboured for years to obtain satisfactory results. In America both silk and wool are used separately and in combination; but coloured wool, the surface of which absorbs light, is the principal kind of thread used. **2.** View of a low-warp or horizontal loom showing the weaver at work. The cartoon is placed beneath the warp, and the design woven over it by hand, the feet meanwhile manipulating the two sets of leashes which form the sheds. Since the tapestries are woven with the under side next to the weaver, the front cannot be seen until the tapestry is completed

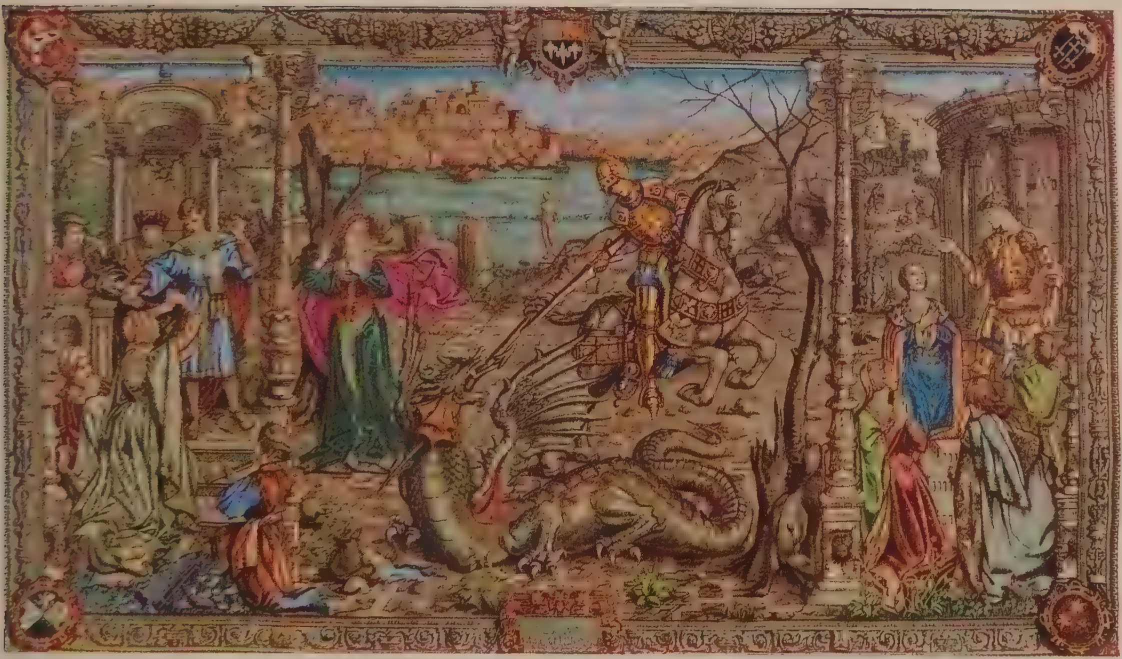
TAPESTRY

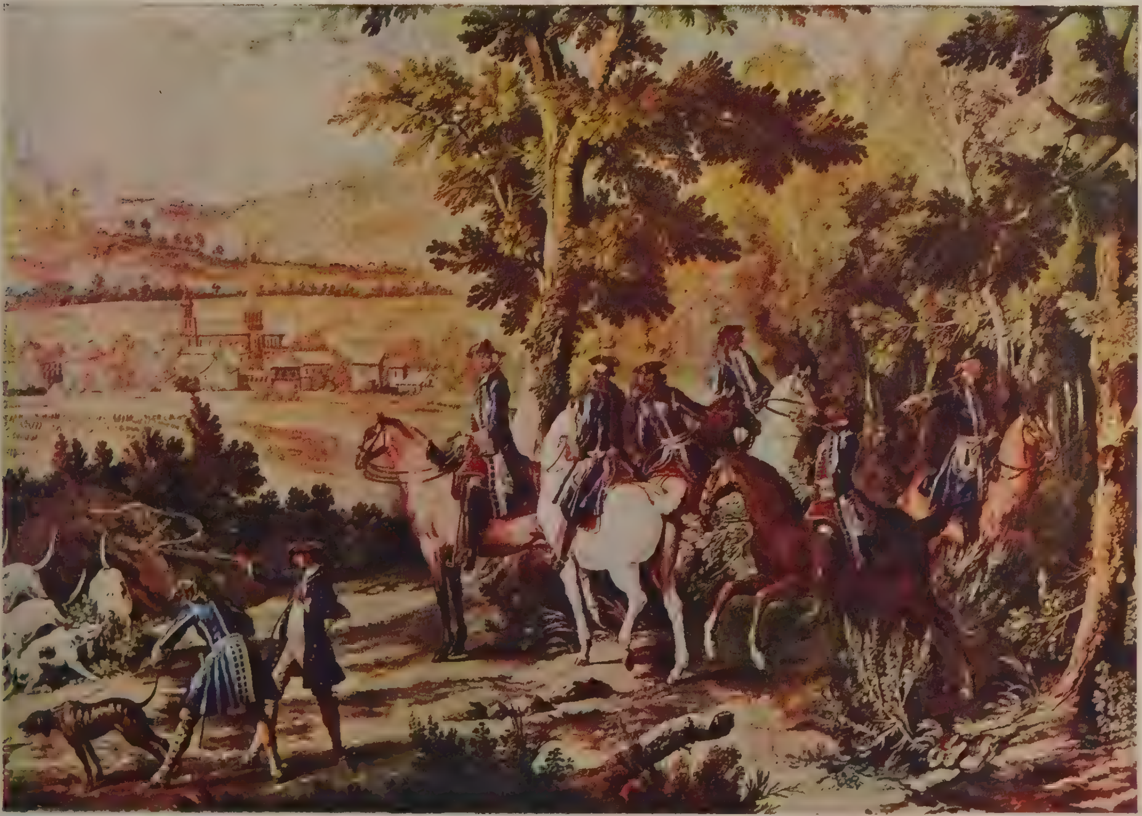


BY COURTESY OF THE EDGEWATER TAPESTRY LOOMS

TAPESTRY WEAVING IN THE UNITED STATES

Weaver bending over horizontal or low-warp loom, and forcing the warp threads apart with his left hand so that the figure on the cartoon beneath it is seen. With his right foot he works a set of leashes attached to the even warp threads, and with his left foot those attached to the odd warp threads. The process of weaving consists in holding the warps parallel and passing the bobbin to the left, alternately under and over the successive warp threads and then back again. The tapestry is woven with the under side uppermost and its face is seen by the weaver by looking into a tiny mirror placed below the warps. The roller, on which the work is wound as it it completed, is next to the weaver





BY COURTESY OF (TOP) THE PROVOST OF ETON COLLEGE, (BOTTOM) THE ADMINISTRATEUR DU MOBILIER NATIONAL, PARIS

TAPESTRIES: MODERN ENGLISH AND 18TH CENTURY FRENCH

Top: "St. George and the World" (showing the call to battle, the struggle and the victory), the second panel of the Legend of St. George series produced at Merton Abbey as part of the Eton College War Memorial. The designs were by Mrs. Ackers Douglas. Bottom: "The Quarry," a portion of the eighth panel in the series of "The Hunts of Louis XV." executed at the Gobelins factory in 1744 after a design by J. B. Oudry

in the year 1905. Spain and Italy each have a factory still at work with a career of two centuries behind it—that of Santa Bárbara at Madrid and of San Michele at Rome. Tapestry-weaving has also been going on in Florence during recent years.

In England, the factory set up at Windsor in the year 1876 lasted for 10 or 11 years; the weavers were mostly from France, and the French tradition was followed, though contemporary English designs were reproduced. About the same time William Morris started tapestry-weaving at Merton abbey. The aim was to revive the mediaeval tradition, and to bring this effort into association with the movement that gave such distinction to English craftsmanship and literature at the time. Among the subjects of the panels woven there, perhaps the series of the Holy Grail is the most famous. A set of four tapestries of the legend of St. George, part of the war memorial for Eton college, has been completed recently (Plate IX.). These tapestries depart in some degree from the tradition of Merton abbey, recalling Flemish work of the early Renaissance, and involving the preparation of a large number of intermediate tints for the interpretation of the cartoons. Some of the weavers employed on these panels were disabled soldiers who had received their training under a scheme subsidized by the Government at the conclusion of the War. The looms set up early in the year 1892 by William Baumgarten at New York, with the assistance of weavers from Aubusson, inaugurated tapestry-weaving in the United States of America. The result was the installation of a factory at Williamsbridge in the suburbs of the city, where tapestry-weaving is still carried on. In 1911, A. Herter's factory in New York and L. Kleiser's at Edgewater, N.J., were founded.

Tapestry-weaving is more widely spread at the present time than this brief summary would suggest. A good deal of work has been done by private individuals, and in the present state of affairs this practice seems to offer the best hope for its maintenance in the future.

Preservation and Repairing.—The lining, mounting and repairing of tapestries has always been an essential, if subsidiary, branch of the tapestry-weaver's calling. The cost of lining and mounting is mentioned in old accounts. Numbers of the Gobelins tapestries now in the Mobilier National in Paris still have their original linen linings. They are stitched down in diagonal lines running the whole way across from right to left and from left to right, making a large diamond network of lines. Where the warp is horizontal, as in the great majority of cases, this arrangement relieves the strain of the weight of the tapestry upon the weft threads. Tapestries thus strengthened are far less liable to dilapidation, and any damage should be made good without delay by competent persons, or it will rapidly become worse.

In the year 1587 two arras-workers showed a piece of Arras half-cleaned. Well-known weavers in the 17th and 18th centuries, like John Vanderbank, and his successor in the Great Wardrobe, John Ellys, included the lining, mending and cleaning of tapestries in their duties. The skill and experience gained by repairers of old tapestries has been largely responsible for a development giving rise to mixed feelings. Complete panels have been woven from time to time, very skilfully imitating some particular class of old work. Generally these tapestries are relatively small and simple in design. It behoves collectors to be on their guard when considering the purchase of tapestries of a class which lends itself to reproduction.

The "tapestries" woven on the Jacquard power loom since the middle of the 19th century need not be described in detail. Their lifeless uniformity renders them unmistakable, and their cheapness is their only commendable quality. (*See* INTERIOR DECORATION.)

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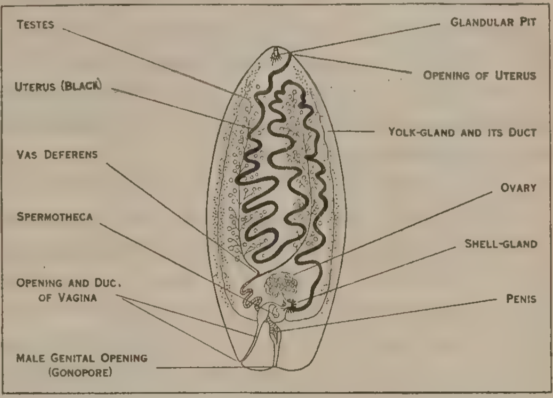
TAPEWORMS (Cestoidea or Cestodes), a class of endoparasitic Platyhelminthes (*q.v.*) in which the body is usually flattened and ribbon-like, and may be unisegmental or composed of a chain (strobila) of "segments" (proglottides). In the latter case the segmentation is not comparable with that of an annelid or arthropod, but is probably to be looked upon as an adaptive device for the multiplication and dissemination of eggs. The number of segments in a complete strobila varies, in different species, from three or four to many hundreds, and the length of the chain from less than a millimetre to several metres. Each segment contains a separate set of reproductive organs, but the nervous and excretory systems are continuous throughout the chain. Tapeworms have no mouth or alimentary canal, liquid food being presumably taken in by absorption through the body-wall. The adult worms are, with few exceptions, intestinal parasites of vertebrates. In almost all known cases the life-history involves an intermediate host and a somewhat complex metamorphosis.



FROM LANKESTER, "TREATISE ON ZOOLOGY" (BLACK)

FIG. 1.—DIAGRAM ILLUSTRATING THE REPRODUCTIVE SYSTEM OF AMPHILINA FOLIACEA

General Morphology.—The body of the adult is covered externally by a cuticle, below which there is a cellular subcuticular layer. All the internal organs are embedded in loose parenchymatous tissue. In most forms the parenchyma contains numerous "calcareous corpuscles"—small refringent nodules composed mainly of carbonate of lime. The function of these is unknown. Possibly they are merely stored-up excretory products. The musculature consists mainly of longitudinal fibres, often in definite bundles and situated, for the most part, rather deeply in the parenchyma.

In the segmented forms there is, at what is usually called the anterior end, a specialized "head" or scolex, serving as an organ of fixation. This is generally provided with muscular suckers or variously modified sucker-like organs known as bothria or bothridia, and may, in addition, bear a central proboscis-like structure, the rostellum, which is commonly armed with chitinoid hooks. The region nearest to the scolex is the zone of proliferation of new segments, which are, as a rule, continually being formed throughout the life of the worm. As they pass back along the strobila the segments become successively sexually mature and finally gravid, the most posterior usually containing little but a uterus crowded with eggs.

The nervous system consists of an intercrossing system of nerve-fibres and ganglionic cells at the anterior end (in the scolex in strobilate forms), and usually a single pair of main lateral nerve cords which are continuous throughout the body and without segmental ganglia. The excretory or "water-vascular" system is composed typically of two pairs (dorsal and ventral) of main longitudinal canals, continuous throughout the strobila and connected together anteriorly.

The animals are, with rare exceptions, hermaphrodite, each individual, or each segment in strobilate forms, being potentially male and female. The male duct and the vagina may have separate apertures or may open side by side into a common atrium. There is considerable variation in the position of these openings. In unsegmented forms they may be terminal, subterminal or ventral, while in segmented forms they may be on the ventral surface or on one of the lateral margins of the segment. The essential organs of the genital apparatus do not differ greatly from those of other groups of Platyhelminthes. The oviduct connected with the ovary and its associated glands, and with the inner end of the vagina, leads into a uterus in which the fertilized eggs are accumulated.

Classification.—There have been considerable changes during recent years in the systematic arrangement of this group. The older division into unsegmented forms (Monozoa) and segmented forms (Merozoa) has been generally abandoned, since it does not correspond with an arrangement based on internal anatomy. In the most recent comprehensive classification (that of Poche) the Cestoidea are primarily divided into two main groups or subclasses, Amphilinoinei and Taenioinei.

The former group contains two families of unsegmented forms, parasitic in fishes:

(1) Amphilinidae. These are leaf-shaped or ribbon-shaped forms, with a more or less well developed proboscis-like organ at the "anterior" extremity, and with the openings of the male and female ducts near the "posterior" end. The long, tubular uterus has an independent pore near the anterior end. These worms inhabit the body-cavity of certain fresh-water fishes.

(2) Gyrocotylidae. These are remarkable forms with frilled margins and with a rosette-like organ at the "posterior" extremity, and having all three genital openings near the "anterior" end. The adults inhabit the intestine of certain marine fishes (the Holocephali), and the intermediate hosts appear to be lamellibranch molluscs.

The Taenioinei are a large assemblage of forms, including about 30 families. They are divided by Poche into four orders:

I. Bothriocephalidea. This order includes one family of unsegmented forms (the Caryophyllaeidae) and several families of strobilate forms, the most important of which are the Diphyllobothriidae and the Bothriocephalidae. In the most typical members of this order the scolex is provided with a pair of longitudinal slit-like bothria, situated dorsally and ventrally, and the genital apertures are on the ventral surface.

II. Echinobothriidea, containing only the family Echinobothriidae, parasitic in elasmobranch fishes.

III. Tetrarhynchidea, containing three families, of which the most typical is the Tentaculariidae (or Tetrarhynchidae). These are forms in which the scolex, in addition to two or four bothria, bears four retractile proboscides armed throughout with hooks or spines. The adults are intestinal parasites of elasmobranch fishes.

IV. Taeniidea. This is the largest and most important order, and may be divided into two suborders, Phyllobothriinea and Taeniinea, and some 17 families. The Phyllobothriinea, in the adult stage, are chiefly parasites of cold-blooded, the Taeniinea of warm-blooded vertebrates. Of the families contained in the former suborder the best-known are the Phyllobothriidae and Proteocephalidae, while the Taeniinea include several large and important families, such as the Anoplocephalidae, Davaineidae, Dilepididae, Hymenolepididae, and Taeniidae.

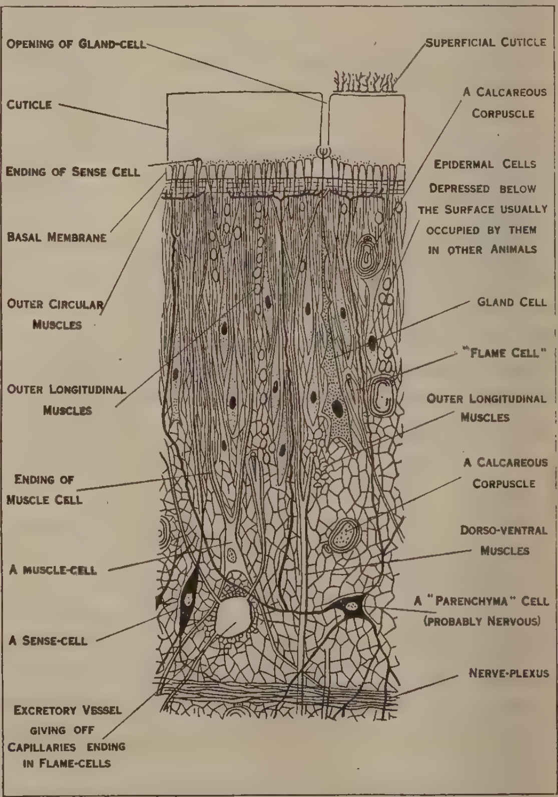
LIFE HISTORY

Development.—The eggs of Cestodes are usually enclosed in two membranes, one of which may show chitinoid thickening, forming a hard "shell." In the Bothriocephalidea the shell is provided with an operculum at one pole, like that of a digenetic Trematode. The embryo, at the stage when it is ready to hatch, is a spherical or oval mass of cells (called an "onchosphere"), provided at one pole with chitinoid hooks, of which in most species there are three pairs—hence the name "hexacanth embryo." In certain Amphilinoinei, however, the embryo has ten hooks. The embryonic hooks are used as levers, chiefly in burrowing among the tissues of the intermediate host.

In some of the Bothriocephalidea the embryo is provided with an external ciliated envelope and hatches in water, where it swims about by means of its cilia. In the human parasite *Diphyllobothrium latum,* for example, the ciliated embryo is at first free in fresh water and is then swallowed by a small Copepod (*Cyclops* or *Diaptomus*). Shedding its ciliated coat, the embryo penetrates into the body-cavity of the Copepod, and develops into a more elongate form called the *procercoid.* If the Copepod is swallowed by a suitable fish, such as a pike, perch or trout, the procercoid develops further among its tissues into a *plerocercoid,* and is then infective for the final host, infection being acquired by eating the fish in a raw or imperfectly cooked state. For the development of this species, therefore, and of others related to it, two successive changes of host are required. The larval forms known as *Sparganum,* which occur in many land vertebrates, including man, have been shown to be the plerocercoids of *Diphyllobothrium.*

The larval forms of Tetrarhynchidea, resembling the scolex of the adult, without the strobila, or with only an unsegmented appendage, occur encysted among the tissues of various marine animals, chiefly teleostean fishes.

Among the best known of the Taeniidea the developmental history is quite different. The human parasite *Taenia solium* may be taken as typical. If an egg of this worm be swallowed by the proper intermediate host (in this case the pig) the hexacanth embryo is liberated in the intestine and proceeds to pierce the intestinal wall, wandering about among the tissues and usually coming to rest among the muscles. Here it grows into a small bladder, in whose wall a depression or invagination appears on the side opposite to the embryonic hooks. At the bottom of this invagination five thickenings appear, destined to become the four suckers and the median rostellum. Finally the hooks are developed on the rostellum, and the bladder-worm, or *cysticercus,* is fully formed. Should this be ingested by a human being with raw or imperfectly cooked pork, the "head" is evaginated and attaches itself to the lining of the intestine, and the "neck" joining it to the bladder begins to form a series of proglottides. Another human parasite,

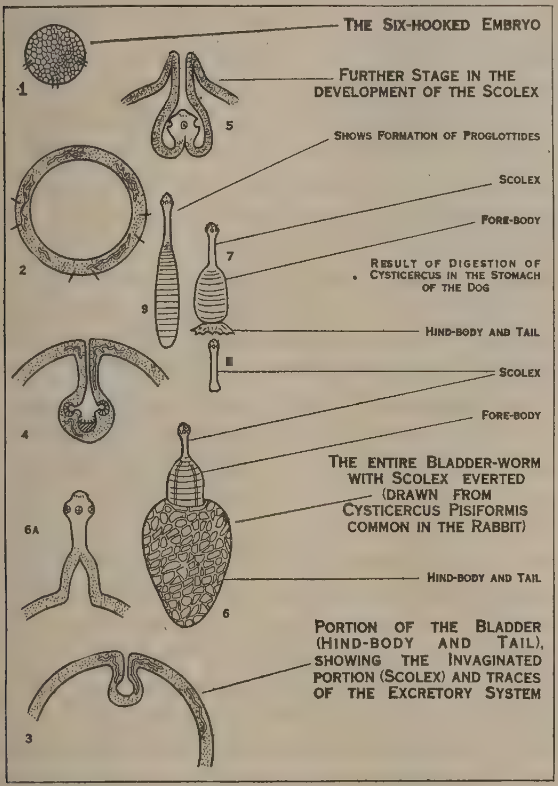


FROM LANKESTER, "TREATISE ON ZOOLOGY" (BLACK)

FIG. 2.—MICROSCOPIC STRUCTURE OF A TAPEWORM. A PORTION OF A TRANSVERSE SECTION THROUGH THE BODY-WALL OF LIGULA INTESTINALIS

Taenia saginata, has a similar development, but is without hooks, and makes use of the ox as intermediate host.

Many modifications occur in the form of the bladder-worm, but the essential features of the development are the same throughout the order. In some forms the original bladder-worm gives rise to several or many scolices instead of the usual single scolex, a phase of asexual multiplication thus being introduced.


THE SIX-HOOKED EMBRYO
1
FURTHER STAGE IN THE DEVELOPMENT OF THE SCOLEX
5
SHOWS FORMATION OF PROGLOTTIDES
SCOLEX
FORE-BODY
2
7
RESULT OF DIGESTION OF CYSTICERCUS IN THE STOMACH OF THE DOG
9
HIND-BODY AND TAIL
SCOLEX
4
FORE-BODY
THE ENTIRE BLADDER-WORM WITH SCOLEX EVERTED (DRAWN FROM CYSTICERCUS PISIFORMIS COMMON IN THE RABBIT)
6A
HIND-BODY AND TAIL
6
PORTION OF THE BLADDER (HIND-BODY AND TAIL), SHOWING THE INVAGINATED PORTION (SCOLEX) AND TRACES OF THE EXCRETORY SYSTEM
3

FROM LANKESTER, "TREATISE ON ZOOLOGY" (BLACK)

FIG. 3.—DEVELOPMENT OF A TAENIID TAPEWORM (TAENIA PISIFORMIS) 1–5, development of the six-hooked embryo, within the intermediate host, into a bladder-worm, and successive stages in the formation of the head. 6–9, evagination of the head, and further development of the larval form into an adult worm, in the final host

In the gid-parasite of the sheep (*Taenia* or *Multiceps multiceps*) the bladder-worm, which occurs in the brain and is often called a *Coenurus,* gives rise to numerous scolices, each capable of developing into an adult worm if ingested by a dog or other suitable carnivorous host.

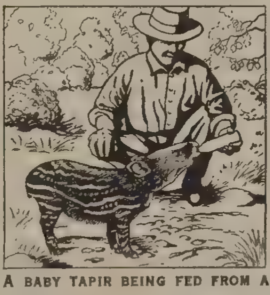
In *Echinococcus granulosus* this phase of multiplication is elaborated still further, the original embryo developing in the intermediate host into a large and relatively thin-walled bladder or cyst ("hydatid"), from the inner surface of which there are budded off a large number of "brood-capsules," each containing from 10 to 30 scolices. Daughter cysts may also be budded off, and these may give rise to further scolices, so that altogether a very large number of potential adult worms may be formed from the original embryo. This worm occurs, in the hydatid stage, in the liver and other organs of a large number of hosts, including man, sheep, ox and pig. The adult is a very small worm with only three or four segments, and occurs in the intestine of the dog, wolf and fox.

As may be noted from the examples already given, the intermediate host is usually an animal likely to be devoured by the final host. Thus the dog harbours several Taenioid tapeworms whose intermediate hosts are rabbits and sheep. The cysticercus of *Taenia taeniaeformis* of the cat occurs in rats and mice. A number of species of *Hymenolepis* parasitic, as adults, in ducks and geese make use of small fresh-water Entomostraca such as *Cyclops* and *Cypris* as intermediate hosts. Houseflies and earthworms are the vehicles of infection for several of the tapeworms of fowls. *Dipylidium caninum,* a common parasite of the dog and cat, passes its cysticercus stage in fleas and in the louse, *Trichodectes.* The louse is capable of swallowing the eggs of the worm, but the adult flea cannot do so. Fleas become infected during their larval period, the eggs, when swallowed, hatching in the hinder part of the intestine and the embryo boring through its wall into the body-cavity. Here they do not continue their development until the pupal stage has been passed, the cysticerci becoming fully formed only in the adult flea. Infection is acquired by dogs and cats, and accidentally by man, through swallowing fleas containing them.

The larvae of many of the Phyllobothriinea, whose adult forms are found in the spiral valve region of the intestine of sharks and rays, occur among the tissues of other marine animals. One such larval form (apparently belonging to a species of *Tylocephalum*) occurs in the pearl-oyster, and is believed to be one of the principal causes of the production of pearls. This, apparently, takes place only in the event of the death of the parasite from some unknown cause.

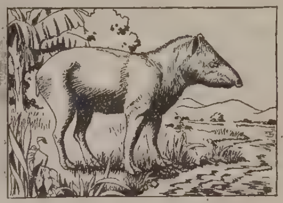
Economic Importance.—From the fact that tapeworms often occur in enormous numbers in the intestine of an apparently perfectly healthy animal, it is clear that they are not always definitely injurious to their hosts. As parasites of man and of domestic animals, however, they have considerable importance. As a rule their ill effects are most manifest in young animals, and they are sometimes responsible for serious digestive and nervous disturbances, and even for severe losses among stock and poultry. The adult worms, besides depriving the host of a certain amount of nutrient material, secrete substances which have been shown to be definitely toxic in many instances, when injected into the blood or body-cavity of experimental animals. The same is true of the larval forms, and certain changes take place in the blood-cells of infested animals which indicate that some of these poisons are normally absorbed into the system. It is probably, however, by the migrations of the larvae within the body, and the secondary invasions by pathogenic organisms for which they prepare the way, that the most serious harm is done. Only in exceptional cases, such as the invasion of the brain by the hydatid of *Echinococcus,* are tapeworms really dangerous to man. (H. A. B.)

TAPIOCA (a native Brazilian word), a farinaceous food substance prepared from cassava starch, the product of the large tuberous roots of the cassava or manioc plant. (*See* CASSAVA.) Cassava starch, separated from the fibrous and nitrogenous constituents of the roots, is spread, while in a moist condition, upon iron plates, and with constant stirring exposed to such heat as causes a partial rupture of the starch granules, which agglomerate into irregular pellets, becoming hard and translucent when cooled. In this condition the starch forms the tapioca of commerce, a light, pleasant and digestible food, much used in puddings and as a thickener for soups.



A BABY TAPIR BEING FED FROM A BOTTLE

TAPIR, the name for large woodland mammals, forming the family *Tapiridae* of the order Perissodactyla (*q.v.*), with five front and three hind toes, massively built and with the nose and upper lip produced to form a short flexible trunk. Four species inhabit South and Central America, and one, *Tapirus indicus,* the Malay region. The latter is the largest, and is readily recognized by its black fore- and hind-quarters and white body. It may stand 3ft. 6in. at the shoulder and is solitary, shy, nocturnal, and inoffensive, frequenting deep forests in the neighbourhood of water. Its diet is exclusively vegetarian. The American species are all nearly uniform dark brown when adult, but the young, like those of *T. indicus,* are spotted and striped with white. The best-known New World form is *T. terrestris* of Brazil and Paraguay. In habits it and the other three species resemble the Asiatic form. The peculiar distribution of the tapirs is explained by the presence of fossil forms in Europe, China and the U.S.A. in Miocene, Pliocene and, in the two latter localities, Pleistocene formations.


THE BRAZILIAN TAPIR (TAPIRUS TERRESTRIS) FOUND ONLY IN CENTRAL AND SOUTH AMERICA

TAPPET is an intermediary fitment which converts the action of a rotary cam or lifter into a linear motion, with a return movement by gravity or spring pressure. The largest tappets are those in the ore stamp batteries, which raise a weight of sometimes as much as a ton. The tappets in internal-combustion engines require nice regulation to ensure obtaining the full power of the engine and to maintain silence in the valve operation. (*See* AERO-ENGINES; MOTOR CAR.)

TAPS AND DIES: *see* MACHINE TOOLS.

TAPTI, a river of western India. It rises in Betul district of the Central Provinces, flows between two spurs of the Satpura hills, across the plateau of Khandesh, and thence through the plain of Surat to the sea. It has a total length of 450 m. and drains an area of 30,000 sq.m. For the last 32 m. of its course it is a tidal river, but is only navigable by vessels of small tonnage; and the port of Swally at its mouth, famous in Anglo-Portuguese history, is now deserted, owing to silting.

TAPUYAN (GES), a large and important group of tribes of South American Indians, forming an independent linguistic stock. The name Tapuya under which this stock is usually known, is a Tupi (*q.v.*) word, meaning "enemy" or "stranger," and was applied by them to tribes of other affiliations as well. The stock has also been called Ges, which being less open to misunderstanding, is in many ways preferable. The area occupied by the Tapuyan (Ges) tribes covered a large part of the highlands of eastern Brazil, extending from the central part of the State of Maranhão south through Goyaz and Bahia to São Paulo and the borders of Matto Grosso. To the west, tribes of this stock are found as far as the Xingu river. At the time of the first European contacts they did not reach eastwards to the Atlantic coast, which was held by a thin strip of intrusive Tupi peoples. But at an earlier period Tapuyan tribes probably extended to the shore both in Bahia and Maranhão.

Physically the majority of the Tapuyan tribes appear to belong to the older long-headed stratum of the population. The Botocudos (*q.v.*) resemble the prehistoric makers of the shell-heaps or sambaquis of the Brazilian coast, whereas the tribes more in the interior represent the type of the crania from the Lagoa Santa caves. The culture of these tribes was generally extremely simple. They went as a rule entirely without clothing, and wore labrets and large wooden discs as ear-ornaments. They built only temporary shelters of poles and leaves, depended mainly on hunting, fishing and wild jungle products for food and were often cannibalistic. They had no pottery, textiles or canoes, and some tribes were said to be without the dog. The bow and club were their chief weapons. For the most part they lived in small local groups, with very simple social organization. The dead were buried in shallow graves, and not interred in burial urns as among the Tupian tribes. Very little is known of their religious beliefs or practices, and in general these tribes have been but superficially studied.

See C. F. P. von Martius, *Beiträge zur Ethnographie und Sprachenkunde Amerika's* (Leipzig, 1867); Maximilian, prince of Wied-Neuwied, *Reise nach Brasilien* (Frankfurt, 1821); H. A. Coudreau, *Voyage au Tacontins-Araguaya* (Paris, 1897); F. Krause, *In den Wildnissen Brasiliens* (Leipzig, 1911). (R. B. D.)

TAR: *see* NAVAL STORES; COAL TAR; CAMPHORS; WOOD FINISHES; GAS MANUFACTURE; TARS, LOW TEMPERATURE.

TARA, THOMAS PRESTON, 1ST VISCOUNT (1585–1655), British soldier, who distinguished himself in the defence of Louvain in 1635, and was in the same Irish regiment in the Spanish service as his rival Owen Roe O'Neill. Preston, who was appointed general of Leinster, took a prominent part in the war of factions that raged intermittently in Ireland from 1642 to 1652. In 1650 Charles II. while in exile created him Viscount Tara; and after his departure from Ireland in 1652 he offered his services to Charles in Paris, where he died in October 1655. His wife was a Flemish lady of rank, by whom he had several children, one of his daughters being the second wife of Sir Phelim O'Neill.

TARA, a village of co. Meath, Ireland. It is celebrated for the Hill of Tara, which was for many centuries a royal residence and the scene of great meetings of the people. The isolated hill, upon which five highroads converged, is about 510 ft. in height. On it are six raths or circular earthworks, the largest of which, the king's rath (*rath-na-riogh*), encloses other works, including the *forradh* or meeting-place, a flat-topped mound. On this (but not in its original position) stands a pillar stone, said to be the stone of destiny on which the Irish kings were crowned. An oblong enclosure, 759 ft. in length by 46 ft. in breadth, formed of earthworks, with entrances at intervals on each side, represents the banqueting hall. In the middle of the 3rd century A.D. King Cormac Mac Art is said to have founded here schools of military science, law and literature. In the time of St. Patrick Tara was a great centre of pre-Christian religious rites, and about 560 it was abandoned as a royal residence. Here the Danes were defeated in 980; here also, in 1798, a severe defeat was suffered by the insurgents; and in 1843 the hill of Tara was the scene of one of Daniel O'Connell's mass meetings in support of the repeal of the legislative union (Aug. 15).

TARAHUMARE, an Indian nation of Uto-Aztecan family, Piman division, in the Sierra Madre in southern Chihuahua and Sonora, Mexico. They number 30,000. Partly converted to Christianity in the 17th century, they preserve much of their ancient religion, including a cult of the peyote, a drug-containing cactus. They farm, but live scattered, are docile in disposition, and still weave cloth, use the bow and arrow, and poison fish in streams. They are remarkable distance runners. Much in their habits and beliefs recalls the Pueblos of the American South-west.

TARAI (*i.e.*, "moist land"), the name of the submontane strip of marshy jungle stretching beneath the lower ranges of the Himalaya in northern India. This strip may be said to extend roughly from the Jumna river on the west to the Brahmaputra on the east, and a large portion of it lies within Nepal. The term, however, is now officially confined to a subdivision of Naini Tal district in the United Provinces. At its northern edge, where the waterless forest tract of the Bhabar ends, a series of springs burst from the surface, and these, increasing and uniting in their progress, form the numerous streams that intersect the Tarai. The Deoha is the great river of the Tarai proper, and is navigable at Pilibhit. Elephants, tigers, bears, leopards and other wild animals are found. Everywhere it is most unhealthy, and inhabited only by tribes who seem proof against malaria, though large tracts are now being reclaimed for cultivation and settled with agriculturists from the plains.

TARANCHI. The Taranchi or Ili-Tatars, numbering about 100,000, are a branch of the Iranian Turks, and live in Semirechie and in Transcaspia, whither they migrated when Kulja passed under Chinese rule. They are closely related to the Sarts in religion, culture and language, differing from them principally in allowing their women more freedom.

TARANTELLA, Italian dance of a rapid whirling character, popularly believed to be a cure for the supposed poisonous sting of the Tarantula spider, whence it would appear to be natural to derive its name. In point of fact, however, this is to be referred, not to the tarantula, but to the place Taranto, in Apulia, which gave its name also to the curious disease known as tarantism. This was an hysterical malady prevalent in the region in question in earlier centuries, one of the characteristic features of which was a tendency to dance, which at the same time served as the best means of working it out of the system. Hence, therefore, the real origin of the name, its popular and mythical association with the tarantula having arisen later.

TARANTO (anc. *Tarentum, q.v.*), a seaport of Apulia, Italy, and the capital of a province 50 m. from Lecce W. by N. by road, and 68 m. by rail (44 m. W. by S. from Brindisi). Pop.

(1921) 55,292 (town) 103,687 (commune). The city proper is situated on a rocky island 56 ft. above sea-level, which, in ancient times was a peninsula, the isthmus on the west having been cut through by Ferdinand I. of Aragon. This island separates the Gulf of Taranto (Mar Grande) from the deep inlet of the Mar Piccolo, and is sheltered by two other flat islands, San Pietro and San Paolo. This rock is the site of the citadel of the ancient town; its population is confined within small houses and narrow streets. The Strada Garibaldi along the Mar Piccolo is inhabited by fishermen whose language retains traces of Greek. The cathedral, dedicated to San Cataldo, an Irish bishop, has externally some remains of Saracenic Gothic; internally it has been completely modernized (retaining however 16 ancient columns in the nave) and the shrine of the patron saint has been termed "an orgy of rococo" (1657). It has a crypt of the 6th or 7th century. There is a museum in the former convent of San Pasquale, with an especially fine collection of vases, terra cottas, and silverware, jewellery, Greek statuary, mosaics, etc., from Taranto and other sites in Apulia. Adjacent is the Palazzo degli Uffizi, containing various public offices. To the east, across the swing bridge over the channel connecting the Mar Grande with the Mar Piccolo is the new part of the town, on the site of the main part of the ancient city, extending as far as the Arsenal and even beyond: while the Boyo, with the railway station, lies to the west of the island. Here too is the unimportant commercial harbour. The chief industry is the cultivation of oysters in the Mar Piccolo; besides oysters Taranto carries on a large trade in *cozze*, a species of large black mussel, which is packed in barrels, with a special sauce. Excellent fish abound in the Mar Piccolo, ninety-three different species being found. The ebb and flow of the tide is distinctly visible here, Taranto being one of the few places in the Mediterranean where it is perceptible. In 1861 the strategic importance of Taranto was recognized, and the arsenal is the most important in Italy after Spezia. It extends for a mile and a half along the southern coast of the Mar Piccolo, which constitutes its chief basin. The receiving-dock and the anchorage for torpedo boats, with its wide landing-stage, form dependencies: and the Mar Piccolo provides a well-sheltered anchorage, 36 ft. deep and 6,325 acres in extent. There is also a large private shipbuilding yard, a brewery, a flourmill, oilmills, etc.

In 927 Taranto was entirely destroyed by the Saracens, but rebuilt (though henceforth restricted to the island) in 967 by Nicephorus Phocas, to whom is due the construction of the bridge over the channel to the north-west of the town, and of the aqueduct which passes over it. The town was taken by Robert Guiscard in 1063. His son Bohemund became prince of the Terra d'Otranto, with his capital here. After his death Roger II. of Sicily gave it to his son William the Bad. In 1301 Philip, the son of Charles II. of Anjou, became prince of Taranto. The musician Giovanni Paisiello (1741–1816) was born here. The castle, originally Byzantine, dates in its present form from 1480 and 1577. The tarantula (*see* below), inhabits the neighbourhood of Taranto. The wild dance, called *tarantella* (*q.v.*), was supposed, by causing perspiration, to drive out the poison of the bite. (T. A.)

TARANTULA, strictly speaking, a large spider (*Lycosa tarantula*), which takes its name from the town of Taranto (Tarentum) in Apulia, near which it occurs and where it was formerly believed to be the cause of the malady known as "tarantism." This spider belongs to the family Lycosidae, and has numerous allies in various parts of the world. The tarantula, like all its allies, spins no web as a snare but catches its prey by speed of foot. It lives on dry, well-drained ground, and digs a deep burrow lined with silk to prevent its falling in. In the winter it covers the orifice with silk, and hibernates in a dormant condition. It also guards its cocoon and young in the burrow. It lives for several years. The sexes are approximately the same size but do not surpass ¾in. in length of body. Like all spiders, the tarantula possesses poison glands in its jaws, but a particle of the secretion of these glands is not more virulent than that of other spiders of the same size.

Tarantula is often applied indiscriminately to many large spiders not related to *Lycosa tarantula;* and to at least one Arachnid belonging to a distinct order, *Galeodes luscasii* of the Egyptian desert. In English-speaking parts of the American continent, the Aviculariidae, or "bird-eating" spiders, much larger and more venomous than any Lycosidae, are called tarantulas.

TARAPACÁ, a northern province of Chile, bounded N. by Tacna, E. by Bolivia, S. by Antofagasta, and W. by the Pacific. Area 16,386 sq. miles. Pop. (1920) 100,553. It is part of the rainless desert region of the Pacific coast of South America, and is absolutely without water except at the base of the Andes where streams flow down into the sands and are lost. In some of these places there is vegetation and water enough to support small settlements. The wealth of Tarapacá is in its immense deposits of nitrate of soda (found on the Pampa de Tamarugal, a broad desert plateau between the coast range and the Andes, which has an elevation of about 3,000 ft.). The mining and preparation of nitrate of soda for export maintain a large population and engage an immense amount of capital. Silver is mined in the vicinity of Iquique, the capital. The ports of the province are Pisagua, Iquique and Patillos, from which "nitrate railways" run inland to the deposits. Tarapacá was ceded to Chile by Peru after the war of 1879–83, and was organized as a province in 1884.

TARARE, a town of east-central France, in the department of Rhône, on the Turdine, 28 m. W.N.W. of Lyons by rail. Pop. (1926) 11,206. It is the centre of a region engaged in the production of muslins, tarletans, embroidery and silk-plush, and in printing, bleaching and other subsidiary processes. The manufacture of muslins was introduced from Switzerland in 1756. The manufacture of Swiss cotton yarns and crochet embroideries was introduced at the end of the 18th century; at the beginning of the 19th figured stuffs, open-works and zephyrs were first produced. The manufacture of silk-plush for hats and machine-made velvets was set up towards the end of the 19th century.

TARASCA, the native people of the State of Michoacan, west of Mexico city and valley; of distinctive language. They beat off Aztec attempts to conquer them, and remained independent under a national overlord residing at Tzintzuntzán, on Lake Pázcuaro. Their culture was the generic one of southern Mexico, but simpler than that of the Aztecs or Mayas, and pottery vases and figures from the Tarascan area show persistence of Archaic traits. Neither their archaeology, ethnology, nor language has been systematically explored by modern methods.

See N. Leon, *Los Tarascos* (1904); E. Seler, *Gesammelte Abhandlungen,* iii. (1908).

TARASCON, a town of south-eastern France, in the department of Bouches-du-Rhone, 62 m. N.W. of Marseilles by rail. Pop. (1926) 5,058. Tarascon stands on the left bank of the Rhône opposite Beaucaire, with which it is connected by a railway bridge and a suspension bridge. The church of St. Martha, built in 1187–97 on the ruins of a Roman temple and rebuilt in 1379–1449, has a Gothic spire and interesting tombs in the crypt. Of the original building there remain a porch and a side portal flanked by marble columns with capitals like those of St. Trophimus at Arles. The former leads to the crypt, where are the tombs of St. Martha (1658), Jean de Gossa, governor of Provence under King René, and Louis II., king of Provence. The castle, built on a rock, was begun by Count Louis II. in the 14th century and finished by King René in the 15th. It contains a turret stair and a chapel entrance, both 15th-century, and fine wooden ceilings. The building is now used as a prison. The hôtel-de-ville dates from the 17th century. The civil court of the arrondissement of Arles is situated at Tarascon, which also possesses a commercial court, and fine cavalry barracks. The so-called Arles sausages are made here, and there is trade in fruit and early vegetables. In *Tartarin de Tarascon* Alphonse Daudet has satirized the provincial life of Tarascon, which has a tribunal of commerce and the fair of Beaucaire. It formerly had the two fêtes of La Tarasque, the latter in celebration of St. Martha's deliverance of the town from a legendary monster of that name. King René presided in 1469, and grand exhibitions of costume and strange ceremonies take place during the two days of the festival. Tarascon was originally a settlement of the Massaliots, built on an island of the Rhône. The mediaeval castle, where

Pope Urban II. lived in 1096, was built on the ruins of a Roman camp. Tarascon preserved the municipal institutions granted it by the Romans, and of the absolute power claimed by the counts of Provence only recognized the rights of sovereignty.

TARASP-SCHULS, a Swiss railway station in the lower Engadine, giving its name to a group of villages of which Schuls, the capital of the lower Engadine, situated about 160 ft. above the Inn river, is the chief. Tarasp is famed for its springs, which have been known since the middle ages, but it lies low in the valley and many visitors live at Vulpera, above the south bank of the Inn river. Above the village of Tarasp is the early mediaeval castle of that name, heavily restored as in 17th century style in recent years. The neighbourhood is famed for its beauty.

TARAXACUM, the botanical name for the common dandelion (*q.v.*).

TARBELL, EDMUND C. (1862–), American artist, was born at West Groton, Mass., on April 26, 1862. He was a pupil of the schools of the Boston Museum of Fine Arts and of Boulanger and Lefebvre, Paris, and became a distinguished painter of the landscape, of the figure, and of portrait. He won the gold medal of the National Academy of Design in 1908, the bronze, silver and gold medals of the Carnegie International exhibition at Pittsburgh, Pa., and various other important prizes and medals. He is represented in the museums of many American cities. In 1906 he was elected a National Academician, besides being a member of the Ten American Painters. He was instructor of painting in the Boston Museum of Fine Arts, and was later principal of the Corcoran School of Art, Washington, D.C., and chairman of the council of the school of the Museum of Fine Arts, Boston, Massachusetts.

See F. W. Coburn, "Edmund C. Tarbell," *International Studio,* vol. xxxii., p. 75–77 (1907); and J. E. D. Trask, "About Tarbell," *Amer. Mag. of Art,* vol. ix., p. 217–228 (1918).

TARBERT, fishing village at the head of East Loch Tarbert, an arm of the sea on the west shore of the mouth of Loch Fyne, Argyllshire, Scotland. Pop. (1921) 1,705. The harbour, though it has a narrow entrance, is absolutely safe and can shelter the whole Loch Fyne fishing fleet. The pier for the passenger steamers that call here is about ¾ m. from the village. The herring fishery—including a large trade in curing—forms the only industry. Overlooking the harbour are the ruins of a castle built by Robert Bruce in 1326. The isthmus connecting the districts of Knapdale and Kintyre is little more than one mile wide, and boats used once to be dragged across to the head of West Loch Tarbert, a narrow sea loch nearly ten miles long.

TARBES, a town of south-western France, capital of the department of Hautes-Pyrénées, 98 m. W.S.W. of Toulouse on the Southern railway. Pop. (1926) 26,745. Under the Roman dominion *Turba,* which was about 11 m. S.E. of the present town of Tarbes, was the capital of the Bigerriones, one of the states of Novempopulania. The bishopric of Tarbes dates from the 5th century, and in feudal times its bishops held the chief temporal authority, that of the counts of Bigorre, of which Tarbes was capital, being limited to the quarter of the town where their castle was built. The English held the town from 1360 to 1406. In 1569–70 Tarbes was twice taken by Gabriel, count of Montgomery, and the inhabitants driven out, but in August 1570 the peace of St. Germain allowed them to return. Subsequently Tarbes was several times taken and re-taken, and a number of the inhabitants of Bigorre were forced to take refuge in Spain, but in 1594 the members of the League were finally expelled. The English, under Wellington, gained a victory over the French near Tarbes in 1814. Tarbes stands in a fertile plain, stretching to the Pyrenees, on the left bank of the Adour, streams from which are conducted through the town. The lines of the Southern railway from Morcenx to Bagnères-de-Bigorre and Lourdes and from Toulouse to Bayonne cross here. Chief among the many open spaces is the Jardin Massey (35 acres), given to his native town by a director of the gardens of Versailles and containing a museum of paintings and antiquities. Near a small lake stands a cloister (15th century) brought from the abbey of St. Sever-de-Rustan, 14 m. N.E. of Tarbes. The architecture of the cathedral, Notre Dame de la Sède, is heavy, but the cupola of the transept (14th century), and a rose window of the 13th century, in the north transept, are interesting. There is also a modernized Carmelite church of the 13th century. Tarbes is the seat of a bishopric under the archbishop of Auch, of a prefecture, tribunals of first instance and of commerce, a chamber of commerce and a board of trade-arbitrators. Tarbes has an important stud for the breeding of Anglo-Arabian horses, much used by light cavalry. The industrial establishments include tanneries, potteries, sawmills and turners' shops. There are important fairs and markets.

TARBUSH, the close-fitting, flat-topped and brimless cap, in shape like a truncated cone, made of felt or cloth, worn by Mohammedan men throughout the East either as separate headgear or forming the inner part of the turban. It used to be worn as the badge of a Turkish subject in Turkey and Egypt, where it was red in colour with a black or blue silk tassel. It is the same as the "fez." In September 1928, Turkish citizens were forbidden to wear the fez, under severe penalties, by President Kemal Pasha.

TARDE, GABRIEL (1843–1904), French sociologist. He was professor of modern philosophy at the Collège de France, Paris, and an official of the ministry of justice. For a bibliography of his many important works *see* M. M. Davis, *Psychological Interpretations of Society* (1909). His *Psychologie économique* (1902) was translated into English as *Social Laws.*

TARDIEU, ANDRÉ PIERRE GABRIEL AMÉDÉE (1876–), French politician and writer, was born in Paris on Sept. 22, 1876. Educated at the École Normale Supérieure, he was *chef de cabinet* to Waldeck-Rousseau from 1899 to 1902. From 1902 to 1914 he lectured at the École des Sciences Politiques and the École Supérieure de la Guerre, and was foreign news editor on *Le Temps.* Entering the chamber of deputies in 1914 he acted as special commissioner in the United States (1917–18), member of the Peace Conference (1918–19), and minister of the liberated regions (1919–20). As captain of Chasseurs between 1914 and 1916, he was wounded and three times mentioned in despatches. At the Peace Conference (1919) he had a considerable share in drafting the political and territorial clauses. He presided over the Committee of Five which drafted the Allied Reply to the German Observations on the draft terms of the Peace Treaty. Tardieu also presided over the Alsace-Lorraine Committee, the Committee of the Saar and that of the execution of the treaty.

Tardieu's political attitude was characterized by his inflexible attachment to the policy of Clemenceau, with whom he was associated in the closest collaboration for war and for peace. Three times in succession, between 1919 and 1924, he refused to enter the Government, in order to maintain his independent defence of this policy. As director of the *Echo National,* the daily paper founded by Clemenceau and himself, he waged a fierce war, in foreign affairs, against the successive revisions of the Treaty of Versailles; and in internal affairs, against the steps which paved the way for the victory of the *cartel des gauches.* Between 1924 and 1926 he had no seat in the Chamber, but in Feb. 1926 he was elected once more, and in July joined the Poincaré cabinet as minister of public works and of the liberated regions.

Tardieu was the author of the following historical works: *Questions Diplomatiques* (1905); *France and the Alliances* (1908); *La conférence d'Algésiras* (1909); *Le Prince de Bulow* (1909); *Fürst v. Bulow* (1910); *La France et les alliances* (1910); *Le mystère d'Agadir* (1912); *Notes sur les Etats-Unis* (1917); *L'Amérique en armes* (1919); *La Paix* (1921); *Le Slesvig et la Paix* (1925).

TARDIGRADA, a class of animals probably belonging to the Arthropoda and sometimes referred to the Arachnida (*q.v.*), but without good reason. The Bear-animalcules, as these animals were formerly called, are all of small size, the largest being not much over 1 mm. in length, while most of them are very much smaller. They are not parasitic but are found in very variable habitats, in damp moss, on flowering plants, in sand, fresh water and even in the sea; and in adaptation to this wide range of external conditions a very large number of genera and species have been evolved.

The organism consists of a well developed head-region in front and of a short body composed of four fused segments, each represented externally by a pair of short, stout, unjointed limbs generally terminated by sharp claws, which seem to range in number from four to nine, but sometimes, as in *Batillipes*, ending in three pairs of racquet-shaped, digitiform outgrowths. The limbs of the last pair project backwards from the posterior end of the body on each side of the anus. The cuticle, which is not chitinised, may be smooth or sculptured in various ways and is sometimes strengthened with segmentally arranged plates (*Echiniscus*) and sometimes provided with long paired hair-like cirri.

No special organs of circulation or respiration are known. The alimentary canal traverses the body from end to end. Within the mouth is a pair of protrusible stylets, large glands open into the oesophagus, there is a muscular pharynx and large median and lateral glands open into the intestine posteriorly. The nervous system, which is remarkably well-developed, consists of a bilobed cerebral ganglion, frequently provided with a pair of eye-spots, and of a ventral chain of five large ganglia connected by lateral commissures. The sexes are not distinct and the generative products are discharged either into the posterior end of the alimentary canal or directly to the exterior through a median pore in front of the anus. The eggs are large and in some cases at least are enclosed, when laid, in the cuticle of the parent which is cast to form a case for them. The young when hatched are about one-third the size of the parent which they closely resemble apart from the occasional absence of one pair of limbs which is subsequently developed.

The Tardigrada are divided into two orders:—(1) The Eutardigrada (*Macrobiotus, Hypsibius, Milnesium*) in which the head is without cirri, the legs are not telescopically retractile and the four claws of each foot are coalesced to form a single pair of branched claws; and (2) the Heterotardigrada (*Echiniscus, Batillipes*, etc.) in which the head is provided anteriorly with two pairs of cirri, and on each side with one long cirrus and a shorter spatulate process, the *clava*, the legs are to a varying extent telescopically retractile and the claws are not coalesced.

The Tardigrada cannot be assigned with complete confidence to the Arthropoda, or Gnathopoda, until it be proved that their oral stylets are modified appendages. Assuming that they belong to the Arthropoda, they must rank as a class by themselves. They have been generally relegated to the Arachnida on the supposition of their kinship with the Acari, but their internal and external anatomy make such an affiliation unlikely. They have also been compared to *Peripatus* mainly on account of the structure of their limbs; but there seem to be no good reasons for regarding the two types as related. (R. I. P.)

TARDIVEAU, RENÉ: *see* Boylesve, René.

TARENTUM, a Greek city of southern Italy (Gr. Τάρας), (mod. Taranto, *q.v.*), situated on the north coast of the gulf of the same name, on a rocky peninsula at the entrance to the only secure harbour in it. The entrance was defended by the two islands called the Choerades (now S. Pietro and S. Paolo). It was a Spartan colony, founded by Phalanthus about 708 B.C. (*See* Sparta.) Taras was a mythical hero, son of Neptune. Situated in a fertile district, especially famous for olives and sheep, with an admirable harbour, great fisheries and prosperous manufactures of wool, purple and pottery, Tarentum grew in power and wealth and extended its domain inland. A great defeat by the natives in 473 B.C., led to a change of government from aristocracy to democracy. A feud with the Thurians about the district of the Siris was settled in 432 by the joint foundation of Heraclea.

In the 4th century Tarentum was the first city of Magna Graecia, and its wealth and artistic culture at this time are amply attested by its coins. (*See* Numismatics.) In the second half of the century Tarentum was in constant war with the Lucanians, and did not hold its ground without the aid of Spartan and Epirote *condottieri*. Then followed war with Rome (281), the expedition of Pyrrhus, whom Tarentum summoned to its aid, and at length, in 272, the surrender of the city by its Epirote garrison. Tarentum retained nominal liberty as an ally of Rome. In the Second Punic War it went over to Hannibal in 212, and suffered severely when it was retaken and plundered by Fabius (209), who sold thirty thousand citizens as slaves. It revived after receiving a colony in 123 B.C., which received the name of Neptunia. In the time of Augustus it was essentially Greek and a favourite place of resort (Horace, *Od.*, iii. 5, 53). Belisarius ordered it to be re-fortified, but it was soon taken by Totila, who made it his treasure store. After his defeat by Narses, it was sold to the Byzantine Empire by its Gothic governor.

One of the most interesting discoveries of recent years has been that of a *terramara* on the so-called Scoglio del Tonno on the north-west of the town, which in its type and in the character of the objects found there, is exactly identical with the *terremare* of the Po valley. It seems, however, to be an isolated colony, and not to prove a parallel development in north and south Italy. The only relic of any building of the Greek city is a part of a Doric temple on the island—two fluted columns, with a lower diameter of 6½ ft., and a height of 28 ft., and some fragments of the entablature, belonging probably to the beginning of the 6th century B.C. The rock occupied by the modern town was the citadel, but was connected with the land to the west by an isthmus, which was only cut through by Ferdinand I. of Aragon. The line of the walls which defended the city on the east (land) side has been traced, and a few remains of well-cut blocks, with Greek masons' marks, have been found. In the centre of the Agora was the huge bronze Zeus by Lysippus, and facing on to it the Ποικιλή, or painted portico, with pictorial representations of the life of Phalanthus, and the foundation of the city, and the museum. There was also a fine gymnasium and other buildings mentioned by classical writers. Strabo's description of the site (vi. 3, 1) is a good one. The Roman amphitheatre, on the other hand, and remains of Roman baths by the seashore, have been found; the former perhaps occupies the site of the ancient theatre, in which the Roman ambassador was received in 281 B.C. Tarentum was the birthplace of Archytas and Aristoxenes (*qq.v.*).

TARENTUM, a borough of Allegheny county, Pennsylvania, U.S.A., 17 m. N.E. of Pittsburgh, on the Allegheny river and the Pennsylvania railroad. Pop. (1920) 8,925 (82% native white). It has large industrial plants and there are several coal mines in the vicinity. Natural gas is used. Plate glass, glass bottles, table glass, steel tubing, brick and paper are leading products. Tarentum was settled in 1796, laid out in 1829 and incorporated as a borough in 1842. The first glass factory was established in 1872.

TÂRGOVIȘTEA, the capital of the department of Dimbovita, Rumania; situated at the foot of the Carpathians, on the right bank of the river Jalomita, 48 m. N.N.W. of Bucharest. Pop. (1928) 16,800. A branch line connects Târgoviștea with the main Walachian system, and is prolonged northwards into the hills, where there are rich deposits of petroleum, salt and lignite. Coal is also found but not worked. Apart from the scanty ruins of a 14th-century palace, the most interesting building in the town is the Metropolitan church, still one of the finest in the country, with its nine towers and monuments of the princely house of Cantacuzino. It was founded in 1515 by Neagoe Basarab, builder of the famous cathedral of Curtea de Argeș. Târgoviștea is a garrison town, with a cavalry training school and an artillery depot and repairing arsenal.

Târgoviștea was the capital of Walachia from 1383–1698. In the 15th century it was sacked by the Szeklers. Michael the Brave defeated the Turks under its walls in 1597. In the 16th century it had a population of 60,000 and contained 70 churches and 40 convents. Its importance and population decreased when the capital was moved to Bucharest.

TARGU JIU, a large garrison town and capital of the department of Gorj, Rumania; situated among the lower slopes of the Carpathians, on the left bank of the river Jiu, and at the terminus of a branch railway which joins the main Walachian line between Turnu Severin and Craiova. Pop. (1928) 20,000. The town has a considerable trade in timber, petroleum and farm produce. Anthracite coal is found in the neighbourhood. In the neighbouring hills are the monasteries of Tismana, Lairnici and Polovraci, much frequented as summer resorts.

TARGUM. The Targums are the Aramaic translations—or rather paraphrases—of the books of the Old Testament, and, in their earliest form, date from the time when Aramaic superseded Hebrew as the *spoken* language of the Jews. (*See* Hebrew

Language.) In their origin they were designed to meet the needs of the unlearned among the people who had ceased to understand the Hebrew of the Old Testament. In the absence of any precise evidence on the point it is impossible to give more than a rough estimate as to the period at which Hebrew, as a spoken language, was finally displaced by Aramaic. It is, however, certain that the latter language was firmly established in Palestine in the 1st century A.D. By that time, as we know from many sources, Aramaic was not only the language in common use, but had also received official recognition despite the fact that Hebrew still remained the learned and sacred tongue. Hence we may reasonably infer that the mass of the people had adopted Aramaic at a considerably earlier period, probably, as early as the 2nd century B.C., and that the need of Aramaic translations of the sacred text made itself felt but little later.

The Talmudic tradition, however, is, doubtless, correct in connecting the origin of Targums with the custom of reading sections from the Law at the weekly services in the synagogues, since the need for a translation into the vernacular must first have arisen on such occasions. As we know from the New Testament, the custom of reading in the synagogues both from the Law (Acts xv. 21) and from the Prophets (Luke iv. 10 f.; Acts xiii. 14, 27) was well established in the 1st century A.D.; its introduction, therefore, will date from a much earlier period. The practice of accompanying these readings with a translation into Aramaic is, further, so generally recognized by the 2nd century A.D. that the Mishna takes it for granted, and merely inculcates certain regulations to be observed by the *Meturgemān* (translator), who had by this time acquired a definite status. From it we learn that the *Meturgemān*, who was distinct from the reader, translated each verse of the Law into Aramaic as soon as it had been read in Hebrew; in the readings from "the Prophets" three verses might be read at a time.

Judging by the contents of our existing Targums, and the Targumic renderings given in Jewish literature, it is improbable that any definite system of interpretation was ever formally adopted, the rendering into the vernacular being left to the discretion of the individual *Meturgemān*. At first, no doubt, the translator endeavoured to reproduce the original as closely as possible, but, inasmuch as his object was to give an intelligible rendering, a merely literal rendering would soon be found to be insufficient, and he would be forced, especially in the more difficult passages, to take a more elastic view of his obligations. To prevent misconception he must expand and explain what was obscure, adjust the incidents of the past to the ideas of later times, emphasize the moral lessons to be learned from the national history, and, finally, adapt the rules and regulations of the Old Covenant to the conditions and requirements of his own age. As time went on the practice of introducing additional matter of an edifying character grew in popular favour, and was gradually extended. Thus, by degrees, the reproduction of the original text became of secondary importance, and merely served as a pretext for the discussion of topics that had little or no bearing on the context. The method, by which the text was thus utilized as a vehicle for conveying homiletic discourses, traditional sayings, legends and allegories, is abundantly illustrated by the Palestinian and later Targums, as opposed to the more sober translations of Onkelos and the Targum to the Prophets.

It would, however, be incorrect to suppose that the translation of the text was left entirely to the individual taste of the translator. The latter is rather to be regarded as the representative of the age in which he lived, and his interpretation is to be taken as reflecting the exegesis of that period. That there were certain limits beyond which the translator might not venture, without incurring the censure of the authorities, may be inferred from the few instances of translation which are mentioned with disapproval in the Mishna and elsewhere. A definite rule for guidance in translating is apparently preserved in the *Tosefta* where it is stated that "he who translates quite literally is a liar, while he who adds anything is a blasphemer."

There can be little doubt that the Targums existed for a long time in oral form. They belonged to the class of traditional literature which it was forbidden to write down, and, so long at least as the Targum tradition remained active, there would be little temptation to commit it to writing. But it is highly probable that this prohibition, in the case of the Targums, was mainly enforced with respect to those parts of the Old Testament which were read in the synagogal services, *e.g.*, the Law and the Prophets, and that it was less rigidly observed in regard to the other portions of Scripture; a written translation of the latter would be of special value for the purpose of private study. Hence there is no need to reject the tradition as to the existence of a written Targum on Job in the time of Gamaliel I. (1st century A.D.), especially as references to Targum mss. occur in the Mishna and elsewhere. But, as Dalman has pointed out, it was not these manuscripts, but the living tradition of the learned which was recognized as authoritative throughout the period which closes with the compilation of the Talmud. . . . The official recognition of a written Targum, and therefore the final fixing of its text, belongs to the post-Talmudic period, and is not to be placed earlier than the 5th century.

I. **Targums on the Pentateuch.**—(1) The so-called Targum of Onkelos admittedly owes its name to a mistaken reference in the Babylonian Talmud. In its original context, that of the Jerusalem Talmud, the passage refers to the Greek translation of Aquila. With the exception of this one reference, the Targum is always introduced in the Babylonian Talmud by the phrase "as we translate" or "our Targum"; it is probable, therefore, that the name of the author, or authors, was unknown to the Babylonian Jews. It is first quoted under the title of the Targum of Onkelos by Gaon Sar Shalom (d. A.D. 850). On the linguistic side we may regard Onkelos "as a faithful representative of a Targum which had its rise in Judaea, the old seat of Palestinian literary activity" (*Grammatik des jüdisch-palästinischen Aramäisch*, p. 12 f.). It is to be regarded as an official translation of the Law, in the Judaean dialect, which was carried out in Babylon, probably about the 4th century A.D.; in its final form it cannot be earlier than the 5th century. The translation, as a whole, is good, and adheres very closely to the Hebrew text, which has not been without its influence on the Aramaic idiom.

Of all the extant Targums that of Onkelos affords perhaps the most characteristic and consistent example of the exegetical methods employed in these works. Two principles may be said to have guided the translators. On the one hand, they had, as their primary object, to produce a faithful rendering of the original which at the same time would be intelligible to the people; for this purpose a purely literal translation would be insufficient. On the other hand, they regarded it as necessary to present the sacred text in such a manner as best to convey the particular form of interpretation then current. But later Jewish exegesis was especially concerned to eliminate everything in the sacred writings that might give rise to misconception with respect to God on the part of the unlearned. Hence we find various expedients adopted in the Targums for avoiding any reference to the Deity which might be misunderstood by the people, or which involved apparent irreverence. Examples of this peculiarly Targumic method are: (1) the insertion of "word," "glory," "presence" before the divine name, when God is referred to in his dealings with men; (2) the insertion of the preposition "before" when God is the object of any action; (3) the use of the passive for the active voice; (4) the use of periphrasis for the more pronounced anthropomorphisms, such as "to smell," "to taste"; (5) the use of different expressions, or the insertion of a preposition before the divine name, when God is compared to man, or the same action is predicated of God and man; (6) the use of ײ for יהוה and אלהים and the rendering טעותא or טעוא when אלהים denotes heathen gods. Instances of this endeavour to maintain, as it were, a respectful distance in speaking of God occur on every page of the Targums, but cases also occur, by no means infrequently, where human actions and passions are ascribed to God.

(2) In addition to the Targum of Onkelos two other Targums to the Pentateuch are cited by Jewish authorities, under the titles of the *Targum Jerushalmi* and the Targum of Jonathan ben Uzziel. Of these the former contains only portions of the Penta-

teuch and is therefore usually designated the Fragmentary (Jerusalem) Targum. Its fragmentary character arises from the fact that it is simply a collection of *variae lectiones* and additions to the version of Onkelos, intended possibly for use at public services.

The second Jerusalem Targum admittedly owes its ascription to Jonathan ben Uzziel to the incorrect solution of the abbreviated form by which it was frequently cited, viz., ת״י or *Targum Jerushalmi*. This Targum represents a later and more successful attempt to correct and supplement the Targum of Onkelos by the aid of variants derived from another source. It is not, however, a revision of the Fragmentary Targum—for it is clearly independent of that version—but is rather a parallel, if somewhat later, production, in which the text of Onkelos is already combined with a number of variants and additions. It exhibits, to a marked degree, that tendency to expand the text by additions of every kind, which has been already noted as characteristic of the later stages of Targumic composition. Homilies, legends, traditional sayings and explanations, in fact every form of Haggadic expansion are utilized by the Targumist, so that at times his works convey the impression more of a late *Midrash* than of a translation.

In regard to the source of the two Palestinian Targums to the Pentateuch, we must accept the conclusion of Bassfreund (*M.G.W.J.* xl.) that they both derived their variants from a complete *Targum Jerushalmi*. But though the existence of an older *Targum Jerushalmi* cannot be denied it cannot be of an early date, for many of the latest elements in the Fragmentary and pseudo-Jonathan Targums were undoubtedly derived from their common source. Moreover, the existence of a written Palestinian Targum at an early date is expressly excluded by the evidence at our disposal. In the middle of the 2nd century A.D. R. Simon ben Gamaliel forbade the translation of the Pentateuch in any language but Greek; and this command was upheld by R. Johanan in the 3rd century. Even in the time of the later Amoraim there is no mention of a written Palestinian Targum, though the official Babylonian Targum is repeatedly referred to in the Babylonian Talmud, in the Midrashim, and at times also by Palestinian Amoraim.

Yet it is impossible to hold that the Targum of Onkelos was the only representative of Targum tradition that existed among the Jews down to the 7th century A.D., the period to which the internal evidence compels us to assign the *Targum Jerushalmi* as used by the Fragmentary Targum and the pseudo-Jonathan. We must rather assume that a tolerably fixed Targum tradition existed in Palestine from quite early times. The language employed in the Targum of Onkelos is, admittedly, Palestinian or Judaean, and we may conjecture that the current Judaean exegesis, which, in part at least, must go back to the 2nd century A.D., was not without its influence on the Babylonian translation. This old Targum tradition, however, never received official recognition in Palestine, and was unable, therefore, to hold its own when the new Babylonian version was introduced. We may infer that, as time went on, a reaction in favour of the older renderings made itself felt, with the result that these were collected in the form of variants and appended to Onkelos. But the authority enjoyed by the latter rendered it secure against any encroachments; hence any later expansions, especially those of a popular Haggadic character, naturally found their way into the less stereotyped *Targum Jerushalmi*.

II. **Targums on the Prophets.**—The official Targum on the Prophets is stated by the Babylonian Talmud to have been "said" by Jonathan ben Uzziel, the disciple of Hillel, and is usually known, therefore, as the *Targum Jonathan*. Elsewhere in the Talmud, however, the quotations from this Targum are given under the name of Joseph bar Chijah, head of the school at Pumbadita in the 4th century A.D. Both in language and style it closely resembles the Targum of Onkelos, and appears to have been modelled on that translation: in certain passages, indeed, it appears to have made use of it. Probably, like Onkelos, it did not assume its final form in Babylon before the 5th century A.D. It naturally follows from the character of the original that the rendering of this Targum is less literal than that of Onkelos, especially in the prophetic books, but, when due allowance is made for the difficulty of the Hebrew, it may be described on the whole as a faithful reproduction of the original text. Its peculiarities of rendering are due to the same principles which were noted as underlying the translation of the Pentateuch. Anthropomorphisms, as a rule, are avoided by means of the same expedients as those employed by Onkelos, expressions derogatory to the dignity of God, or of the heroes of the nation, are softened down, while figurative language is either boldly transposed, or its character clearly shown by the introduction of the particle "as" or "like." There is, further, a tendency to narrow down the scope of the prophetic utterances, and to limit their application to Israel and its immediate enemies. Lastly, in the obscurer passages the Haggadic method of interpretation is employed to its fullest extent, while the translation throughout shows a marked tendency to explanatory additions.

Of a *Targum Jerushalmi* to the Prophets but little is known, though it is hardly doubtful that such a Targum existed, if only in oral form. Traces of this version have been discovered by Bacher in the variants attached to the margin of the *Codex Reuchlinianus*, and printed by Lagarde in his edition of *Prophetae Chaldaice* (1872). The quotations in *'Arūk* from Kings, Ezekiel, Proverbs and Lamentations point to the existence of a *Targum Jerushalmi* to those books.

III. **Targums to the Hagiographa.**—These Targums possess but little interest for the student of Jewish literature as they are almost entirely the work of individuals, made in imitation of the older Targums.

(1) *Targums to the Psalms and Job.*—These Targums present certain features in common and may therefore be treated under the same heading. Like all the later Targums they exhibit a large amount of explanatory addition, chiefly Haggadic in character. At the same time the translation of the original is not neglected; and, when separated from the later accretions, this is found to follow the Hebrew tolerably closely. Peculiar to these Targums are the double translations, which they give to many verses, one of which is usually Haggadic in character, while the other is more literal. They cannot be earlier than the 7th century A.D., and possibly are of a considerably later date.

(2) *The Targum to the Proverbs* stands apart owing to the peculiarity of the language in which it is written. The influence of the Peshitta version is so clearly marked, that Dalman describes it as a Jewish revision of that version. But setting aside the Syriasms due to the use of the Peshitta, the Targum shows affinity to the Targums to the Psalms and Job. The translation is literal and almost entirely free from Haggadic additions.

(3) *The Targums to the Megilloth.*—The chief characteristic of these Targums is their exaggerated use of paraphrase. They mark the final stage in the development of Haggadic interpretation, in which the translation of the text has practically disappeared in a mass of fantastic and irrelevant matter. The Targum of Esther is known to us in three recensions (1) that of the Antwerp Polyglot, almost a literal translation; (2) that of the London Polyglot, which gives practically the same text with many additions of a Haggadic character; (3) the so-called second (*shēnī*) Targum, a much larger work, containing a collection of later *Midrashim* to this book. According to Zunz this "second" Targum is quoted by Rashi (to Deut. iii. 4) as a Jerusalem Targum, and also (I Kings x. 19) as the "Haggada" of the Megilloth Esther. The Targum to Canticles is of a similar character to that of the "second" Esther. Dalman assigns these Targums to a date halfway between the Babylonian Targums (Onkelos and that to the Prophets) and the Jerusalem Targums to the Pentateuch and those to the greater Hagiographa. The British Museum possesses three important Yemen manuscripts for the five Megilloth and the "second" Esther Targum in mss. Or. 1302, 1476 and 2375.

(4) *The Targum to the Chronicles* was first edited from an Erfurt manuscript by M. F. Beck, 1680–1683. A more complete and accurate edition from a Cambridge manuscript was edited by D. Wilkins in 1715. In the translation, which at times is fairly literal, use appears to have been made of the Jerusalem Targums

to the Pentateuch, and of the Targums to the books of Samuel and Kings. The text represented by the Erfurt manuscript is assigned to the 8th, that of the Cambridge manuscript to the 9th century A.D.

No Targums have so far been discovered to Daniel and Ezra and Nehemiah. (J. F. S.)

See bibliog. on p. 39 of W. O. E. Oesterley and G. H. Box, *Short-Survey of Lit. of . . . Judaism* (1920). *See* also P. Churgin, *Targum Jonathan* (Yale, 1927).

TÂRGU-MUREȘ, a town of Transylvania, Rumania, capital of the department of Mureș, 79 m. E. of Cluj by rail. Pop. (1928), 23,500. It is situated on the left bank of the Mureș, and is a well-built town, once the capital of the territory of the Szeklers. On a hill dominating the town stands the old fortress, which contains a beautiful church in Gothic style built about 1446, where in 1571 the diet was held which proclaimed the equality of the Unitarian Church with the Roman Catholic, the Lutheran and Calvinistic Churches. The Teleki palace contains the Teleki collections, which include a library of 70,000 volumes and several valuable manuscripts (*e.g.*, the Teleki Codex), a collection of old Hungarian poems, and a manuscript of Tacitus, besides a collection of antiquities and another of minerals. Târgu-Mureș has also an interesting Szekler industrial museum. The trade is chiefly in timber, grain, wine, tobacco, fruit and other products of the neighbourhood. There are manufactures of sugar, spirits and beer.

TÂRGU-NEAMȚU, a town in the department of Neamtu, Rumania, situated among the lower slopes of the Carpathians, and on the left bank of the Neamtu, an affluent of the Moldova. Pop. (1928) 10,500, about half being Jews. A branch railway runs to Jassy. Nearby is the ruined fortress of Neamtu, constructed early in the 13th century by the Teutonic Knights against the Cumans (*q.v.*), and the monastery of Neamtu, founded in the 14th century, and containing two churches and many ancient and interesting relics. Before the secularization of the monastic lands in 1864, it was one of the richest and most important of the Rumanian monasteries. Baltatești, 10 m. W. by S. of Neamtu, is locally famous for its mineral springs and baths.

TARGU OCNA, a town of Rumania, on the left bank of the river Trotoș, an affluent of the Sereth, and on a branch railway which crosses the Ghimeș pass into Transylvania. Pop. (1928) 10,500. Targu Ocna is built among the Carpathian mountains, on bare hills formed of rock salt. Outside the town stands the largest prison in Rumania; beyond this are the mines, worked, since 1870, by convicts, who receive a small wage. The estimated total of the salt deposits is 264,000,000 tons, about 11,000 being extracted annually.

TARIFA, a seaport of Spain, in the province of Cadiz, at the extreme south point of the Peninsula, 21 m. by rail W.S.W. of Gibraltar. Pop. (1920) 11,957. Tarifa is the *Iulia Ioza* of Strabo, between Gades and Belon. According to that writer, it was colonized by Romans and the removed inhabitants of Zelis in Mauretania Tingitana. The *Iulia Transducta* or *Traducta* of coins and of Ptolemy appears to be the same place. Its present name, dating from early in the 8th century, is derived from Tarif. (*See* CALIPHATE and SPAIN: *History*.) In 1292 Tarifa was taken by Sancho IV. of Castile from the Moors. In the defence of Tarifa Alphonso XI. gained the battle of Salado, a short distance to the westward, in 1340. In 1812 a French force under Victor and Laval vainly endeavoured to capture Tarifa, then held by General Gough.

The town is nearly quadrangular, with narrow, crooked streets, and is still surrounded by its old Moorish walls. The rocky island in front of the town, connected with the mainland by a causeway, is fortified.

TARIFFS are lists of articles with their import or export duties noted. The term is also used for the laws regulating the duties and, in a number of countries, for any price schedules.

The United States.—The tariff history of the United States, like that of European countries, divides itself into two great periods, before and after the year 1860. The period before 1860 may again be divided into three sub-periods, the first extending from 1789 to 1816, the second from 1816 to about 1846, the third from 1846 to 1860.

I. (*a*) The Tariff Act of 1789 was the first legislative measure passed by the United States. The Protectionists have pointed to it as showing the disposition of the first Congress to adopt at once a policy of protection; the free traders have pointed to it similarly as showing a predilection for their policy. Each has some ground for the claim. The duties of the act of 1789 were very moderate, and, as compared with those which the United States has had under any subsequent legislation, may be described as free trade duties. On the other hand, the spirit of the act of 1789 was protective. Such in the main remained the situation until 1816, duties being indeed raised from time to time in order to secure more revenue, but the spirit and the general rate of the duties not being sensibly modified.

(*b*) After the close of the War of 1812, however, a new spirit and a new policy developed. A demand arose for two closely connected measures: protection to domestic manufactures and internal improvements. Protection was demanded as a means both of aiding young industries and of fostering a home market for agricultural products; it was a part of the "American system." Some movement in the direction of lighter duties was manifested as early as 1816. Still greater changes were made in 1824, 1828 and 1832. The tariff of 1828 was affected by some political manipulation, which caused it to contain objectionable provisions, and to be dubbed "the tariff of abominations." The so-called abominations were removed in 1832, when the protective system was deliberately and carefully rearranged. By this time, however, the opposition to it in the South had reached a pitch so intense that concessions had to be made. The nullification movement led in 1833 to the well-known compromise, by which the rates of duty as established by the act of 1832 were to be gradually reduced, reaching in 1842 a general level of 20%. But the reductions of duty made under it proved ephemeral. In 1842, when the final 20% rate was to have gone into effect, the protectionists again had control of Congress, and after a brief period of two months, during which this 20% rate was in force, passed the Tariff Act of 1842, which once more restored the protective system in a form not much less extreme than that of 1832.

(*c*) Four years later, however, 1846, a very considerable change was secured by the South, and a new era was entered on. The Democratic party now was in control of legislation, and in the Tariff Act of 1846 established a system of moderate and purely *ad valorem* duties, in which the protected articles were subjected, as a rule, to a rate of 30%, in some cases to rates of 25 and 20%. The system, often spoken of as one of free trade, was in reality only one of moderated protection. In 1857 duties were still further reduced, the rate on most protected commodities going down to 24%.

II. The second great period in the tariff history of the United States opens with the Civil War. In the session of 1860–61, immediately preceding the outbreak of the conflict, the Morrill Tariff Act was passed by the Republican party, then in control because the defection of Southern members of Congress had already begun. The advances then made were of little importance as compared with the far-reaching increases of duty during the Civil War. Duties were steadily raised, partly by way of off-set to the internal taxes, partly to get additional revenue and largely because of a disposition to protect domestic industries. The close of the war thus left the United States with a complicated system of very high taxes both on imported and on domestic products.

The main features of the tariff history of the United States in the years after the Civil War were that the internal taxes were almost entirely swept away and the import duties on purely revenue articles similarly abolished, while those import duties that operated to protect domestic industries were maintained, and in many cases increased. Efforts were indeed made to reduce the tariff duties, but met with strong opposition, and in the end were almost completely frustrated. The decade immediately following the war brought about the gradual transformation of the high taxes levied on all commodities for revenue purposes into a system of high duties almost wholly on protected commodities. This transformation met with much opposition, not less in the Republican party than in the Democratic party. The opposition led to a general revision in 1883, which, on the whole, served rather to put things in order than to make any change of policy.

The tariff system as revised and codified in 1883 would probably have remained unchanged for many years had it not been for an unexpected turn taken by political and financial history. In the second half of the decade 1880–90, a continuous large surplus in the Treasury directed attention to the state of the revenue, and gave strength to the protests against excessive taxation. In addition, the Democratic party, which had long been committed, though in a half-hearted way, against the policy of high protection, was brought to a vigorous and uncompromising attack on it through the leadership of President Cleveland. In his presidential message of Dec. 1887 he attacked the system in unqualified terms. The Republicans, as is almost inevitable under a party system, championed the policy opposed by the other side, and declared themselves in favour of the consistent and unqualified further application of protection. The protective question thus became the main issue in the presidential election of 1888, which resulted in the defeat of the Democrats. In the next ensuing session of Congress, the Republicans passed the McKinley Tariff Act. It advanced duties materially on a considerable number of commodities, both raw materials and manufactured articles. A further step towards consolidating the protective system was taken by abolishing the duty on sugar, mainly a revenue duty. For consistency in maintaining the protective principle a direct bounty was given to the domestic producers of sugar in Louisiana. Another turn in the political wheel brought an abrupt change four years later, in 1894. President Cleveland, defeated four years before, was now again elected, and the Democratic party came into power, pledged to change the tariff system. Accordingly the tariff act of 1894 was passed, known as the Wilson Tariff, bringing about considerable reductions of duty. The measure, however, was less incisive than its chief sponsors had planned, because of the narrow majority commanded by the Democrats in the Senate. The most radical change was that the duty on wool, typical among the duties on raw materials, was completely abolished, and with this came a great reduction in the duties upon woollen goods. A duty was reimposed on sugar, chiefly as a means of securing needed revenue, but at a less rate than had existed before 1890; the bounty of 1890 was abolished. The next election in 1896 brought still another turn, the Republicans being once more brought into power under the leadership of President McKinley. At the extra session which President McKinley called in 1897, almost the sole measure considered was the tariff act, known as the Dingley Act. This reimposed the duties upon wool, on most qualities at the precise rates of 1890, on some qualities at even higher rates. Necessarily the duties on woollens were correspondingly raised, and here again made even higher than they had been in 1890. The tariff act of 1909, amending that of 1897, did not appreciably change the situation. It made certain reductions in duties, such as the rates on hides, wool tops and various iron and steel products; but except in the case of hides, the reductions were in most cases more nominal than real. The net result was to leave the general height of the tariff at much the same level as had previously ruled. At the next presidential election in 1912 the Democrats, for the first time since 1892–4, gained control of both the executive and legislative branches of the Government. Immediately the Democratic leaders began the revision of the tariff law. In the act of 1913 most raw materials, including raw wool, were placed upon the free list; the complicated schedules that had grown up in the Republican tariffs were largely scrapped; and the effective protection upon semi-manufactured and wholly manufactured articles was markedly decreased. Sugar was to be admitted free. But the abolition of the sugar duty was not to take effect till 1917; by that time the great war had set in; and under the war conditions, the duty was retained, though at a lower rate than that of 1909.

The act of 1913, however, proved to be of little practical significance. The outbreak of the World War in 1914 made impossible all competition from abroad with United States industries. This situation endured for a year or two after the close of the war, and it was not until the collapse of 1920–21 that serious consideration was again given to the tariff problem. By that time the Republicans were again in power, and were so firmly entrenched, after their decisive victory at the polls in 1920, that they did not hesitate to restore the protection of pre-war days and even increase it. The agricultural regions of the Central West were hardest hit by the great decline in prices, and clamoured for some remedy. The Republicans followed their traditional policy of holding forth a high tariff as the remedy for all ills, and at once enacted the Emergency Tariff Act of 1921, which provisionally reimposed the duty on wool, and raised those on sugar, wheat, corn, meat. In 1922 a general revision was made, and a new complete tariff act was passed. The duties on agricultural products were still further increased, and those on manufactured goods, such as woollens, cottons, silks, pottery, hardware, were either put at the level of the tariff act of 1909 (the last preceding high tariff act) or raised above that level. Some articles previously admitted at low rates were now subjected to high ones, such as dyestuffs and chemicals. All in all, the protective policy was carried higher than ever before. At the same time a new administrative policy was introduced, by giving the tariff commission certain powers as regards modification and adjustment of duties.

Great Britain.—England emerged from the mercantilist policies of the 17th and 18th centuries with a tariff system that not only imposed high rates but was extraordinarily complicated and confused. The first steps toward the radical change which was to come in the 19th century were taken by Pitt. In 1787 he caused the Consolidation Act to be passed, which codified the previous intricate mass of scattered, inconsistent and cumulative duties. In 1786 he also arranged a commercial treaty with France providing for substantial reciprocal reductions of duties; but this measure, unlike that for consolidation, was swept away by the French Revolution. After 1815 English tariff history is marked by two great changes: on the one hand the modification and finally the repeal of the corn laws; on the other, the steady succession of acts which gradually cut down the duties on all other goods and led eventually to the complete adoption of free trade. The corn laws, it is true, were first strengthened; then experiments were made with sliding scale duties, designed to keep the price of corn stable; and finally they were suddenly wiped out at the time of the Irish famine of 1846. They had political support because of the predominance of the gentry and the landed interests in both houses of parliament. But industrially as well as politically they were vulnerable, and inevitably collapsed in a crisis like that of the famine. The other series of events began with Huskisson's measures of 1824, which reduced duties, especially on raw materials such as wool, and went on with a succession of measures until the last remnant of protection disappeared in 1860. The notable steps were Peel's act of 1842, an important and far reaching measure; Peel's second important act, in 1846, contemporaneous with the corn law repeal; Gladstone's famous budget of 1853; and finally in 1860 the removal of the silk duties, the last of the protective duties which had been retained. This final step of 1860 was taken in connection with the Cobden-Chevalier treaty with France, noted below. For half a century thereafter, England was on a free trade basis and was the stronghold of free trade. The system was suited to her industrial development during the period, enabling her manufactures to develop at an extraordinary rate, while foodstuffs and raw materials were imported in ever increasing volume. The system seemed entrenched beyond attack, and this notwithstanding the fact that the landed interest was hard hit by the decline in agricultural prices from 1873 to the close of the century. It was not until the World War of 1914–18 that a change took place, and it then took place to an extent which could not have been expected and, indeed, was not expected when the initial steps were taken. Very shortly after the outbreak of the war in 1915 certain duties were imposed upon luxuries, the so-called McKenna duties; being at the rate of $33\frac{1}{3}\%$ on watches, pleasure motors, cinema films and the like. Immediately after the war some further changes were made in the same direction, yet still susceptible of interpretation on other grounds than that of a return to protection pure and simple. In 1919 imperial preference to the colonial products, long urged by the colonies themselves, was granted on tea, coffee, cocoa, sugar, the most important being the preference on sugar. In 1920, again, the imports of dyestuffs and coal-tar dyes were completely prohibited, this being in the nature of a war measure, designed to ensure the domestic production of military explosives, and also that of dyestuffs whose importance to textile industries was deemed cardinal. In 1921 came the Safeguarding of Industries Act, which went a step further, imposing a duty of 33⅓% on the product of the so-called key industries, such as optical instruments, barometers, wireless apparatus. In the same year came the anti-dumping act, imposing a 33⅓% duty on goods sold in England below cost or sold at particularly low prices because of depreciated currency elsewhere. Some of these duties were repealed by the Macdonald Labour government in 1924. But all were re-enacted in 1925; and then at last the Baldwin government took steps which clearly were not explicable on political or military grounds, or as means for meeting special emergencies. In 1925 not only were the McKenna duties restored, but, what was more important, the safeguarding of industries provisions were given a wide scope. In advocacy of them, most was said about the desirability of preventing unemployment through the protection of established industries. The board of trade was made a sort of tariff commission which should investigate particular cases and recommend to parliament advances in duties; not merely for key industries or because of special circumstances, but as part of a general industrial policy. While the import duties to which this measure led were not, as compared with the entire volume of Britain's trade, of great substantive consequence, they marked unmistakably a departure from the principles of the free trade régime as it existed before 1914.

France.—The tariff history of France during the 19th century, like that of England, is divided into two parts, one running to the year 1860, and the other beginning after 1860. France emerged from the revolutionary wars with a cumbrous system, resting partly upon the highly complicated measures left over from the mercantilism of the 18th century, and for a part upon complete prohibition of importation (directed primarily against England) which had been adopted during the war period and was left in force, largely through inertia, for almost half a century thereafter. The tariff system of France, in other words, from 1815 until 1860, was rigidly protectionist. In 1860 the Cobden-Chevalier treaty made an abrupt change, to which the Emperor Napoleon III. was led in some part by intellectual conviction, but much more by the desire to get on good terms with Great Britain. The treaty provided for great reductions on manufactured goods imported from England, while England in her turn not only conceded the free admission of silks, but also reduced duties on French wines. After 1860 France virtually universalized these lower duties, extending them by a series of commercial treaties to almost all the countries of the Continent. These treaties commonly contained the most-favoured-nation clause, and were in turn fortified by treaties which the various countries concluded between themselves as well as with France. The result was an interlacing network of commercial engagements which covered almost the whole of Europe, and brought about not indeed a system of free trade, but one of nearer approach to free trade than had ever before been widely practised. Such, at all events, was the situation for two decades from 1860. The French people, however, had always been restive under the treaty system imposed upon them by the will of Napoleon III. The English treaty, which was terminable after the lapse of ten years, was at first renewed with reluctance, and finally terminated for good in 1891. The protectionist revival culminating in the great Méline Act of 1892. By that France established a double system: maximum duties which were not to be exceeded, and specified minimum duties which the government might concede to other countries in return for concessions supposed to be equivalent. The maximum duties, however, were in no case to be reduced on agricultural products; for in France, as in England, agricultural producers were hard hit by the decline in prices. One important purpose of the act was to deprive the ministry of discretionary power as regards reductions through commercial negotiation; the minimum duties which might be conceded to other countries were specified by the legislature. The system was maintained in essentials, though not without some modification, until the outbreak of the war in 1914. The revival of high protection in France did not run its course without serious difficulties, especially in the way of controversy on rates with other countries. There was a tariff war with Italy in 1888–90 and one in 1892–95 with Switzerland. In 1910 there was again a revision upward, which, however, left the general system intact.

One further factor in French tariff policy during this period was the Treaty of Frankfurt (1871) terminating the war of 1870–71. By that treaty France and Germany had guaranteed each other most-favoured-nation treatment,—not complete, but almost complete, in that they guaranteed to each other the same rates as they conceded to the important neighbouring countries of central Europe. Being incorporated in the general treaty, these provisions, unlike the special commercial treaty of 1860 with England, could not be denounced; and they were felt by both countries to hamper their commercial negotiations, being the more unwelcome because of the constantly growing national antagonism. When all treaties and engagements with Germany, and practically those with other countries also, were swept away with the World War, France was able to proceed untrammelled with a new course of policy. It rested upon the maintenance of a high protective system, susceptible of some liberalization through special bargains with other countries, by which these were to be induced to admit French goods at lowered rates in exchange for specified concessions in the French duties, varying from country to country. In 1920 the maximum and minimum system was virtually given up and the government given free hand in commercial negotiations. The result was a highly complicated series of engagements, which brought into vivid contrast two essentially different lines of policy: that of special bargaining, and that of equal treatment under a most-favoured-nation clause. The second policy was unpopular in France, partly because of its association with the Treaty of Frankfurt, but partly for other reasons connected with peculiarities of French foreign trade. Not only as regards France, but as regards Europe at large, the alignment was marked by one or the other of these two ways of procedure. Those in favour of closer commercial relations preferred the most-favoured-nation method, while high protectionists looked to the policy of specific bargainings. On the whole France was not successful in securing what she wished by bargaining, even though she had political advantages in dealing with States like Czechoslovakia, Hungary, Yugoslavia, and even Belgium. In 1927 she was compelled to arrange with Germany a treaty virtually upon most-favoured-nation basis, a change which marked a halt in the other policy, and perhaps the beginning of a general trend the other way.

Germany.—The tariff history of Germany, like that of German history in general, is closely connected with Prussia. Prussia took the lead in the creation of the German customs union (*Zollverein*). She arranged a partial union in 1819 which was followed by the *Zollverein* of 1834, including practically the whole of the later Empire. Prussia was then a grain exporting country, and favoured a liberal tariff system. As time went on, manufacturing industries developed, especially in the west and south of Germany, and contests arose within the *Zollverein* between the free trade and protectionist parties. In these, upon the whole, the anti-protectionists were victorious until after the establishment of the Empire. A commercial treaty with France in 1862, a sequel of the Anglo-French treaty of 1860, confirmed the liberal tendency. But after 1871 Germany, like France, and at about the same time, turned the other way. Under Bismarck's lead, and in consequence of an alliance between the industrialists of the west and south and the agricultural interests of the east (now threatened by imports), Germany returned in 1879 to protection. Grain duties were imposed, and proved an important source of revenue, because imports continued on a large scale; at the same time the continuing imports made the landed interest firmly protectionist.

At the beginning of 1892 Germany entered upon a policy of commercial treaties which were based upon special negotiation with each particular country; though they were prevented by the treaty of Frankfurt from having as much effect in the way of discriminations between countries as might otherwise have been the case. This policy of specialization was continued in the legislation of 1902, when rates were further increased and further commercial treaties were initiated. As in the case of France, the policy of specialized commercial negotiations led to quarrels and retaliations, there being tariff wars with Russia, Spain and Canada. After the World War, Germany for a while was restricted by certain provisions of the Versailles Treaty. These required her for five years from the date of the treaty (that is, during 1919–24) to give most-favoured-nation treatment to the Allies, while at the same time leaving the Allies free. With the termination of this arrangement in 1924 Germany proceeded more freely, and in 1925 adopted a new tariff. A protectionist régime was established both for agricultural products and for manufactured goods, with an expectation, however, that the duties might be reduced through bargaining for lower duties by other countries on German goods. Success in this direction was achieved in 1927 by the commercial treaty with France, which provided for certain reductions upon French goods, and also secured for German goods imported into France treatment virtually on a most-favoured-nation basis. Treaties with other countries contained similar provisions, and emphasized the acceptance by Germany of the most-favoured-nation policy and of a general disposition to moderate the protectionist régime.

Other Countries.—The same trend in tariff legislation appeared in other countries during the years succeeding 1860. In almost all, the protectionist movement gathered strength again after 1880. Austria, Russia, Italy turned to high tariffs, sometimes mitigated by commercial agreements, sometimes aggravated by the failure of commercial negotiations. The greatest extreme was reached in Russia, which under the leadership of Witte developed a system of protection more extreme than that of any other country, not excepting the United States. After the World War, when the financial and treaty arrangements had all to be remodelled, there was the same resurgence and accentuation of protective tariffs. The main cause lay in the strengthening of national feeling and in the persistence of nationalist antagonisms engendered by the war. The new States which arose after the war or were greatly enlarged by it, such as Poland, Czechoslovakia, Yugoslavia, Greece, Rumania, turned to protective measures. In good part they were influenced by imitation of the larger powers and not least by imitation of the United States. The glamour of the prosperity of the United States led easily to an imitation of American policy in all respects. A system of high protectionism, which in the United States was comparatively harmless, threatened to have serious evil consequences on the Continent.

Tariff Commissions.—A new administrative policy in reference to tariff matters came into existence in various countries after the World War, by which considerable powers were given to other than legislative bodies in the determination of rates. The United States in the Tariff Act of 1922 gave certain powers or duties to the U.S. tariff commission, which had been established in 1916. Under the so-called flexible provisions of the act of 1922, the commission was empowered to investigate the cost of production of goods in the United States and in foreign countries, and to ascertain what rates of duty would equalize competition between domestic and foreign producers. If the rates of duty, as fixed in 1922, were less than the difference between the foreign cost and domestic cost, a recommendation for an increase of duties was to be made; if greater, a recommendation for a decrease. No change, however, was to be made amounting to more than 50% of the actual duties appearing in the act of 1922. Nominally the tariff commission had no powers in this regard; it merely recommended to the president that the changes should be made. The expectation, however, was that the president should *ipso facto* proceed in accord with the recommendations, and that the system should operate automatically. It represented an endeavour to withdraw the detailed fixing of duties from the legislature, and to entrust the task to a supposedly expert body. The same sort of thing was done by Australia in 1921. A tariff board was then established, with authority to make similar investigations and to report to the minister of trade and customs, who was then empowered to make changes as recommended by the board. In practice this meant that the board made the changes. Boards of a similar sort, though with powers of more distinctly an advisory kind, were established in Great Britain itself, in British India, South Africa, and in the Irish Free State. In Great Britain the board of trade, through a committee, was authorized to make inquiries under the act of 1925 for the safeguarding of industries. The changes recommended by the board of trade had then to be submitted to parliament, and did not go into effect unless sanctioned by parliament. In Ireland an act of 1926 established a tariff commission of three members, required to report the pertinent facts to the minister of finance, but making no specific recommendations.

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TARIJA, a department and town of south-eastern Bolivia. The department lies on the northern frontier of Argentina, and is bounded W. by Potosí, N. by Chuquisaca, and E. by Paraguay. Pop. (1915 estimated) 31,567. Area, 164,704 sq.m. The eastern and larger part of the department belongs to the great Chaco lowland region. The Chaco districts are inhabited by small nomadic tribes of Indians, and the grassy Llanos de Manzo by the Chiriguanos, many of whom live in permanent villages, breed horses, cattle and sheep, and till the soil. In the mountains are remnants of the Quichuas, once masters of an empire.

The capital, SAN BERNARDO DE TARIJA (pop. 1924 estimate, 10,843), is the only town of importance in the department. It is situated on the Río Grande de Tarija, about 85 m. E. of Tupiza. It is about 6,500 ft. above sea level and its climate is mild and healthful. The town was founded in 1577 by Luis de Fuertes, by orders of the Viceroy of Peru, as a military post to hold the Chiriguanos in check. About the same time the Jesuits established themselves here, and the most important building in the town is their convent.

TARIM, the river which gives its name to the great basin between the Tien Shan and Kunlun mountain systems of central Asia. The area of the basin is over 350,000 sq.m. and the length of the river may be said to be about 1,000 miles. The mountain frame dies away to the north-east in the arid Gobi, so that beneath the slopes of the Kunlun lies the Kansu highway from China. The river is formed by the confluence of the Kashgar and the Yarkand; it then flows for some 230m. north-eastwards between high banks, bordered by poplars and reeds, and joins the Aksu, a swift and powerful stream from the north; 20m. further on the Khotan river flows in from the south, and after another 150m. it begins to come into direct conflict with the sand dunes of the great desert and to form lateral lakes in the hollows between the great dunes, which the Khotan river has had to fight in the lower part of its course. Numerous streams flow in from the Kunlun northward parallel to and east of the Khotan river, but lose themselves in the desert, and the Khotan reaches the Tarim only some 40 days in a year. Further to the east the Tarim breaks up in deltaic fashion and swings north and south. Here it skirts the north-east front of the great dunes and has a number of long lakes on its course, stretching mostly north to south or north-west to south-east. The lakes act as filters and the river emerges from them bright and clear. A little north of lat. 40, at Airylgan, it receives the Koncheh river, which issues from the lake called Bagrach-Köl. This river has poplars on its left bank which hinder the spread of the desert from the north-east. Below Airylgan the remains of the river, which has diminished practically all the way down from its confluence with the Aksu, enter the dwindling lakes of Kara-Buran, a sort of ante-room to the real terminal basin of the river, the Kara-Koshun (Lop-Nor, *q.v.*) at an altitude of 2,675 ft. above sea-level. In 1900–01 Dr. Sven Hedin discovered several fresh desert lakes forming to the north of Kara-Koshun, and branches of the deltaic arms of the Tarim, or overflows of such branches, straining out in the same direction; facts which he interpreted as showing a tendency of the river to revert to its former more northerly terminal basin of the old (Chinese) Lop-Nor.

The lower part of the course of the river is, on the whole, moving south-westward into lower ground. Its course is so sluggish that sediment is deposited in its bed, which is thus raised above the surrounding country. The river is usually frozen during December, January and February. The thaw in March causes a flood, followed by a greater one, due to the melting of snows on the mountains, and the high water can be traced down the river during the summer.

The basin is often divided into four main regions:—(*a*) The Takla-Makan desert (*q.v.*) or central area of bare drift-sand desert. Its borders on the west, north and east are determined by the belts of vegetation accompanying the Tisnaf, Yarkand and Tarim rivers respectively. The area has outliers beyond these riverine borders. (*b*) The oasis belts south of the Tien-shan, east of the Pamir and north of the Karakorum and Kunlun. The oases on the south lie between the gravel glacis of the Kunlun and the sands of Takla-Makan. The best known are Karghalik, Khotan, Keriya, Niya, Cherchen and Charkhlik. Those on the north include Uchturfan, Aksu, Bai-Kuche, Kuerhlei, Karashar, Turfan, Pichan and Hami. To the west the two chief ones are Kashgar and Yarkand. The cultivable areas are usually greater in the west and the north than in the south. (*c*) The terminal depression of Lop and the Turfan basin. The Lop basin contains the terminal marshes of the Tarim river, the salt-encrusted bed of the former extension of Lop-Nor beyond the marshes, and the dune-covered area east of the final course of the Tarim river between it and the north-western shore of the old lake. The Turfan depression is enclosed on the north by a portion of the Tien-shan; on the west by an outlying range of the same, and on the east and south by the barren hills of the Kuruk Tagh. Within these boundaries there are belts of glacis, desert, oasis-cultivation and dune-covered desert, exactly as one finds them in the Tarim basin. (*d*) The Sulo-Ho basin, and the cultivated area along the route north of the Nan-shan, leading into Kansu from the eastern Tarim. The basin is covered with bare gravel, except for a narrow belt of vegetation accompanying the lower course of the river, and the limited area capable of cultivation by means of irrigation around the oasis of Tun-huang. South of Tun-huang accumulations of drift-sand, approach or overlie the foothills of the Nan-shan.

Problems of Climatic History.—The present-day climate of the Tarim basin is discussed in the article on Sin-kiang (*q.v.*), but the problems of its possible changes of climate in the past have been the subject of much investigation during recent years. The expeditions into the Tarim basin which have been undertaken by Sir Aurel Stein and Dr. Sven Hedin have resulted in a great mass of evidence bearing on the problem. This evidence has been interpreted by various authorities, who have each put forward a theory to explain the facts reported by the explorers. The problem is connected with the supposed "desiccation" of Central Asia. (*See* Asia, *Archaeology*.)

Great changes have come about in the Tarim basin during the last two thousand years. Settlements have been abandoned and fresh ones made; some regions, once prosperous, are now deserted and are quite uninhabitable; rivers have forsaken their old beds, and other rivers do not extend as far as they once did, while the lakes in the centre of the basin appear to be shrinking in size.

Historical Geography.—The Tarim basin lies on a highway of the nations; the main routes through it being in an east-west direction, the northern route along the southern foot of the Tien-shan and the southern one along the northern foot of the Kunlun. Both unite at Kashgar, whence the route leads over the Pamirs to the trans-Caspian lowlands.

The region has always been one having an essentially "corridor" nature. There is not, and never has been, sufficient atmospheric moisture or subterranean water supplies to support a large agricultural population. The narrow belts of riverine jungle could never, within historic times, have afforded the possibility of nomadic existence to any but quite insignificant communities, such as the present Dolans on the Yarkand river. This point is very important, for it explains why the great nomadic tribes of the Wu-sun, Sakas, Yueh-chih, Huns, Turks and Mongols were always ready to raid, or to make tributary, the oases of the Tarim, but never crossed the Tien-shan, permanently to occupy the basin. Nature has denied grazing grounds to the Tarim, and has thus protected it against ever becoming the scene of great migratory movements and the upheavals which accompany them. Within the basin itself, the only basis of life was painstaking agriculture, possible only by means of irrigation. This mode of life did not appeal to the neighbouring nomads; the plateaux of the Tien-shan or the Mongolian steppes were more suitable for them. Because of these conditions, we find each great wave of Central Asian migration moving along the northern foot of the Tien-shan, or even further north.

Modern Economic Conditions in the Tarim Basin.—The potential wealth of the Tarim basin is as yet untouched by modern developments. Hitherto its commercial importance as a highway has benefited those people who used the highway. Beyond the protection afforded at times by Chinese troops, and the benefits of an effective administration, which the region enjoyed when Chinese authority was sufficiently strong to assert itself, the native oasis dwellers have not prospered overmuch from the advantages which their land offers to neighbouring peoples as an easy trade route between East and West.

The fertile "loess" which composes much of the western part of the basin is eminently suitable for cultivation. The total amount of land under cultivation could be increased if a scientific system of irrigation were developed by the Chinese administrators. The chief obstacle to wider cultivation of the oases is found in the people themselves. They are mostly Turki, engaged in either agriculture or commerce, and, although they do not resent foreign interference, they show no desire to enlarge their commercial and agricultural enterprises. The attitude of the Chinese in the matter of foreign exploitation of the Tarim basin is very discouraging. Foreign capital is needed to develop the resources of the country, and the Chinese are not anxious to admit this, owing to their dread of alien domination.

The products are chiefly grain of all kinds, wool, cotton and silk. Khotan is the centre of the silk industry, and also the centre of valuable jade deposits. Agriculture is the most important and widespread industry. The natives depend on it for their existence, as foodstuffs are not imported from the neighbouring States. The cotton and jute industries could be turned into a flourishing trade if properly exploited, both products being of excellent quality. Soil, labour and material are there to cooperate in the development of these industries.

The political disturbances in the Tarim basin during the last century and the recent upheavals in China itself have been responsible to a large extent for the commercial apathy prevailing in East Turkistan. (*See* also Sin-kiang, Kashgar, Khotan, Yarkand, Lop-Nor, and for bibliography *see* Asia.)

TARKANRÍ or **TARKILANRI,** a Pathan tribe inhabiting the valleys of Bajour, on the border of the North West Frontier Province of India.

TARKINGTON, NEWTON BOOTH (1869–), American author, was born in Indianapolis (Ind.), July 29, 1869. After studying at Phillips academy, Exeter (Mass.), he entered Purdue university, Lafayette (Ind.), but later transferred to Princeton, whence he graduated in 1893. He was a member of the Indiana House of Representatives in 1902–03. One of the most versatile of American writers of fiction, Tarkington won early recognition with his novel, *The Gentleman from Indiana* (1899).

Among his outstanding successes were the charming romance *Monsieur Beaucaire* (1900), which was later presented on the films and on the legitimate stage; the humorous portrayals of boyhood and adolescence, *Penrod* (1914) and *Seventeen* (1916); his delineations of the modern industrial city, *The Turmoil* (1915); *The Magnificent Ambersons* (1918), and *The Midlander* (1924), combined as *Growth* (1927); and *The Plutocrat* (1927). Perhaps his most finished novel is *Alice Adams* (1921), which, like *The Magnificent Ambersons,* was awarded a Pulitzer prize. Tarkington is also the author of a number of plays including *Beauty and the Jacobin* (1912), *Mister Antonio* (1916), *The Man from Home* (1906), and *Up from Nowhere* (1919), the latter two with Harry Leon Wilson.

TARLAC, a municipality (with administration centre and 39 *barrios* or districts) and capital of the rich province of Tarlac, Luzon, Philippine islands. It is located on the central plain of Luzon in the region drained by the Agno river. Pop. (1918), 23,888. Tarlac, located on the Manila-Dagupan railway is an important commercial centre. Two crops of rice are grown annually in the vicinity, one by means of irrigation. Sugar, tobacco, corn, beans, sweet-potatoes, coconuts, pineapples and other products are raised in the region. In 1918, it had 12 manufacturing establishments, 7 rice mills, 16 sugar mills and 43 household industry establishments, with outputs valued at 43,700; 1,700,000, 128,000; and 17,700 pesos respectively. Of the 20 schools, 18 were public. Tarlac was founded in 1686. The language is Pampango, but there are many Tagalogs, Ilocanos and Pangasinans in the municipality and other parts of the province.

TARLETON, SIR BANASTRE (1754–1833), English soldier, the son of John Tarleton (1719–1773), a Liverpool merchant, was born in Liverpool on Aug. 21, 1754. Educated at Oxford, he entered the army and in Dec. 1775 he sailed as a volunteer to America with Earl, afterwards Marquess, Cornwallis. His services during the American War of Independence in 1776, gained him the position of a brigade-major of cavalry. In 1780, as commander of the British legion, a mixed force of cavalry and light infantry, he went to South Carolina, supporting Sir Henry Clinton in the operations which culminated in the capture of Charleston. After taking part in many successful engagements, he marched with Cornwallis into Virginia and was instructed to hold Gloucester. This post, however, was surrendered to the Americans with Yorktown in Oct. 1781, and Tarleton returned to England on parole. From 1790 to 1812, with the exception of one year, he sat as M.P. for Liverpool. In 1794 he was promoted to major-general, and in 1812 general; he held a military command in Ireland and another in England. In 1815 he was made a baronet. He died without issue at Leintwardine, Shropshire, on Jan. 25, 1833.

He wrote a *History of the Campaigns of 1780 and 1781 in the Southern Provinces of North America* (1781) which was criticized by Col. Roderick Mackenzie in his *Strictures on Lieutenant-colonel Tarleton's History* (1781), and in the *Cornwallis Correspondence.*

TARLTON, RICHARD (d. 1588), English actor, according to Fuller (*Worthies* iii. 139) was born at Condover, Shropshire. He was probably at one time an inn-keeper. In 1583 he is mentioned as one of the original company of queen's players and he had become an experienced actor; he was their chief comedian and remained with them until his death. He was Elizabeth's favourite clown, and his talent for impromptu doggerel on subjects suggested by his audience has given his name to that form of verse. For the Queen's men he wrote *The Seven Deadly Sins.* Many songs and witticisms of the day were attributed to him, and after his death *Tarlton's Jests,* many of them older than he, made several volumes. He is said to have been the Yorick of Hamlet's soliloquy.

TARN, a department of France, formed in 1790 of the three dioceses of Albi, Castres and Lavaur, belonging to the province of Languedoc. Pop. (1926) 301,717. Area, 2,231 sq. miles. Tarn is bounded north and east by Aveyron, south-east by Hérault, south by Aude, south-west and west by Haute-Garonne, north-west by Tarn-et-Garonne. The department forms the southern buttress of the Plateau Central, with the Montagne Noire (3,970 ft.) near its southern border. The general slope is from east to west, and in the east the Monts de Lacaune reach 4,154 ft. at the Pic de Montalet. The greater part of the department is floored by ancient rocks with some granite, especially in the north, and the general level is from 1,500 to 2,000 feet. The Aveyron runs along the northern boundary, the Tarn across the middle of the department, and the Agout across the south, and they join one another west of the boundary on their way to Garonne. The Aude receives the streams from a part of the Montagne Noire.

The limestone and sandstone foot-hills are clothed with vines and fruit trees, and are broken by deep alluvial valleys of extraordinary fertility. The eastern portion of the department has the climate of Auvergne, the severest in France, but that of the plain is Girondin. The winter average temperature reduced to sea-level is 41° and the summer average temperature is 70°, but the great elevation often reduces these figures by 15° to 20°. The rainfall, 29 or 30 in. at that place, exceeds 40 in. on the Lacaune and Montagne Noire.

The west and centre produces cereals, wheat, oats, maize, and vines; the valleys around Castres provide natural pasture for cattle; market-gardening is carried on in the west. There are mines of coal and iron, and quarries of lime. The industries include the manufacture of textiles, hosiery, brushes, morocco leather, hats, metal foundries, dye-works and glass-works. The department is famous for its sparkling wines. The department is divided into two arrondissements (Albi and Castres) and there are 36 cantons and 323 communes. The department is in the 16th military region, and the académie (educational division) of Toulouse, where is its court of appeal.

The chief towns are Albi, the capital and seat of an archbishop, with suffragan bishops at Rodez, Cahors, Mende and Perpignan, Castres, Gaillac, Lavaur, Mazamet and Cordes (*qq.v.*). Burlats has ruins of an old church and château; Lisle d'Albi, a *bastide* with a 14th century church, and Penne has ruins of a mediaeval château.

TARN, a river of southern France, 234 m. long, a tributary to the Garonne. It rises at 5,249 ft. on the Hercynian gneisses of Mt. Lozère, flows westward and, having received the Tarnon, enters a gorge in the Jurassic limestones, which separates the Causse de Sauveterre from the Causse Méjan. It receives the Jonte (left) and passes between the Causse Noir, the Larzac plateau and the Causse de St. Affrique (left) and the Lévezou range and the Plateau of Ségala (right). At Millau it receives the Dourbie (left) and lower down the Dourdou (left) and from here to the cascade of Sabo, above Albi, the river crosses Permian and Silurian rocks. Having entered the plain, the river, has cut out a deep bed in the Tertiary strata, passes Gaillac, and, after receiving the Agoût (left), it turns north-west, receiving the Tescou (right) at Montauban, and the Aveyron (right). After passing Moissac it joins the Garonne on its right bank.

TARN-ET-GARONNE, a department of south-western France, formed in 1808 of districts formerly belonging to Guienne and Gascony (Quercy, Lomagne, Armagnac, Rouergue, Agenais), with the addition of a small piece of Languedoc. From 1790 to 1808 its territory was divided between the departments of Lot, Haute-Garonne, Tarn, Aveyron, Gers and Lot-et-Garonne. It is bounded north by Lot, east by Aveyron, south by Tarn and Haute-Garonne, and west by Gers and Lot-et-Garonne. Area, 1,440 sq.m. Pop. (1926) 164,191. The department is the region focussing upon Montauban and includes the junction of the Aveyron and the Tarn and their union with the Garonne. These rivers separate hills of Pliocene strata, and in the extreme north-east stands out the edge of the Plateau Central and the limestone Causse de Quercy (1,634 ft.). The climate is mild and agreeable; the mean annual temperature being about 56° F. Rain falls seldom, but heavily, especially in spring, the annual rainfall being 28 or 30 in.

The wide alluvial valleys of the three large rivers are most productive. Cereals, especially wheat, maize and oats, occupy more than two-thirds of the arable land of the department. The vine is grown everywhere and large quantities of grapes are exported as table fruit. Potatoes are also grown. Plums and apricots are abundant. The breeding of horses, especially for cavalry purposes, is actively carried on; and the rearing of horned cattle, both for draught and for fattening, is also important. Sheep, pigs, poultry, and silk-worms are also sources of profit. There are metal-foundries, various kinds of silk-mills, and manufactories of straw-hats, wool, paper and brooms. The principal exports are fruit, wine, flour, truffles from the Rouergue, and early vegetables. The canal of the Garonne traverses the department for 48 m. and the Garonne and the Tarn furnish 82 m. of navigable waterway. The department is served by the Orléans and the Southern railways. The department forms the diocese of Montauban under the archbishop of Toulouse, and belongs to the académie (educational division) of Toulouse, where is its court of appeal, and to the district of the XVII. corps d'armée (Toulouse). It has two arrondissements (Montauban, the capital, and Castelsarrasin), 24 cantons and 195 communes.

TARNOPOL, a province of Poland, bounded on the north by the province of Volhynia, on the west by Lemberg, on the south by Stanislawów provinces, and on the east by Russia. Area 6,268 sq. miles. Pop. (1921) 1,429,000, of whom 45% are Poles, 49·7% Ruthenians and 4·9% Jews. The Ruthenians belong to the same race and religion as those in Stanislawów province (*q.v.*), but the Poles are more numerous in Tarnopol, since they have been colonizing the Podolian plateau since the 14th century. Tarnopol is part of the plateau of Podolia joining up with the Lublin uplands, having the appearance of hills where the land slopes down to the Volhynian plain, especially in the Gologory. The south is bounded by the Dniester, with its lower valley, the tributaries of which drain the bulk of the province except in the north, where the Bug and Styr have their sources. These tributaries all flow from north to south and from the deep ravines which are a distinctive feature of Podolia. The plateau is sometimes flat, sometimes hilly and wooded, as on the Miodobory along the eastern border. The Strypa and the Lipa are famous for the stubborn Russian defence during the World War. Tarnopol is a fertile agricultural province, densely populated with small peasant proprietors. It is famous for its horses and cattle, which thrive on the well-watered pastures. The chief towns are Tarnopol (pop. 30,900), Zloczów, Bareźany, Busk, Brody, Zbaraź and Trembowla.

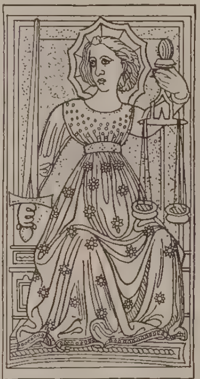
TARNOPOL, a town of Poland, in the province of the same name, 87 m. E.S.E. of Lemberg by rail. Pop. (1921) 30,900, half of whom are Jews. The town was founded in 1540 by Jan Tarnowski, first of a series of Polish generals. It became a fortress and received many privileges from the Polish kings. The ancient synagogue of the reign of Casimir the Great remains, and there is a museum. Industry consists in corn milling and the preparation of wax and honey. The chief trade is in horses, agricultural produce and spirits.

TARNÓW, town of Poland, in the province of Cracow, 164 m. W.N.W. of Lemberg by rail. Pop. (1921) 35,700, of whom about 40% are Jews. It is situated on the river Biala, not far from its junction with the Dunajec, and is the seat of a Roman Catholic bishop. It possesses a cathedral in Gothic style, built in the 15th century, with monuments of the Tarnowski and Ostrogski families, to which the town formerly belonged, another church, built in 1454, and a diocesan museum with Polish paintings of the 15th and 16th centuries. On a hill near the town stand the ruins of an old castle of the Tarnowski family and a small church over 800 years old. The town hall is an old and interesting building. Agricultural implements, glass and chicory are manufactured.

TARNOWSKI, JAN [called MAGNUS] (1488–1561), Polish general. After a careful education at the palace of Matthew Drzewicki, bishop of Przemysl, he occupied a conspicuous position at court in the reigns of John Albert, Alexander and Sigismund I. In 1509 Tarnowski distinguished himself in Moldavia, taking part in the victories of Wisniowiec (1512) and Orsza (1514). He then travelled in the Near East, and northern and western Europe. While in Portugal he received from King Emanuel the chief command in the war against the Moors, and was promoted by Charles V. to a count of the Empire. On the death of Nicholas Firlej in 1526 Tarnowski became grand hetman of the crown, or Polish commander-in-chief, and won his greatest victory at Obertyn (August 22, 1531) over the Moldavians, Turks and Tatars. Tarnowski took the royal side during the "Poultry War" of 1537; and also in 1548 when the *szlachta* tried to annul by force the marriage of Sigismund Augustus (*q.v.*) with Barbara Radziwill. In 1553, indeed, he was in opposition to the young king; yet he remained emphatically an aristocrat, intensely opposed to the democratic tendencies of the *szlachta,* and working for a firm alliance between the king and the magnates. Though a devout Catholic, he was opposed to the exclusive jurisdiction of the bishops and would have limited the authority of Rome in Poland. Tarnowski invented a new system of tactics to increase the mobility and security of the armed camps within which the Poles had so often to encounter the Tatars. His principles are set forth in his *Consilium Rationis Bellicae* (best edition, Posen, 1879). As an administrator he did much to populate the vast south-eastern steppes of Poland.

See Stanisław Orzechowski, *Life and Death of Jan Tarnowski* (Pol.) (Cracow, 1855).

TARO (*Colocasia esculenta*), a coarse herbaceous plant of the arum family (Araceae, *q.v.*), called also eddo and dasheen, probably native to the Pacific islands, where it is extensively cultivated for its large, spherical, underground tubers, which form an important article of food, especially in Hawaii. It is closely allied to or is perhaps a variety of *C. antiquorum,* native to the East Indies, a stately ornamental plant, with large shield-shaped leaves, various cultivated forms of which are known as elephant's-ear.



FROM CHATTO, "ORIGIN AND HISTORY OF PLAYING CARDS"

A MAJOR TRUMP TAROK CARD, ELEVENTH IN THE SERIES, AFTER AN OLD PAINTED CARD ASCRIBED TO GRINGONNEUR

TAROK, a game of cards very popular in Austria and Germany, and played to a limited extent in some parts of France. Special cards are used, and the rules are complicated. The name *Tarok* was originally given by the Italians to a certain card in the pack as early as the 13th century, but was afterwards applied to the game itself.

TARPAULIN or **TARPAULING** (as if *tarpalling,* from *tar,* and *palling,* a covering, Lat. *palla,* a mantle), and a heavy well-made, double warp plain fabric, of various materials, used chiefly in the manufacture of covers for weather protection. To make it proof against rain and other atmospheric influences it is generally treated with tar, though various compositions of different kinds are also employed, especially for the finer fabrics such as are used for motor-car hoods, van tops, etc., which are generally made of flax, hemp and cotton. A lot of tarpaulin is made entirely of jute (*q.v.*). Formerly the word was used as a sort of nickname for a sailor, the modern "tar" in the same sense being an abbreviation of it.

TARPEIA, in Roman legend, daughter of the commander of the Capitol during the war with the Sabines caused by the rape of the Sabine women. According to the story, she offered to betray the citadel, if the Sabines would give her what they wore on their left arms, meaning their bracelets; instead of this, keeping to the letter of their promise, they threw their shields upon her and crushed her to death. Simylus, a Greek elegiac poet, makes Tarpeia betray the Capitol to a king of the Gauls. The story may be an attempt to account for the Tarpeian rock being chosen as the place of execution of traitors. According to S. Reinach, however, in *Revue archéologique,* xi. (1908), the story had its origin in a rite—the taboo of military spoils, which led to their being heaped up on consecrated ground that they might not be touched. Tarpeia herself is a local divinity, the manner of whose death was suggested by the tumulus or shields devoted to her cult, a crime being invented to account for the supposed punishment.

See Sir George C. Lewis, *Credibility of early Roman History;* A. Schwegler, *Römische Geschichte,* bk. ix. 10; Livy, i. 11; Dion. Halic.,

ii. 38–40; Plutarch, *Romulus*, 17; Propertius, iv. 4; Ovid, *Fasti*, i. 261; C. W. Müller, *Frag. Hist. Graec.*, iv. p. 367.

TARPON (*Megalops atlanticus*), a fish allied to the herrings, but with a large mouth and very large, thick, silvery scales. It occurs in the warmer parts of the western Atlantic, and is an active fish, preying on the fry of other fishes. It reaches a length of 7 ft., and a weight of more than 200 lb.

TARQUINIA (anc. TARQUINII), a town of Italy, in the province of Rome, 62 m. north-west by rail from the city of Rome, 490 ft. above sea-level. Pop. (1921), 6,320 (town), 7,972 (commune). It is picturesquely situated, and commands a fine view of the sea. It possesses mediaeval fortifications, and no less than 25 towers are still standing in various parts of the town, which thus has a remarkably mediaeval appearance. The castle, on the north, contains the Romanesque church of S. Maria in Castello, begun in 1121, with a fine portal of 1143, a *ciborium* of 1166 and a pulpit of 1208, both in "cosmatesque" work; the pavement in marble mosaic also is fine. There are several other Romanesque and Gothic churches and other buildings. The Gothic Palazzo Vitelleschi (1439) with remarkably rich windows, contains the fine Government museum, now including the Bruschi collection, of Etruscan antiquities from the tombs of the Etruscan city, which probably occupied the site of the Roman town, now deserted, its last remains having been destroyed by the inhabitants of Corneto (the mediaeval name by which the town was till lately known) in 1307. Scanty remains of walling and of buildings of the Roman period exist above ground.

The importance of Tarquinia to archaeologists lies mainly in its necropolis, situated to the south-east of the mediaeval town, on the hill which, from the tumuli raised above the tombs, bears the name of Monterozzi. The tombs themselves are of various kinds. The oldest are *tombe a pozzo*, or shaft graves, containing the ashes of the dead in an urn, of the Villanova period, the earliest belonging to the stage known as First Benacci (*see* ETRUSCANS) and the latest to the middle or end of the 9th century B.C. immediately after the coming of the Etruscans, a few contemporary graves of whom, containing Egyptianizing scarabs and some gold and silver, have also been found. In some of these tombs hut urns, like those of Latium, are found. Next come the various kinds of inhumation graves, the earliest of which, the so-called warrior's grave, belongs to the early "Vetulonian" period, and the Bocchoris tomb to 730–690 B.C. (MacIver, *Villanovans and Early Etruscans*, 1924, 40–56; 158–166): the most important are rock-hewn chambers, many of which contain well-preserved paintings of various periods.

Tarquinia was the chief of the 12 cities of Etruria, and appears in the early history of Rome as the home of Tarquinius Priscus and Tarquinius Superbus. The people of Tarquinia and Veii attempted to restore Tarquinius Superbus after his expulsion. In 358 B.C. the citizens of Tarquinia captured and put to death 307 Roman soldiers; the resulting war ended in 351 with a 40 years' truce, renewed for a similar period in 308. When Tarquinia came under Roman domination is uncertain, as is also the date at which it became a municipality; in 181 B.C. its port, Graviscae (mod. Porto Clementino), with Government salt-works 4 m. S.W., in an unhealthy position on the low coast, became a Roman colony. It exported wine and carried on coral fisheries.

TARQUINIUS PRISCUS, LUCIUS, fifth legendary king of Rome (616–578 B.C.). He is represented as the son of a Greek refugee, who removed from Tarquinii in Etruria to Rome, by the advice of his wife, the prophetess Tanaquil. Appointed guardian to the sons of Ancus Marcius, he supplanted them on their father's death. He laid out the Circus Maximus, instituted the "great" games, built the great sewers (*cloacae*), and began the construction of the temple of Jupiter on the Capitol. He carried on war successfully against the Sabines and subjugated Latium. He is said to have raised the number of the senators to 300, and to have doubled the number of the knights.

The introduction of many of the insignia of war and of civil office is assigned to his reign, and he was the first to celebrate a Roman triumph, after the Etruscan fashion, in a robe of purple and gold, and borne on a chariot drawn by four horses. He was assassinated at the instigation of the sons of Ancus Marcius.

The legend of Tarquinius Priscus is in the main a reproduction of those of Romulus and Tullus Hostilius. There seems to have been originally only one Tarquinius; later, when a connected story of the legendary period was constructed, two (distinguished as the "Elder" and the "Proud") were introduced, separated by the reign of Servius Tullius, and the name of both was connected with the same events.

For the constitutional reforms attributed to Tarquinius, *see* ROME: *Ancient History; for* a critical examination of the story, Schwegler, *Römische Geschichte*, bk. xv.; Sir George Cornewall Lewis, *Credibility of early Roman History*, ch. 11; W. Ihne, *History of Rome*, i., E. Pais, *Storia di Roma*, i. (1898), who identifies Tarquinius with Tarpeius, the eponymus of the Tarpeian rock. Ancient authorities:—Livy i. 34–41; Dion. Hal. iii. 46–73, Cic. *de Repub.*, ii. 200.

TARQUINIUS SUPERBUS, LUCIUS, son of Lucius Tarquinius Priscus and son-in-law of Servius Tullius, the seventh and last legendary king of Rome (534–510 B.C.). On his accession he proceeded at once to repeal the recent reforms in the constitution, and attempted to set up a pure despotism. Many senators were put to death, and their places remained unfilled; the lower classes were deprived of their arms and the completion of the fortress-temple on the Capitoline confirmed his authority over the city. The outrage of his son Sextus upon Lucretia (*q.v.*) precipitated a revolt, which led to the expulsion of the entire family. All Tarquinius's efforts to force his way back to the throne were vain (*see* PORSENA), and he died in exile at Cumae.

In the story certain Greek elements, probably later additions, may easily be distinguished. Tarquinius appears as a Greek "tyrant" of the ordinary kind; on the other hand, an older tradition represents him as more like Romulus. This twofold aspect of his character perhaps accounts for the making of two Tarquinii out of one (*see* TARQUINIUS PRISCUS). The well-known story of Tarquinius's repeated refusal and final consent to purchase the Sibylline books has its origin in the fact that the building of the temple of Jupiter Capitolinus, in which they were kept, was ascribed to him.

For a critical examination of the story *see* Schwegler, *Römische Geschichte*, bk. xviii.; Sir G. Cornewall Lewis, *Credibility of early Roman History*, ch. 11; E. Pais, *Storia di Roma*, i. (1898); and, for the political character of his reign, ROME: *Ancient History*. Ancient authorities:—Livy i. 21; Dion. Hal. v. 1–vi. 21.

TARRAGON (*Artemisia Dracunculus*), a smooth green herb of the family Compositae, called also estragon, native to Europe and closely allied botanically to the mugwort and wormwood (*qq.v.*). It is widely grown in gardens for its slightly bitter aromatic foliage used in flavouring vinegar, pickles, salads and other dishes.

TARRAGONA, a maritime province in the north-east of Spain, formed in 1833 from the southern part of the province of Catalonia, and bounded on the south-east by the Mediterranean, north-east by Barcelona, north by Lerida, west by Saragossa and Teruel, and south-west by Castellon de la Plana. Pop. (1920) 355,148; area 2,505 sq.m. The Ebro flows through the southern portion of the province, and below Tortosa forms a conspicuous marshy delta, but elsewhere the coast-line is unbroken. The hills are clothed with vineyards, which produce excellent wines, and in the valleys are cultivated all kinds of grain, vegetables, rice, hemp, flax and silk. Olive, orange, filbert and almond trees reach great perfection, and the mountains yield rich pastures and timber. Manufactures are well advanced, and comprise silk, cotton, linen and woollen fabrics, velvet, felt, soap, leather and spirits. There are also many potteries and cooperages and flour, paper and oil mills. Silver, copper, lead and other minerals have been found, and quarries of marble and jasper are worked in the hills.

TARRAGONA, the capital of the Spanish province of Tarragona, a flourishing seaport, and the seat of an archbishop; at the mouth of the river Francoli, 63 m. by rail W.S.W. of Barcelona. Pop. (1920) 27,883.

Tarraco, the capital of the Iberian Cessetani, many of whose coins are extant, was one of the earliest Roman strongholds in Spain. It was captured in 218 B.C. by Gnaeus and Publius Cornelius Scipio, who improved its harbours and enlarged its walls. A Roman monument on a hill 3 m. E. is known as the Sepulcro de los Escipiones, and locally believed to be the tomb of the Scipios, who were defeated and slain by the Carthaginians under Hasdrubal Barca in 212 B.C., but there is no good reason to believe that the monument is older than the 1st century A.D. As the Colonia Triumphalis, so called to commemorate the victories of Julius Caesar, Tarraco was made the seat of one of the four assize courts (*conventus juridici*) established in Hispania Citerior. Augustus spent the winter of 26 B.C. here, and made Tarraco the capital of the whole province, which received the name of Hispania Tarraconensis. A temple was built in his honour. It was afterwards restored by Hadrian (A.D. 117–138), and the city became the Spanish headquarters of the worship of the goddess Roma and the deified emperors. Its flax trade and other industries made it one of the richest seaports of the empire.

To the Romans the Visigoths under Euric succeeded in 467, but on their expulsion by the Moors in 711 the city was plundered and burned. In 1089 the Moors were driven out by Raymond IV. of Barcelona, and in 1118 a grant of the fief was made to the Norman Robert Burdet, who converted the town into a frontier fortress against the Moors. In 1705 the city was taken and burned by the British; in 1811, after being partly fortified, it was captured and sacked by the French.

Tarragona is on the coast railway from Barcelona to Valencia, and is connected with the Ebro Valley Railway by a branch line to Reus. The old town, with its dark and steep alleys, occupies a rugged hill which rises abruptly from the sea to an altitude of about 550 ft. Many of the houses in this quarter are very old, and are built partly of Roman masonry; one such fragment, immured in the palace wall, is inscribed with the epitaph of a charioteer (*auriga*). Massive ruined walls encircle the old town. Their lowest course is "Cyclopean," consisting of unhewn blocks about 12 ft. long and 6 ft. wide; Roman masonry of the Augustan age is superimposed. The six gates and the square towers are also, to a great extent, "Cyclopean." Tarragona cathedral is one of the noblest examples of early Spanish art. The main body of the building dates from the end of the 12th century and the first half of the 13th, and is of transitional character. On the north-east side is a cloister contemporary with the church, with which it communicates by a very fine doorway. The cloister contains much remarkable work, and the tracery of the windows bears interesting marks of Moorish influence. Two other noteworthy churches in the city are San Pablo and Santa Tecla la Vieja, both of the 12th century.

There is a fine Roman aqueduct; the Roman amphitheatre was dismantled in 1491 to furnish stone for the eastern mole, though a few rows of seats are left near the sea-shore; and the museum contains a large collection of Roman antiquities. The Torreón de Pilatos is said to have been the palace of the Emperor Augustus. When the monks of the Grande Chartreuse were compelled to leave France, they settled at Tarragona in 1903, and established a liqueur factory. A characteristic feature of Tarragona is the number of its underground storehouses for wine (bodegas); wine is exported in large quantities. There is a British steel file factory; chocolate, soap, flour, ironware, paper, pipes and salted fish are also manufactured.

TARRASA, a town of Spain, in the province of Barcelona, 6 m. W.N.W. of Sabadell on the Barcelona-Lérida railway. Pop. (1920) 30,532. Tarrasa was a Roman municipality, and a bishopric from the 5th century to the Moorish invasion in the 8th. Tarrasa is now mostly a modern industrial town.

TARRYTOWN, a village of Westchester county, New York, U.S.A., on the east bank of the Hudson river, 25 m. N. of New York city, opposite Nyack; served by the New York Central railroad, interurban trolleys, motor-bus lines, river steamers and ferry to Nyack. Pop. (1925) 6,199 (State census). North Tarrytown and Irvington, separately incorporated villages of 7,013 and 3,296 inhabitants respectively (1925), adjoin it on the north and south, and are practically part of the same community. Tarrytown rises above the river (here expanded into Tappan Zee) to a considerable height. The main street (Broadway) is a section of the King's highway laid out in 1723 from New York to Albany, later called the Albany Post road. Washington Irving's home "Sunnyside" still stands in the village, and in North Tarrytown are the Philipse manorhouse (built in 1682, partly of brick brought from Holland) and mill (1682) and the old Dutch church (1685). In Sleepy Hollow cemetery, adjoining the church, are some Revolutionary earthworks, and the graves of Washington Irving, Carl Schurz and Robert G. Ingersoll. Among the large modern estates in the environs are those of John D. Rockefeller and Mrs. Finley Shepard (Helen M. Gould). The village has several manufacturing industries and there are large nurseries and market-gardens in the vicinity. It is the seat of several private schools. Tarrytown stands on the site of an Indian village, burned by the Dutch in 1644. Settlement by the whites began in 1645, and there were about a dozen Dutch families living here in 1680, when Frederick Philipse acquired title to several thousand acres and built the manorhouse, mill and church mentioned above. During the Revolution Tarrytown was in the "Neutral Territory" between the British and the Continental lines, and was the scene of numerous skirmishes between the "cowboys" and "skinners," unorganized partisans of the Colonies and the king respectively. On the Albany Post road, at a point now marked by a monument, Maj. John André was captured on Sept. 24, 1780. Tarrytown was incorporated as a village in 1870, Irvington in 1870 and North Tarrytown in 1875. The name is probably a corruption of the Dutch Tarwen Dorp (wheat town).

TARS, LOW TEMPERATURE, the oily distillates obtained by the destructive distillation of organic substances such as wood, peat, lignite and bituminous coal at temperatures not exceeding 650°C.

Wood Tar, obtained as a by-product in the carbonization of wood for the production of charcoal, methyl alcohol and acetone (*qq.v.*). Two distinct types of wood tar are recognized: (*a*) hardwood tar and (*b*) resinous wood tar, the former derived from woods such as oak, beech, etc., and the latter from resinous stools and roots and particularly from pinewood.

Hardwood Tars. The condensed volatile product of wood distillation is known as crude pyroligneous acid, which has the average composition: water 81%, methyl alcohol 3–4%, acetic acid 6–8%, tar 7%. After settling, the major portion of the tar separates from the aqueous acid although the latter always retains some tar in solution. The chemical constituents of wood tar form a very complex mixture comprising the "fatty" acids, esters, ketones, alcohols, phenols (usually polyhydric) and their methyl ethers, together with waxes. The most important representatives of these groups present in the tar are formic and acetic acids, with their methyl esters, acetone, methyl and allyl alcohol, guaiacol, catechol, and esters of pyrogallol.

Beech-wood tar is practically the only wood tar subjected to a complete straight distillation. Three fractions are usually collected, first the light oils and water containing acetic acid and methyl alcohol up to 180°C., then the heavy oils up to 240°C. and finally the pitch. The important fraction is the "heavy oil" distillate from which beech-wood-tar creosote is obtained (*see* CREOSOTE). The oils from wood-tar distillation receive some application in flotation methods of purification, whilst the pitch is used in briquetting and in insulating compositions.

Resinous Wood Tars are almost wholly represented by pinewood tar, which is commonly termed "Stockholm" or "Archangel" tar and is made extensively in the forests of Russia, Finland and Sweden. It is an important commercial product and differs from hard wood tar in containing the pleasant smelling mixture of terpenes known as turpentine. Pine-wood tar is the residue left after the turpentine has been distilled, usually with the aid of steam. It is used widely in the manufacture of cordage, *e.g.*, tarred ropes and twine, and for impregnation of hemp-fibre for oakum. It is used to a slight extent in pharmacy as a component of some ointments and antiseptics. Distillates of pine-wood tar, particularly the creosote fraction, are used in froth flotation processes.

Peat Tar, a jet black, semi-solid oil, lighter than water, which can be dehydrated by heating at 100°C. On distillation up to 360°C. a hard pitch is obtained along with an oily distillate, the latter consisting of a neutral fraction, containing the solid waxes, phenols and only traces of basic compounds. The most striking characteristic of the neutral oils is their high degree of unsaturation as manifested by absorption of atmospheric oxygen. The waxes, which resemble the *montan wax* of lignite, melt at about 40°C. The acidic (phenolic) constituents of the tar consist of phenol and its homologues, the cresols and xylenols in small quantity, mixed with tar acids boiling at 250–360°C. The latter show a carbolic acid coefficient of 31, *i.e.,* they are 31 times more powerful than phenol as bactericides. Among the phenolic constituents of peat tar, guaiacol, methylguaiacol and a methyl ether of pyrogallol have been identified. These ethers are absent from coal tar, but are found in wood-tar creosote, of which they form the major portion. Peat tar may therefore be looked on as one of the transition steps from wood tar to coal tar. Although the products which can be isolated from peat tar are of undoubted value, the difficulty of winning and drying peat militates against the carbonization of this fuel on an industrial scale.

Lignite and Brown Coal Tars resemble peat tar in many respects. They are usually black oils of a buttery consistency owing to the presence of paraffin wax. Of an average density of 0·95, they retain a high percentage of water but solidify completely at 6–8°C. In contradistinction to tars from bituminous coal, they are almost completely soluble in petrol, a residue of about 5% only being usually left.

They are paraffinoid in nature, the wax content being as high as 10%. The crude wax melts at about 40°C. but from it a series of waxes with melting points from 46° to 73°C. has been obtained. The phenolic constituents resemble those of peat tar and are efficient bactericides. The basic components belong to the pyridine and quinoline series and are chiefly methylated derivatives. A distinctive characteristic of lignite tars is the presence of ketones in the neutral oils—a resemblance to the oils of wood tar. Lignite tars are of increasing importance as a source of fuels for internal-combustion engines, burning and lubricating oils and pitch.

Low-temperature Coal Tars.—(*a*) *Vacuum Tar* has only been produced experimentally with the object of elucidating the composition of coal and the effect of heat upon this material. It is obtained when coal is carbonized at temperatures up to 450° C. under a pressure of 5–40mm. and the average yield is 14 gallons (6·5% by weight) per ton of coal. It is usually lighter than water (sp.gr. 0·99) and is especially interesting in that some of its constituents are identical with substances found in petroleum oils, and extractable from coal itself by solvents such as pyridine. It consists of 40–45% paraffins and naphthenes, 40% "ethylenic" hydrocarbons richer in carbon than mono-olefines, 7% aromatic hydrocarbons, chiefly homologues of naphthalene, and 10% phenols, mostly cresols and xylenols, with smaller amounts of tertiary alcohols and basic compounds. Naphthalene, anthracene, benzene and its homologues are all absent.

Amongst the more interesting constituents of vacuum tar are the naphthene, $C_{30}H_{60}$ called *melene* which is also found in Galician petroleum and in the distillate of bees' wax, and the hydrogenated phenols (alcohols) such as hexahydro-*p*-cresol and its homologues.

(*b*) *Low-Temperature Tar* is produced by the carbonization of bituminous coals, containing 28–35% volatile matter, at temperatures not exceeding 650°C., which is an optimum temperature for the production of gas, tar and smokeless fuel (*see* CARBONIZATION). It is essentially a mixture of those volatile products of coal which are liquid at ordinary temperatures and which have not been subjected to the secondary thermal decomposition incidental to high-temperature carbonization in horizontal retorts. It is therefore regarded as a "primary" tar. Many factors affecting the yield, composition and other characteristics of low-temperature tars have been varied in experimental plants with the result that there have been produced many types of tars to which it has been impossible to assign a common composition. Certain well defined characteristics may be shortly summarized of primary tars obtained by low-temperature carbonization processes which have been commercially established.

Low-temperature tar is usually a brownish black oil, much less viscous than the tar made from the same coal at high temperatures. It is obtained in an average yield of 16–18 gallons per ton of coal carbonized, or 8–9% by weight. This is approximately double the weight obtained by distilling the coal at 900–1,200°C. Its sp. gr. is 1·02–1·07, and owing to the low temperature at which it is formed, it is mainly paraffinoid in character, whereas high-temperature tar is almost wholly aromatic.

The most distinctive characteristics of low temperature tar are the almost entire absence of benzene and its homologues, naphthalene, anthracene and phenol; the unsaturated nature of the neutral oils, from which can be isolated solid paraffins; and the presence of solid, amorphous compounds, of either basic or phenolic nature.

The crude tar is a most unstable product and begins to decompose at about 200° C., finally yielding, when distilled to 360°C., an average of 65% oily distillate and 35% pitch. The amount of pitch formed on distilling low-temperature tar is therefore only half that obtained in a similar operation with high-temperature tar. The former, too, contains much less "free carbon" (*i.e.,* matter insoluble in benzene) than the latter, the average amount being 2–4%. By modified extractions with caustic soda and sulphuric acid (*see* COAL TAR) the crude distillate can be divided into (i.) neutral oils, (ii.) phenols and (iii.) bases.

(i.) *Neutral oils* consist almost wholly of paraffins, naphthenes and olefines, with comparatively small amounts of methylated derivatives of naphthalene and anthracene. On treatment with concentrated sulphuric acid, the neutral oils are absorbed with the exception of some 12% consisting mainly of paraffins. Crude solid wax representing over 1% of the tar is obtained on cooling an acetone solution of the neutral oils. In the paraffin series, all the lower members have been identified, and in the higher ranges, the solid members from $C_{26}H_{54}$ to $C_{29}H_{60}$. The latter melt at 62°C. *α*- and *β-methylnaphthalenes* have been isolated, but no naphthalene. Similarly *β-methylanthracene* occurs in a complex mixture of hydrocarbons crystallizing on cooling the high fractions of the distillates, but anthracene is absent. No phenanthrene or carbazole has been found, and in place of the hydrocarbons fluorene, acenaphthene and diphenyl, there occur the fully hydrogenated products, *perhydrofluorene, perhydroacenaphthene* and *dodecahydrodiphenyl.*

(ii.) *Phenols.* The extraction of the phenolic constituents of the tar or its distillates is complicated by the fact that resinous and asphaltic substances accompany the phenols in solution in the alkali. These impurities, however, can be eliminated by agitation of the alkaline solution with organic solvents or by saturation with salt. The crude phenols (10–20% of the tar) obtained on acidification as a black oil, can be further purified by extraction with light petroleum, followed by precipitation of the residue from an ethereal solution by fresh petroleum. The petroleum extract consists of low-boiling phenols including *phenol* itself, the *cresols* and 1:2:4-, 1:3:5-, 1:3:4-, and 1:4:2- xylenols. *Catechol, β-naphthol* and *trimethylphenols* have also been identified. The higher phenols of the tar are amorphous solids varying in colour from pale yellow to black.

(iii.) *Bases.* The crude bases, representing 2–3% of the tar, are also composed of a low mobile fraction and a higher viscous fraction containing solid, amorphous substances of unknown constitution. The lower bases consist of pyridine and quinoline with their mono-, di- and tri- methyl derivatives. Only traces of primary bases are present in the tar. There have been identified *pyridine, 2-methylpyridine,* 2:4-*dimethylpyridine,* 2:4:6-*trimethylpyridine, aniline, quinoline* and 2-*methylquinoline.* Stable sulphur compounds are present in all fractions of the tar and are only destroyed by treatment with granular sodium at high temperatures.

Utilization of Low-Temperature Tar Products.—The commercial possibilities of low-temperature tar have not yet been fully developed, but its application in various directions has been demonstrated. The low-boiling distillates, owing to their "unsaturated" nature, form satisfactory fuel possessing certain antidetonating qualities. It has been claimed that the higher fractions of the neutral oils form an exceptionally good lubricant, whilst the "middle" or "dead" oils are suitable for combustion in the Diesel engine. Special characteristics are also claimed for low-temperature tar pitch, which can be used along with or in place of high-temperature tar pitch.

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TARSIER, a small lemur-like animal, *Tarsius spectrum*, of the Malay Peninsula and islands, and typifying a sub-order. The name tarsier refers to the great elongation of two of the bones of the tarsus, or ankle, and *spectrum* to the huge goggle-like eyes and attenuated form which constitute two of the distinctive features of this creature. In organization the tarsier in several particulars approximates to monkeys. Rather smaller than a squirrel, with dusky brown fur, it has immense eyes, large ears, a long thin tail, tufted at the end, and disc-like adhesive surfaces on the fingers, which assist the animal in maintaining its position on the boughs. Four species of the genus are recognized, whose range includes the Malay Peninsula, Java, Sumatra, Borneo, Celebes and some of the Philippines. The tarsier feeds on insects and lizards, sleeps during the day, but is active at night, moving by jumping, an action for which the structure of its hind-legs is well adapted. It is rare, not more than two being found together, and only brings forth one young at a time. It appears to be nearer the ancestral tree of man than any other of the lemurs. (*See* Primates.)

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TARSUS (mod. *Tersous*), an ancient city in the fertile plain of Cilicia. The small river Cydnus flowed through the centre of the town, and its cool swift waters were the boast of the city. The city is first mentioned on the Black Obelisk, as captured by the Assyrians *c.* 850 B.C. It was probably an old Ionian colony, settled (like Mallus) under the direction of Clarian Apollo. Its importance was due (1) to its excellent and safe harbour, (2) to its possession of a fertile territory, and (3) to its command of the first waggon-road made across Mount Taurus, which was cut through the Cilician Gates, a narrow gorge 100 yards in length, originally only wide enough to carry the waters of a small affluent of the Cydnus. The greatness of Tarsus rested therefore mainly on the two great engineering works, the harbour and the road.

Tarsus is most accessible from the sea or from the east. Even after the "Cilician Gates" were cut, the crossing of Taurus was a difficult operation for an invading army (as Xenophon and Arrian show). Hence Tarsian history (where not determined by Greek maritime relations) has been strongly affected by Semitic influence, and Dion Chrysostom, about A.D. 112, says it was more like a Phoenician than a Hellenic city (which it claimed to be). After the Assyrian power decayed, princes, several of whom bore the name or title Syennesis, ruled Tarsus before and under Persian power. Persian satraps governed it in the 4th century B.C.; and struck coins with Aramaic legends there. The Seleucid kings of Syria for a time kept it in a state of servitude; but it was made an autonomous city with additional citizens (probably Argive Greeks and Jews) by Antiochus IV. Epiphanes in 171 B.C.; and then it began to strike its own coins. It became one of the richest and greatest cities of the East under the Romans after 104 B.C., and was favoured by both Antony and Augustus: the reception there by the former of Cleopatra, who sailed up to the city in a magnificent vessel, was a striking historic event. In spite of its oriental character, it maintained a university where Greek philosophy was taught by a series of famous Tarsians, who influenced Roman history. Chief among them was Athenodorus Cananites (*q.v.*), teacher and friend of Augustus for many years, a man of courage and power, who remodelled the Tarsian constitution (making it timocratic and oligarchic).

Tarsus depended for its greatness on commerce, peace and orderly government. It was not a strong fortress, and could not be defended during the decay of the empire against barbarian invasion. The Arabs captured the whole of Cilicia shortly after A.D. 660; and Tarsus seems to have been a ruin for more than a century after the conquest. But Harun al-Rashid rebuilt its walls in 787, and made it the north-western capital of the Arab power in the long wars against the Byzantine empire. All the raids, which were made in Asia Minor regularly, year by year, sometimes twice in one year, through the Cilician Gates and past the fortress Loulon, issued through the north gate of Tarsus, which was called the "Gate of the Holy War." The western gate is still standing, and is misnamed "St. Paul's Gate." The caliph Mamun died on such a foray in A.D. 833, having caught a chill at a great spring north of the Cilician Gates beside Ak-Keupreu. He was brought to Tarsus where (like the emperor Tacitus) he died, and (like the emperor Julian) was buried. His illness recalls the fever which Alexander the Great contracted from bathing in the Cydnus. Nicephorus Phocas reconquered Tarsus and all Cilicia for the empire in A.D. 965. In the First Crusade Baldwin and Tancred captured Tarsus A.D. 1099, and there the two leaders had a serious quarrel. It formed part of the kingdom of Lesser Armenia for great part of the three centuries after A.D. 1180, and it was fortified by Leo II. and Hethoum I. But Turkoman and Egyptian invaders disputed its possession with the Greek emperors and Armenian kings and with one another. Finally it passed into Ottoman hands about the beginning of the 16th century.

The ruins of the ancient city are very extensive, but they are deeply buried, and make little or no appearance above the surface except in the Dunuk Tash (popularly identified as the "Tomb of Sardanapalus," a monument which, however, was at Anchiale, not at Tarsus). This shapeless mass of concrete was probably the substructure of a Graeco-Roman temple, from which the marble coating has been removed. The modern town has considerable bazaars and trade; but the climate is very oppressive, owing to the proximity of vast marshes which occupy the site of the harbour and the lower part of the original Cydnus course. The river was diverted from its former course by Justinian in the 6th century. The emperor's intention was only to carry off the surplus waters in time of flood and prevent inundations in the city, not to deprive Tarsus of what was its chief pride and boast; but gradually the neglect of subsequent centuries allowed the channel in the city to become blocked by accumulation of soil, and now the whole body of water flows in the new channel east of the city, except what is drawn off by an artificial irrigation course to water the gardens on the western side of the city. The population in 1927 was 73,680.

Bibliography.—The literature regarding Tarsus is scanty, and few ancient inscriptions have been published. *See* W. B. Barker, *Lares and Penates* (1853); G. F. Hill in the British Museum Catalogue of Coins; Six in *Numismatic Chronicle* (1884), pp. 152 ff., 1894, pp. 329 ff.; E. Babelon in the Catalogue Bibl. Nat., "Perses Achémenides"; the numismatic works of B. V. Head, F. Imhoof Blumer, etc.; Waddington in *Bulletin de Corr. Hell.*, vii., pp. 282 ff.; Ramsay, *Cities of St. Paul* (1907), pp. 85–245, and "Cilicia, Tarsus and the Great Taurus Pass" in *Geographical Journal* (1903), pp. 357–410; R. Heberdey and A. Wilhelm, "Reisen in Kilikien" (in the *Denkschriften d. kais. Akademie Wien*, 1896, xliv.), with works of other travellers, especially V. Langlois and Macdonald Kinneir. Callander in *Journal of Hellenic Studies* (1904), pp. 58 ff., studied Dion Chrysostom's two *Tarsian Orations*.

TARTAGLIA or Tartalea, **NICCOLO** [Nicola Fontana] (*c.* 1506–1559), Italian mathematician, was born at Brescia. His childhood was passed in dire poverty. During the sack of Brescia in 1512, he was horribly mutilated by some French soldiers. From these injuries he slowly recovered, but he long continued to stammer in his speech, whence the nickname "Tartaglia." He was self-taught, but we find him at Verona in 1521 an esteemed teacher of mathematics. In 1534 he went to Venice. For Tartaglia's solution of cubic equations, which he derived from his master Scipione Ferro (d. 1525), and his contests with Antonio Marie Floridas, *see* Algebra: *History*. In 1548 Tartaglia accepted a situation as professor of Euclid at Brescia, but returned to Venice at the end of 18 months. He died at Venice in 1559.

Tartaglia's first printed work, entitled *Nuova scienzia* (Venice, 1537), dealt with the theory and practice of gunnery. He found the elevation giving the greatest range to be 450, but failed to demonstrate the correctness of his intuition. His *Quesiti et invenzioni diverse* (1546), a collection of the author's replies to questions addressed to him, was dedicated to Henry VIII. of England. Problems in artillery occupy two out of nine books;

the sixth treats of fortification; the ninth gives several examples of the solution of cubic equations. He published in 1551 *Regola generale per sollevare ogni affondata nave, intitolata la Travagliata Invenzione* (an allusion to his personal troubles at Brescia), setting forth a method for raising sunken ships, and describing the diving-bell, then little known in western Europe. His largest work, *Trattato generale di numeri e misure*, is a comprehensive mathematical treatise (Venice, 1556, 1560). He published the first Italian translation of Euclid (1543), and the earliest version of some of the works of Archimedes (1543), including *De insidentibus aquae*, of which his Latin now holds the place of the lost Greek text. Tartaglia claimed the invention of the gunner's quadrant.

Tartaglia's own account of his early life is contained in his *Quesiti*, lib. vi., p. 74. *See* also Buoncompagni, *Intorno ad un testamento inedito di N. Tartaglia* (Milan, 1881); Rossi, *Elogi di Bresciana illustri*, p. 386. Tartaglia's writings on gunnery were translated into English by Lucar in 1588, and into French by Rieffel in 1845.

TARTAN, a worsted cloth woven with alternate stripes or bands of coloured warp and weft, so as to form a chequered pattern in which the colours alternate in "sets" of definite width and sequence. The weaving of particoloured and striped cloth cannot be claimed as peculiar to any special race or country, for such checks are the simplest ornamental form into which dyed yarns can be combined in the loom. But the term tartan is specially applied to the variegated cloth used for the principal portions of the distinctive costume of the Highlanders of Scotland. For this costume, and the tartan of which it is composed, great antiquity is claimed, and it is asserted that the numerous clans into which the Highland population were divided had each from time to time a special tartan by which it was distinguished. After the rebellion of 1745 various acts of parliament were passed for disarming the Scottish Highlanders and for prohibiting the use of the Highland dress in Scotland, under severe penalties. These acts remained nominally in force till 1782, when they were formally repealed, and since that time clan tartan has, with varying fluctuations of fashion, been a popular article of dress, by no means confined in its use to Scotland alone; and many new and imaginary "sets" have been invented by manufacturers, with the result of introducing confusion in the heraldry of tartans, and of throwing doubt on the reality of the distinctive "sets" which at one time undoubtedly were more or less recognized as the badge of various clans.

Undoubtedly the term tartan was known, and the material was woven, "of one or two colours for the poor and more varied for the rich," as early as the middle of the 15th century. In the accounts of John, bishop of Glasgow, treasurer to King James III., in 1471, there occurs, with other mention of the material, the following:—"Ane elne and ane halve of blue Tartane to lyne his gowne of cloth of Gold." It is here obvious that the term is not restricted to particoloured chequered textures. In 1538 accounts were incurred for a Highland dress for King James V. on the occasion of a hunting excursion in the Highlands, in which there are charges for "variant cullorit velvet," for "ane schort Heland coit," and for "Heland tartane to be hose to the kinge's grace." Bishop John Lesley, in his *De origine, moribus, et rebus gestis Scotorum*, published in 1578, says of the ancient and still-used dress of the Highlanders and Islanders, "all, both noble and common people, wore mantles of one sort (except that the nobles preferred those of several colours)." A hint of clan tartan distinctions is given by Martin Martin in his *Western Isles of Scotland* (1703), which work also contains a minute description of the dress of the Highlanders and the manufacture of tartan.

The following lines give a brief description of the colours of the tartans of the principal clans. The kilt-tartan colour is given in each case; the plaid-tartans vary in slight particulars.

Campbell of Breadalbane, light green, crossed with darker green, the stripes broad with narrow edging of yellow. *Campbell of Argyll*, light green crossed with dark green, narrow independent cross lines of white. *Cameron*, brick-red with broad chequered cross of same colour, edged white and with broad centre of ground colour, two independent cross lines of green. *Forbes*, yellow green, crossed with broad dark-green lines, centred black, independent cross lines yellow. *Fraser*, red ground, main cross lines red with deeper red centre edged with blue, independent cross lines blue. *Gordon*, dark blue-green ground, with broad cross lines of lighter green, narrow centre line yellow. *Graeme*, light green ground, crossed with darker green in small chequer, independent cross lines dark green. *Grant*, scarlet, with broad black-edged scarlet crossings, black independent cross lines. *Macdonald of Glengarry and Keppoch*, red, with open broad blue cross lines, and two independent blue crossings. *Macdonald of Glencoe*, green with broad dark-green crossing, the whole covered with fine red lines. *Macdonald of Clanranald*, light green with broad dark-green crossing, covered with fine red lines. *Macgregor*, scarlet, with narrow scarlet cross lines, edged and centred blue, widely spaced. *Mackintosh*, red with blue-edged and centred crossings of red, and independent blue cross lines. *Mackenzie*, blue-green, broad crossing of same colour with darker edges, independent cross lines, alternately red and white, over the main crossings. *Macleod*, green, with dark-green crossings, over crossings, every other square, a red line. *Macpherson*, pale grey, four darker grey bars at crossings, the whole covered with red double independent lines. *Munro*, red with broad green stripe and narrow lines forming a check of black and yellow. *Murray*, green, close crossings of darker green, independent lines red. *Stewart*, scarlet, deep coloured crossings with scarlet centre, fine widely spaced dark independent lines.

See W. and A. Smith, *Tartans of the Clans of Scotland* (1850); J. Sobieski Stuart, *Vestiarium Scoticum* (1842); R. R. M'Ian, *Clans of the Scottish Highlands* (1845–46); J. Grant, *Tartans of the Clans of Scotland* (Edinburgh, 1885).

TARTAR, in chemical technology, a name applied to crude acid potassium tartrate (bitartrate of potash) deposited in wine casks or vats during the process of vinous fermentation as a crystalline crust of "argol," containing about 75% of potassium bitartrate. This argol when partly purified by recrystallisation is known as "tartar," and when further purified and freed from colouring matter it becomes "cream of tartar." Cream of tartar is used medicinally as a diuretic and purgative.

The term "tartar" was formerly employed in a wider generic sense by the iatrochemists who included under this heading both the above *tartarus vini* and various substances obtained from it and even salts such as salt of sorrel (potassium oxalate) which resembled it. Thus *sal fixum tartari* was dry potassium carbonate which on exposure to air deliquesced to *oleum tartari per deliquium*. Neutral potassium tartrate was termed *tartarus tartarisatus* because it was prepared by neutralising ordinary tartar with the *sal fixum* (K_2CO_3). *Spiritus tartari* employed by Paracelsus was prepared by dry distillation of tartar. This iatrochemist also used the term in a still wider sense to signify abnormal sediments deposited from animal secretions such as the concretionary masses separating in the liver, kidney or bladder, and usually referred to as "stone."

Wine "Lees" and Argol.—Tartaric acid occurs in the juices of various fruits particularly the grape and tamarind. With the grape this acid passes into the expressed juice and during fermentation a deposit of sparingly soluble acid potassium tartrate is thrown down which forms the "lees" of wine. During the process of maturing, a further quantity of this tartrate is precipitated and the deposit of "argol" constitutes the main source of commercial tartaric acid.

Cream of Tartar.—Granulated argol is dissolved to saturation in boiling water and the clear solution allowed to crystallise. The coloured crystals are redissolved in hot water and decolorised by means of pipeclay or egg albumen. On subsequent crystallisation, small, hard, colourless, transparent, rhombic prisms are obtained of cream of tartar. This salt dissolves in 15 parts of hot water but requires for solution 416 parts of water at 0° C. It dissolves freely in solutions of boric acid or borax giving soluble cream of tartar, a white powder, permanent in air when made with boric acid but deliquescent when prepared with borax. Rochelle salt or potassium sodium tartrate, $KNa\ (C_4H_4O_6)$, a purgative drug, is made by dissolving cream of tartar in aqueous sodium carbonate. On ignition cream of tartar evolves inflammable gases and leaves a residue of potassium carbonate and carbon.

Tartar Emetic (potassium antimonyl tartrate),

$K.(SbO)C_4H_4O_6, \frac{1}{2}H_2O$,

a long-known drug, being mentioned by Basil Valentine, is prepared by warming 3 parts of antimony oxide or powder of algaroth (*q.v.*) with four parts of cream of tartar in presence of water. It separates from the filtered solution in colourless octahedra which gradually lose their combined water, becoming opaque. It is soluble in 14·5 parts of cold and 1·9 parts of hot water. It has a nauseous metallic taste and produces vomiting when taken internally. In large doses it is poisonous. Besides its medicinal use it is employed as a mordant in dyeing and calico printing. (G. T. M.)

TARTARIC ACID, is now one of the most important of the organic acids and probably one of the first to be recognised, for its sparingly soluble acid potassium salt (*see* TARTAR) was known to the Greeks and Romans in the form of a deposit from fermented grape juice. K. W. Scheele first isolated tartaric acid in 1769 by boiling tartar with chalk and decomposing the product with sulphuric acid. Ordinary tartaric acid crystallises from water in large colourless hemihedral monoclinic prisms containing no water of crystallisation. It melts at 168–170° C and at higher temperatures decomposes into a variety of products; its formula is $C_4H_6O_6$. (*See* PYRUVIC ACID.)

Manufacture.—The starting material, argol or wine lees, is boiled with dilute hydrochloric acid and the solution treated with milk of lime and calcium carbonate, when calcium tartrate is precipitated. This deposit is then decomposed with dilute sulphuric acid, when sparingly-soluble calcium sulphate remains largely undissolved whereas the tartaric acid passes into solution, which is concentrated to the crystallising point in vacuum pans. The liquid is then cooled in tubs by stirring in order to obtain the crude tartaric acid in granular form. This product is redissolved in water and the solution decolorised by heating with animal charcoal previously freed by acid from calcium phosphate. The clear solution is concentrated and allowed to crystallise, when purified commercial tartaric acid is obtained.

Applications.—Tartaric acid is used as a mordant in wool dyeing. It is employed by the calico printer in conjunction with bleaching powder for the liberation of chlorine, as a resist for alumina and other basic mordants and in the discharge colours for Turkey red. By successive nitration and autoxidation, tartaric acid is converted into dinitrotartaric acid and dihydroxytartaric acid, the latter being an intermediate in the manufacture of the wool dye, tartrazine. Tartaric acid also serves in certain photographic processes for printing and developing. It is employed for the production of baking powders, Seidlitz powders, sherbet and similar effervescent drinks. Medicinally it is used to make saline draughts and cooling drinks for febrile and diabetic patients. If unneutralised it must be taken in largely diluted solution otherwise severe gastroenteritis may result. Lime water, magnesia and alkalis are antidotes.

Chemical Properties.—Tartaric acid is oxidised by hydrogen peroxide in presence of ferrous salts to dihydroxymaleic acid (H. J. H. Fenton, 1894) and reduced by hydriodic acid and phosphorus to malic and succinic acids. Tartaric acid prevents the precipitation by alkalis of many metallic hydroxides (*e.g.*, copper and iron). Calcium chloride gives a white calcium tartrate in neutral solution, the precipitate being soluble in cold aqueous potash but reprecipitated on boiling. Added to concentrated sulphuric acid containing 1% of resorcinol, tartaric acid develops a violet red coloration. With warm ammoniacal silver nitrate it furnishes a silver mirror.

Stereoisomeric Tartaric Acids.—Four varieties of tartaric acid are recognised: (1) The ordinary dextrorotatory tartaric acid found either free or as potassium and calcium tartrates in the juices of tamarinds, mulberries, pineapples, unripe beetroot and especially in grapes; (2) laevorotatory tartaric acid which does not occur in nature but is obtained by the resolution of the salts of racemic acid. Its chemical properties are identical with those of the dextro-acid and in all its physical properties it resembles this acid except that it turns the plane of polarisation of light to the left and its crystalline salts show hemihedral faces like those of the dextro-acid but oppositely situated, as object to mirror image; (3) racemic acid, $(C_4H_6O_6)_2,2H_2O$, which is obtained from the tartar mother-liquor, melts at 206° C and is produced synthetically by the oxidation of fumaric acid or by mixing molecular proportions of the *d*- and *l*-acids; (4) mesotartaric acid, melting at 143° C, is obtained when cinchonine tartrate is heated for some time at 170° C, and also by the oxidation of maleic acid; it is inactive like racemic acid, but unlike the latter is not resolvable into optically active varieties. The chemical study of the optical properties of these four tartaric acids by L. Pasteur forms the foundation of our modern conceptions of stereoisomerism. (*See* STEREOCHEMISTRY.) (G. T. M.)

TARTARUS, in Greek mythology, the son of Aether and Gē, father of Typhoeus and the giants. In the *Iliad* the word denotes an underground prison, as far below Hades as earth is below heaven, in which those who rebelled against the will of Zeus were confined. In later commentaries Tartarus is the place of punishment of the wicked after death, and is used for the underworld generally. (*See* ABYSS.)

TARTINI, GIUSEPPE (1692–1770), Italian violinist, composer and musical theorist, was born at Tirano, Istria, on April 8, 1692. In early life he studied, with equal want of success, for the church, the law courts and the profession of arms. As a young man he was wild and irregular, and he crowned his improprieties by clandestinely marrying the niece (or the daughter of a dependent) of Cardinal Cornaro, archbishop of Padua. The cardinal resented the marriage and Tartini, thinking his life in danger, fled for safety to a monastery at Assisi, where his character underwent a complete change. He studied the theory of music under Padre Boemo, the organist of the monastery, and learned to play the violin in so masterly a style that his performances in the church became the wonder of the neighbourhood. For more than two years his identity remained undiscovered, but one day the wind blew aside a curtain behind which he was playing. His retreat was betrayed to the cardinal, who, hearing of his changed character, readmitted him to favour and restored him to his wife.

Tartini next removed to Venice, where he repaired, by the aid of good instruction, the shortcomings of his own self-taught method. After a period of study at Ancona, he returned to Padua, where he was appointed solo violinist at the church of San Antonio. From 1723 to 1725 he acted as conductor of Count Kinsky's private band in Prague. In 1728 he founded a school for the violin in Padua. The date of his presence in Rome does not seem to be clearly established, but he was in Bologna in 1739. Afterwards he returned to his old post in Padua, where he died on Feb. 16, 1770.

Tartini's numerous compositions illustrate his passionate and masterly style of execution, in which he surpassed all his contemporaries. He frequently headed his pieces with an explanatory poetical motto, such as "Ombra cara," or "Volgete il riso in pianto o mie pupille." He told Lalande in 1766 that the sonata known as *Il Trillo del Diavolo*, or *The Devil's Sonata,* was the fruit of a dream, in which the devil played an exquisite sonata. Tartini's first book of sonatas was published at Amsterdam in 1734, the second at Rome in 1745, and many chamber works appeared during his lifetime.

Tartini contributed to the science of acoustics by his discovery (independently of Sorge, 1740, to whom the primary credit is now given) of what are still called "Tartini's tones" (*see* SOUND AND HEARING), or differential tones. When any two notes are produced steadily and with great intensity, a third note is heard, whose vibration number is the difference of those of the two primary notes. It follows from this that any two consecutive members of a harmonic series have the fundamental of that series for their difference tone—thus, $\frac{E}{C}$, the fourth and fifth harmonic, produce C, the prime or generator, at the interval of two octaves under the lower of those two notes; $\frac{E}{G}$, the third and fifth harmonic, produce C, the second harmonic, at the interval of a 5th under the lower of those two notes. The discoverer was wont to tell his pupils that their double-stopping was not in tune unless they could hear the third note; and Henry Blagrove (1811–1872) gave the same admonition. Tartini made his observations the basis of a theoretical system which he set forth in his *Trattato di Musica, secondo la vèra scienzia dell' Armonia* (Padua, 1754) and *Dei Principij dell' Armonia Musicale* (Padua, 1767; Eng. trans. 1771). He also wrote a *Trattato delle Appogiature,* posthumously printed in French, and an unpublished work, *Delle Ragioni e delle Proporzioni,* the MS. of which has been lost.

TARTU [Dorpat], a town of Estonia, situated on the Embach, in 58° 23′ N. and 26° 23′ E. Pop. (1924) 50,000. Until the formation of the Estonian State in 1918 the town was called Dorpat. The name Tartu means lowland of Tar or Taara, a god of Estonian mythology probably related to the Scandinavian Thor. The principal part of the town lies south of the river, and the more important buildings are clustered round the two eminences known as the Domberg (cathedral hill) and the Schlossberg (castle hill), which in the middle ages were occupied by the citadel, the cathedral and the episcopal palace. Owing to a great fire in 1777, the town is almost entirely modern; and its fortifications have been transformed into tree-lined promenades. Besides a good picture gallery in the *Ratshof,* and the 13th-century church of St. John, Tartu possesses a university, with an observatory, an art museum, a botanical garden and a library of 250,000 volumes, which are housed in a restored portion of the cathedral, burned down in 1624. A National Museum of Estonia was founded in 1892 and contains a fine ethnographic section.

The university was founded by Gustavus Adolphus of Sweden in 1632; but in 1699 teachers and students removed to Pernau on the advance of the Russians, and on the occupation of the country by Peter the Great again took flight to Sweden. In spite of the treaty of 1710 and the efforts of the Livonian nobles, it was not till 1802 that its restoration was effected under the patronage of Alexander I. Down to 1895, in which year it was thoroughly Russified, the university was German in spirit and in sentiment. It is now attended by some 4,500 students. The astronomical department is famous, owing partly to the labours of F. G. W. von Struve (1820–39), and partly to Fraunhofer's great refracting telescope, presented by the emperor Alexander I.

The foundation of Dorpat is ascribed to Yaroslav, prince of Kiev, and is dated 1030. In 1224 the town was seized by the Teutonic Knights, and in the following year Bishop Hermann erected a cathedral on the Domberg. From that date till about 1558 the town enjoyed great prosperity, and the population reached 50,000. In 1558 it was captured by the Russians, but in 1582 was yielded to Stephen Bathori, king of Poland. In 1600 it fell into the hands of the Swedes, in 1603 reverted to the Poles, and in 1625 was seized by Gustavus Adolphus of Sweden. The Russians again obtained temporary possession in 1666, but did not effect a permanent occupation till 1704. In 1708 the bulk of the population were removed to the interior of Russia. The town passed from Russian to Estonian rule in 1918, but suffered much both during the German occupation and during the later struggle with the Bolshevists.

TARWEED, the name given in the United States to various plants of the tribe Madieae of the family Compositae (*q.v.*), natives chiefly of the Pacific coast of North America. They are mostly annuals, with showy yellow or white flowers. Some 25 species occur in California, Oregon and Washington. Several of these, as the yellow tarweed (*Hemizonia virgata*), the coast tarweed (*H. corymbosa*) and the clustered tarweed (*H. fasciculata*), are valuable honey plants. The most widely known species is the Chile tarweed (*Madia sativa*), native to Chile and naturalized in California and Oregon, a useful forage plant, the seeds of which yield a pleasant, edible oil.

TASCHEREAU, SIR HENRI ELZEAR (1836–1911), chief justice of Canada, was born at St. Mary's in Beauce county (Quebec), on Oct. 7, 1836, the son of P. E. Taschereau. He was educated at the Seminary of Quebec, and was called to the bar there in 1857, becoming a Q.C. in 1867. He entered parliament, and was elected conservative member for Beauce county in the Legislative assembly (1861–67). He gained a reputation in 1874–75 with his work on *Criminal Law Consolidation and Amendment Acts of 1869 for the Dominion of Canada with Notes, Commentaries, etc.* (vol. i. Montreal, 1874; vol. ii. Toronto, 1875, and later editions); and soon afterwards published *Le Code de Procédure Civile du Bas-Canada* (Quebec, 1876). He became successively puisne judge of the superior court of Quebec (1871), judge of the supreme court of Canada (1878), and chief justice of Canada (1902–06), being knighted in 1902. In 1895 he had become dean of the faculty of law at Ottawa university, where he had previously held a chair. Taschereau became a member of the judicial committee of the privy council in 1904. He died at Ottawa on April 14, 1911.

TAS-DE-CHARGE, in architecture, a French term for which there is no English equivalent, given to the lower courses of a Gothic vault, which are laid in horizontal courses and bonded into the wall; they generally rise about one-third of the height of the vault, and as each course projects beyond the course below, following the curve of the vault, they lessen the span to be vaulted.

TASHI-LHÜNPO: *see* Shigatse.

TASHKENT or **TASHKEND,** a city of Asiatic Russia in the Uzbek S.S.R., in 41° 30′ N., 69° 20′ E., situated in a loess oasis, watered by the interlocking Chirchik and Keles tributaries of the Syr-Darya. Irrigation cultivation is very ancient in the oasis; the town itself dates back at least to the seventh century A.D. In 582 the Turks of Transoxiana divided into two khanates, the western one having two headquarters, one at Urumchi and one north of Tashkent, and it is recorded that the Chinese in 659 claimed the territory of the western Turks, including Tashkent. It was captured in 1865 by the Russians and was made the administrative centre of the former Government of Russian Turkestan. The Russians then built a new town nearly 8 m. long and 4 m. broad, considerably to the north-east of Eski-tashkent (old Tashkent), which is now practically deserted.

The houses are low because of frequent earthquakes, and are almost hidden by the poplar, willow and fruit trees which surround them and line the broad streets. Its population in 1926 was 312,811. It has cotton-cleaning factories, makhorka-tobacco factories, a leather, machinery and cellulose industry, and sawmills; there is a municipal electricity, water and tram service. Much fruit and agricultural produce are grown in the oasis. The population is mixed, Russians, Sarts and Uzbeks predominating. Under the new régime efforts have been made to raise the status of women and a woman's co-operative store now exists in the town with a membership of about 600 Uzbek and Tatar women. The town has a good library, a museum which includes a collection of Graeco-Bactrian coins, and a Teachers' training college.

TASHKURGHAN or **KHULM,** a khanate and town of Afghan Turkestan. The khanate lies between Kunduz and Balkh. The ancient town of Khulm stood in the Oxus plain, surrounded by orchards of famous productiveness; but it was destroyed by Ahmad Shah Abdali, who founded Tashkurghan in the middle of the 18th century, and took all the inhabitants away from Khulm to populate it. Ancient Khulm is now only a mass of ruins; but Tashkurghan, lying two or three miles to the south of it, has become the great trade-mart of Afghan Turkestan. At Tashkurghan the caravans from India and Bokhara meet, and from here the merchandise is distributed.

TASMAN, ABEL JANSZOON (*c.* 1603–1659), the greatest of Dutch navigators, the discoverer of Tasmania, New Zealand, the Tonga and the Fiji Islands, and the first circumnavigator of Australia, was born at Lutjegast in Groningen, about 1603. In 1634 we first meet with him in the East Indies, sailing from Batavia (Feb. 18) to Amboyna. After a short visit to Holland he was again in Batavia in 1638. On June 2, 1639 Tasman, with Matthew Quast, was despatched by Antony Van Diemen, governor-general of the Dutch East Indies, on a voyage to the north-western Pacific, in quest of certain "islands of gold and silver," supposed to lie in the ocean east of Japan. On this voyage Tasman and Quast visited the Philippines and improved Dutch knowledge of the east coast of Luzon; they also discovered and mapped various islands to the north, apparently the Bonin archipelago. Sailing on to N. and E. in search of the isles of precious metals, they ranged about fruitlessly in the northern Pacific. In October the navigators decided to return, and, after touching at Japan, anchored at the Dutch fortress-station of Zeelandia in Formosa on Nov. 24, 1639. After this Tasman was engaged in operations in the Indian seas (sailing to Formosa, Japan, Cambodia, Palembang, etc., as a merchant captain in the service of the Dutch East India Company) until 1642, when he set out on his first great "South Land" expedition. Several Dutch navigators had already discovered various portions of the north and west coasts of Australia (as in 1605–06, 1616, 1618–19, 1622, 1627–28, etc.), but Tasman now first showed that this great South Land was an island.

Van Diemen's Land and New Zealand.—Sailing from Batavia on Aug. 14, 1642 with two vessels, the "Heemskerk" and "Zeehaen," and calling at Mauritius (Sept. 5 to Oct. 8), Tasman sailed first S., then E., almost seven weeks, and on Nov. 24 sighted (in 42° 25′ S., as he made it) the land which he named *Anthoonij van Diemen's landt* after Van Diemen, now called Tasmania. He coasted its southern shores, and, running up Storm Bay, anchored on Dec. 1, in Frederick Henry's Bay, on the east coast of Tasmania. There he hoisted the Dutch flag. Tasman then steered E. for the Solomon Islands, and on Dec. 13 discovered a "high mountainous country," which he called *Staten landt* ("Land of the States," *i.e.*, of Holland, now New Zealand). Tasman believed the newly discovered land to form part of the same great antarctic continent as the other *Staten landt* which Schouten and Lemaire had sighted and named to the east of Tierra del Fuego. He anchored on Dec. 18 in 40° 50′ S., at the entrance of a "wide opening," which he took to be a "fine bay" (Cook's Strait). He gave the name of *Moordenaars* (now *Massacre*) *Bay* to this spot, where several of his men were killed by the natives (Dec. 19). He then sailed along the south shore of Cook's Strait, but without discovering the full extent of the strait here dividing New Zealand into two main islands. Returning westward he then coasted the west side of the North Island, till, on Jan. 4, 1643, he reached the northern extremity of New Zealand.

Thence he bore away to N.N.E. and on Jan. 19–25 he discovered various islands of the Tonga or Friendly group. Here the ships provisioned, for the first time since leaving Mauritius. Thence Tasman steered N. and W., reaching on Feb. 6 the eastern part of the Fiji archipelago, which he called Prince William's Islands and Heemskerk's Shoals. He reached the western extremity of New Guinea on May 18. He arrived at Batavia on June 15, 1643 after a ten months' voyage.

Second Voyage.—The materials for an account of Tasman's important second voyage in 1644 are scanty. He was instructed to obtain a thorough knowledge of Staten Land and Van Diemen's Land, and to find out "whether New Guinea is a continent with the great Zuidland, or separated by channels and islands," and also "whether the new Van Diemen's Land is the same continent with these two great countries or with one of them." In this voyage Tasman had three ships under his command, the "Limmen," "Zeemeeuw" (or "Meeuw"), and "Brak" (or "Bracq"). He coasted the south-west coast of New Guinea; he mistook the western opening of Torres Straits for a bay, but explored (and perhaps named) the Gulf of Carpentaria: for the first time the coast-line of this great bay was mapped with fair accuracy. Though preceded by Jansz (1606) and Carstensz (1623) on the east shore of the gulf as far as 17° S., Tasman first made known the south, and most of the west, coast. Beyond this he explored the north and west coasts of Australia as far as 22° S., and established the absolute continuity of all this shore-line of the "Great Known South Continent"; his chart gives soundings for the whole of this coast. Tasman's achievements were coldly received by the Dutch colonial authorities; but on Oct. 4, 1644 they rewarded him with the rank of commander (he had frequently enjoyed the use of the title already). He was also made a member of the Council of Justice of Batavia. He was a member of the committee appointed on April 18, 1645 to declare a truce between the Dutch East India Company and the viceroy of Portuguese India. In 1647 he commanded a trading fleet to Siam, and in 1648 a war-fleet sent against the Spaniards of the Philippines (May 15, 1648, to January 1649). By 1653 he had quitted the company's service. He died probably before Oct. 22, 1659, and certainly before Feb. 5, 1661.

See R. H. Major, *Early Voyages to . . . Australia* (London, Hakluyt Society, 1859), especially pp. xciii.–ciii., 43–58 (here are printed the instructions for Tasman and his colleagues on the voyage of 1644); G. Collingridge, *Discovery of Australia* (Sydney, 1895), especially pp. 238–40, 279–80; and, above all, J. E. Heeres and others, *Tasman's Journal . . . facsimiles of the original MS. . . . with . . . life . . . of . . . Tasman,* etc. (Amsterdam, 1898)—here the *Life of Tasman,* with its appendices, is separately paged (163 pp.). *See* also *Aandeel der Nederlanders in de Ontdekking van Australië,* 1606–1765 (in Dutch and English, Leyden and London, 1899), especially pp. vi., viii., xii.–xv., 72; the valuable summary of the voyage of 1642–43 in the anonymous *Account of several late Voyages and Discoveries* (beginning with Sir John Narborough's), London, 1711, with sub-title, *Relation of a Voyage . . . of Captain Abel Jansen Tasman* (originally extracted from his journals by Dirk Rembrantse in Dutch, published in English in Dr. Hook's collections); also *The Discovery of Van Diemen's Land in 1642,* by James Backhouse Walker (Hobart, 1891).

TASMANIA, a State of the Commonwealth of Australia consisting of one large and numerous smaller islands, the largest of which, King, Flinders and Cape Barren Islands, lie in Bass Strait (total area, 26,215 miles—roughly that of Scotland—forming 0·88% of the area of the Commonwealth). The island of Tasmania extends from about lat. 40° 40′ S. to lat. 43° 40′ S., is of a maximum length (N.–S.) of 180 m. and breadth (E.–W.) of 190 miles, and has a shield-shaped general outline tapering southwards. It lies upon the main continental platform and at various periods formed part of the continent to its north. Bass Strait, though some 140–150 miles wide, is relatively shallow so that Tasmania is linked to the mainland by a submarine ridge carrying only 30–40 fathoms from which rise the groups of islands mentioned above. The latest severance of Tasmania is probably geologically recent and a rise of *c.* 200 ft.—or a corresponding fall in sea-level—would reunite it to the mainland. It is, in fact, essentially a portion of the eastern highland belt of Australia (*see* AUSTRALIA: *Geomorphology*) and has the same general physiographic character modified, to some extent, by climate. Subjected to repeated strains and stresses, and also to active denudation, throughout its history, the island-mass has assumed the character of an extremely irregular upland block, or group of blocks, with generally flattened tops but steep, and often precipitous (step-faulted) sides—*cf.* the term "tiers"—and possessing several coastal, and also some inland, lowlands in which crustal oscillations have produced features of both emergence and of submergence. The nearness in time of some of the most influential of these movements is proved by the freshness and sharpness of many of the forms (*e.g.*, "drowned" coastal features, valley gorges, waterfalls and generally ungraded stream courses), by the signs of dislocated drainage, and by the general irregularity, and even wildness, of the topography. The extensive and varied igneous intrusions—Palaeozoic granites and serpentine, Cretaceous diabase, Tertiary basalts, etc.—evidence the intensity of the movements, while weathering has flattened, but also in part, by means of differential erosion, diversified the surface.

Physiography.—Several divisions may be distinguished. (i.) The south and west are occupied by a broad belt of highlands presenting abrupt irregular fronts to the west and north. They are composed mainly of very ancient sedimentary rocks (Pre-Cambrian—Palaeozoic schists, quartzites, slates, sandstones and limestones) much intruded by granite and other igneous formations. The general surface level rises to some 4,000 ft. with many summits approaching 5,000 ft. (Cradle Mountain, 5,069 ft.), but the incision of streams and the cutting of deep valleys and gorges (King River, 3,000 ft. deep, and *cf.* the valleys of the Arthur, Pieman, Gordon Rivers) has given rise to a wild, inaccessible, and little known landscape, with some lakes and forests, much poor and sterile rock and soil, but possessing great actual and potential mineral wealth. (ii.) The Central (Lake) Plateau, only partly dissevered from the above, consists mainly of Mesozoic rocks (Permo-Carboniferous) and slopes down from a general level of 3,500 ft. in the northwest to lower levels in the southeast, in which direction it is drained by the streams of the Derwent system. To the north and northeast it presents a towering escarped front ("tiers") with individual elevations of over 4,000 ft. fashioned mainly out of igneous (diabase) intrusions. The rocks contain some oil shale and coal, but for the rest supply only grasslands. The heights which flank the central east coast are a portion of this formation, being severed only by the Macquarie-Coal River depression (elevation 660 ft. near Tunbridge). (iii.) The northeast highlands, though detached from the central massif by the broad Tamar-Esk depression, resembles it in being a plateau with levels rising to 3,000–4,000 ft. The Palaeozoic sediments have been penetrated by igneous intrusions of various dates and composition (granite, diabase, basalt), the harder of which form great bosses (Ben Lomond, highest elevation in the island, 5,160 ft.). They constitute a group of wild and mineralised mountain-blocks towering above the adjoining lowlands. (iv.) The northern lowlands a down-faulted area fronting Bass Strait and broadest in the northwest, consist substantially of the same rocks as the highlands behind (pre-Cambrian schists, Palaeozoic slates, sandstones, etc.) and, besides rich deposits of metallic ores, include valuable limestones, oil-shales and coal. Many of these rocks yield infertile soils, but the great basalt (Tertiary) flows which characterise this area redeem this quality, and these lowlands, with their irregular terrain and diversified potentialities form one of the richest regions. (v.) The east and southeast lowlands are even more irregular, and are worked out mainly in Mesozoic (Triassic–Jurassic) strata which contain coal. Diabase and older rocks form irregular, rough and infertile ranges, spurs and platforms over considerable areas, but the later strata yield soils useful for pasturage and cultivation.

Lakes are an especial feature of the Tasmanian highlands, and especially of the central plateau. Here, at an elevation of about 2,500 ft., the heavy rainfall is held up in impervious (diabase, etc.) rock-basins, and elsewhere (*e.g.,* in the west) are lakes of glacial origin. Great Lake (alt. 3,800 ft.) is 15 miles long and its natural depth was only 20 ft. It has importance in connection with a great hydro-electric supply scheme.

The *coast-line* (900 miles) receives its special character from recent subsidence, though there has been a still later but smaller elevation. Where the coast runs parallel to the grain of the highlands it is mostly closed (*e.g.,* on the west) and presents few good openings. On the northeast and southeast, on the other hand, are many curious features of submergence (*e.g.,* Freycinet and Tasman's peninsulas) and also some fine "drowned valley" harbours (Tamar, Derwent, *see* LAUNCESTON, HOBART) (*v. inf.*).

Climate.—Tasmania lies in the southern temperate zone in the track of the east-moving cyclonic systems ("lows"), while no part is far removed from the sea. Hence its climate is cool, equable and moist, somewhat resembling that of southwest England and Ireland. Like these, too, its weather conditions are exceedingly variable—hardly four consecutive days showing the same conditions—but in its case there is added to this variability an extraordinary local diversity due to the irregular and sharp-cut topographical features. Thus there is strictly no general climate of Tasmania, but, within limits, temperatures, and particularly rainfall, show remarkable ranges (*e.g.,* 130 in. at Lake Margaret on the west coast; 18 in. at Antill Ponds in the east midlands). Broadly speaking temperatures range from 65° F in summer to 45–50° F in winter, the east coast having temperatures in general *c.* 4° above those of the west coast owing to the influence of warm (north) and cool (south) sea-currents respectively. Rainfall is greatest in the west, where the highlands force precipitation from the moist westerly winds (40 in. av. ann. along the coast, rising to 60 in., and to 140 in. in the central northwest, with a late-winter maximum (*e.g.,* Queenstown: 100 in.; Aug., 10 in.; Feb., 4 in.). The northeast highlands also receive 40–80 in., but the eastern and central lowlands are in the "rain-shadow" of the western heights and receive some 20 in. more or less with a maximum in spring and summer when southeast winds blow in with rain. (*See* also LAUNCESTON, HOBART.) It is the cool and moist climate of Tasmania which lends it that relatively verdant and garden-like character which is such an attraction to Australians from hotter and drier latitudes.

Vegetation.—The natural vegetation was one of the finest and, potentially, the most valuable in the Commonwealth though its natural riches have been largely dissipated. The chief controlling factor appears to be rainfall—or rather, availability of moisture. Thus the beech forests—so-called "myrtle"—which are peculiar to Tasmania are found in various separate areas but always where the av. ann. rainfall is over 50 in. Eucalypts form the bulk of the forests in areas of intermediate rainfall and range from swamp and blue "gums" in the lower river-flats to the "snow" or "mountain" gum on higher slopes. Some of the "pines" (Huon, "celery-top," etc.) are also denizens of the lower and wetter valleys, *e.g.,* in the southwest. The "wetter" forests have also often a dense and almost impenetrable undergrowth (tree-ferns, laurels, etc.). In the drier "rain-shadow" lowlands of the east and centre the forests become thinner—though the trees tend to become individually finer—and a type of wooded "park" or grass-land prevails. The wind-swept plateau-tops carry little but stunted scrub, grasses, and bog and moorland vegetation merging in places into "alpine," and the lower hills which lie along and immediately behind the west coast, with their relatively light rainfall (20–40 in.) are matted over with the strange and impassible "horizontal" (*bauera*) scrub. The western mountains and valleys still contain fairly large forest patches (*e.g.,* the fine eucalypt forest of the Huon Valley), and the northeast also is well clad. In the lowlands and on the more accessible slopes the forests have been largely destroyed or wastefully depleted for their valuable contents. Commercially useful timber is supplied by many of the gums—blue, yellow (cider), swamp and stringy gums, peppermint, etc.—by the soft-wood pines, the beech, the blackwood of the northern basaltic slopes and valleys and also by the acacias (*e.g.,* the "black wattle" supplying tanning bark). Tasmania has a relatively large extent of forested land (1,500,000 acres, nearly 9% of total area). But, from the scientific forester's point of view, the forests are not as valuable as might appear. There were (1926) only 176,000 ac. of reserved forests, or, with timber and fuel reserves, 1,817,200 ac.

General Economic Aspects.—The extraordinary diversity of soil, climate, and of topographical feature within even a quite restricted area has given to Tasmanian land development a sporadic and somewhat "patchy" nature. This, and the very large extent (about ⅔) of broken and uncultivable terrain, has prevented the growth of large and simple types or areas, such as, *e.g.,* the wheat belt in Australia, and has rendered difficult any large-scale unified economic organization.

Mining and Metallurgy.—If Tasmania's mineral output is not relatively large it is large in proportion to the area of the State. The island contains some notable individual deposits and its reserves are also probably considerable, much of the country being as yet inadequately prospected. The minerals fall into two main classes: (a) *metallic minerals* occur chiefly in the older rocks of the western highlands where the extensive igneous activity has led to mineral concentrations. In the central west the Queenstown-Gormanston area has been developed, under conditions of extraordinary physical difficulty, upon a large scale, outlet being chiefly by Macquarie Harbour (Strahan, Pillinger). Northwards from this are the Zeehan-Dundas, Read-Rosebery, Waratah, Mt. Bischoff and other areas. Many of these mines produce varying quantities of silver, lead, copper and gold, partly as a by-product, *e.g.,* in copper refining. The copper is produced almost entirely by the Mount Lyell Mining and Railway Company which owns extensive workings, railway lines, electric (power and light) supply schemes (Lake Margaret). The output of this Company's mines in 1927–28 was 7,060 tons copper, 121,456 oz. silver, 2,360 oz. gold; the year's profits amounted to over £200,000, the liquid assets are valued at £1,043,000. Mount Bischoff is still noted for tin, while the Read-Rosebery zinc reserves are estimated at over 2,500,000 tons. In addition valuable osmiridium alluvial deposits occur along the west coast. The similar rock formations of the north, north-east and east contain gold (Beaconsfield, Lefroy, Lisle, Mathinna, Mangana) but more important is tin, the bulk of the Tasmanian output coming from the north-eastern fields (Gladstone, Derby, Branxholm, Ringarooma) and also from the east (St. Helen's, etc.), while a rich deposit has also been discovered on King Island. Tasmanian iron reserves are estimated at 100,000,000 tons; the ore occurs in the ancient rocks of the west and north, notable deposits being at Rio Tinto (Savage River on the west coast: about 50,000,000 tons) and at Burnie where the Blythe River has cut through a deposit of 17–30,000,000 tons. The iron ores are as yet little exploited. (b) *Non-metallic minerals* consist chiefly of coal, oil-shales, limestones, and pottery clays. Coal (125,000,000 tons, actual, 123,000,000 probable, reserves) occurs in the Permo-Carboniferous, Trias–Jura and Tertiary strata along the north and east coastal areas and is increasingly mined around St. Mary's, in the Mersey Valley, etc. In the northern coastal areas occur large deposits of oil-shales, while limestones and clays in great quantity occur there and elsewhere. The shales are as yet little worked, but the limestones and clays form the basis of the potentially important cement industry of Maria Island, etc., the limestones of Melrose are exported through Devonport for fluxing purposes to New South Wales (*see* BROKEN HILL), those near Hobart (*q.v.*) are used for the carbide industry (1926: £68,400), and the clays are also used for tile, etc., manufacturing (*e.g.*, near Launceston). Metal concentrating and refining is conducted on a large scale on the Zeehan and Mount Lyell areas, but Mount Bischoff ores are smelted at Launceston (*q.v.*). The important Electrolytic Zinc Company's works at Risdon (*see* HOBART and BROKEN HILL) recovered (1926) 41,840 tons zinc (£1,428,000) and cadmium valued at £27,750 from Broken Hill ores (exclusive of Tasmanian concentrates treated). The Mount Lyell Mining and Railway Co. has also engaged in the production of superphosphates, sulphuric acid, etc. As elsewhere in Tasmania the growing success of mining, metallurgical, etc., industries is due to hydro-electric power.

Timber, Fruit, etc.—Tasmania's saw-mill output (1925–26) was 53,600,000 super ft. (exports: 42,600,000=£534,000). Recent discovery of the high value of Australian hardwoods for making paper-pulp has led to the establishment of a promising new industry which, able to absorb poorer timbers and "offal" formerly wasted, has, allowing for re-growth, unlimited reserves. The cultivation of imported soft-wood species also holds out promise. Fruit-growing in Tasmania has progressed as over-sea markets have become available.

Agriculture and Dairying.—The products of arable agriculture are characteristically oats, barley, potatoes and fodders. Tasmania was once the granary of Australia, but the uncertainty and dampness of the native climate, together with the competition of the later-developed and more suitable continental wheat-lands, have discouraged home production. A little is grown near Launceston and Hobart under the influence of the milling industry there (*cf.* the slight rise in recent years: 1924–25: 13,000 ac., 231,000 bu.; 1927–28: 28,000 ac., 672,000 bu.), but in general Tasmania tends to import wheat and similar products. Her position opposite the great port and market of Melbourne—and more remotely and occasionally, that of Sydney—greatly aids this process of specialisation. Oats, barley (malting), hay (chaff), pulses, potatoes—and also dairying with its associated pig-rearing, bacon-curing, cheese and butter making—have in fact a distribution clearly influenced by climate, soils and commercial position. The central northern lowlands—from Deloraine, through Westbury, Longford, Evandale, to Lilydale may be said to centre on Launceston which is both a market and exporting centre. The 15 mile wide strip of fertile coastal lowlands which stretches north-west to Stanley, backed by a similar belt of pastoral country and, beyond this, by timber areas, finds an outlet in such ports as Ulverstone, Penguin, Burney.

Pastoral Industries.—As more intensive forms of land utilisation have progressed, the pastoral industries have tended to decline, especially as in Tasmania there is small room to move away as settlement advances. To some extent, however, this tendency has been checked by specialisation, "meat" cattle, for example, being replaced by dairy herds, while in the case of sheep, careful local adaptation has led to survival, *e.g.*, of "utility" (meat-wool) types as elements in a mixed farming régime. Notable, also, is the achievement of several long-established sheep-breeding families in rearing high-class strains.

Sheep.—The whole of the west of the island is too wet, or too wild, for sheep, and these are confined mainly to the areas with 30 in. or less av. ann. rainfall which comprise the south-east ⅓ of the island, relatively few being scattered along the north coastlands. The greatest concentrations are in the upper and central Macquarie River basin and in the northern hill-lands of the Derwent-Coal basin ("The Midlands"). The Longford, Evandale and Oatlands districts show densities of 300 per sq. mile, and here the sheep fit into the farming rotation and are mainly marketed as meat, fresh (Launceston, Hobart) or refrigerated (export). In the north other cultivations (*v. sup.*) are more profitable. In the poorer and rougher eastern hill and coast lands fewer are kept, but the central highlands provide good summer grazing-grounds for sheep from the adjoining districts to the east. *Cattle,* apart from dairy cattle (*v. sup.*), are decreasingly important, but they are found in the rougher lands around the borders of, and between, the better farming areas along the north and east and more particularly in "the midlands" (*i.e.*, northern Derwent-Coal River hill-lands) and here tanning assumes local importance.

Manufacturing Industries; Power Supply.—These have grown up upon the basis of the primary producing industries and are still often locally associated with them: extraction and refining of metals; sawmilling; making of jams and preserves, dairy products, bricks, tiles and pottery; tanning, etc. (*v. sup.*). Secondary are the chemical, cement, carbide and electrode industries; making of furniture, agricultural implements, etc. A new tendency, however, has now appeared, namely for industries of a larger and more derivative type to concentrate in Launceston and Hobart (*qq.v.*). As this tendency develops greater strength, the manufacture of chemical products, cement, iron, paper, artificial silk, woollen and other textiles may be expected to assume considerable proportions. The reasons lie partly in the presence of raw materials, partly in the favourable position of Tasmania with relation to (chiefly) Victoria, New South Wales and South Australia, but mainly in the fact that Tasmania, along with a cool climate, possesses reserves of water-power. The *water-power* resources are the property of the State which develops them and sells power in bulk to large consumers and municipalities, though it also retails power to consumers in Hobart. The Great Lake scheme (63,000 h.p.) is completed. Advantage has been taken here of the Great Lake, whose area has been increased to 60 sq. miles and depth to 55 ft. by means of a dam, and also of a difference in level of 1,250 ft. between the parallel valleys of the Shannon and the Ouse. The Shannon scheme, adjacent (13,000 h.p.), is under construction. Launceston (*q.v.*) and its district, as well as Hobart, is supplied from the Great Lake system, other systems being the Lake Margaret-Zeehan, Zeehan-Rosebery (under construction), Country District and North-west Coast Service. So far only 52,000 h.p. has been utilised, the Electrolytic Zinc Works (Risdon) consuming 35,000 h.p.; the Carbide works, 3,500; Hobart, 8,500; Launceston, 3,000. The further reserves of Tasmania are estimated at over 500,000 continuous h.p. Besides the State schemes the Mount Lyell Mining and Railway Co. can supply 8,000 continuous h.p., and there are numerous smaller mining and municipal supplies.

The coasts abound in good natural harbours—though some are exposed and not very useful—but the main sea traffic centres on Hobart, Launceston, on the north coast ports and on those of Macquarie Harbour.

See G. L. Wood, *The Tasmanian Environment* (1923).

Statistical Summary: *Area and Occupation.*—26,215 sq. miles (=16,778,000 acres)=0·88% of the Commonwealth, wholly in temperate zone. Coast-line: 900 miles=1 mile per 29 sq. miles of land surface. Of the total area 6¼ million acres had been alienated in 1925; over 8 million acres were unoccupied; pastoral leases, 1,685,000 acres; timber leases, 285,000 acres. Of private holdings 87% were 1–500 acres, and there were 4 holdings of 50,000–100,000 acres and over.

Population (1927/8): 215,862 (males, 107,036; females, 108,826)=8·2% per sq. mile; 3·5% of total population of Commonwealth; 1921–26: total natural increase, 90,147 and loss by migration, 48,293; 1924–5–6: net decreases of 1,235, 807, 2,278 respectively. Metropolitan: Hobart and suburbs (54,890 acres), 55,000 (1927/8)=25·67% of total population.

Occupations (Census, 1921: total population 213,780). *Breadwinners* 39·19%, allocated thus: industrial, 10·55%; agricultural, 9·98%; commercial 4·79%; professional and domestic (each), 3%; transport, 2·84%; mining, 1·59%; pastoral, ·87%.

Production (net value): agricultural and pastoral (1922/3–1925/6), *c.* £4,400,000; manufacturing (1924–6), £3,400,000. (Net figures, on new basis, not yet available for other industries.)

Mining (gross value of metal contents of ores produced, 1926): Total, £1,574,000 copper, £455,000; tin, £323,000; lead and zinc (each), £183,000; silver, £98,000; coal, £90,400 (102,000 tons); osmiridium, £62,000; limestone, £54,000; gold, £18,000. In the case of copper, lead and tin these figures fairly represent the general level of annual production during 1919–26; zinc production (Tasmanian-mined ore) shows a great rise, that of coal a steady rise, that of silver, osmiridium, wolfram, great fluctuation during the same 8 years. Gold production (1927), £20,650.

Trade, Commerce, Communications.—Trade: Total (1925–6) £17,155,000 (£80·8 per caput). *Exports*: £8,704,000 (Interstate: £6,125,000; overseas—*i.e.*, outside the Commonwealth—£2,579,000). Metals: £2,704,000 (zinc, including imported ores treated, £1,589,000); fruits, £1,000,000; jams and other prepared foods, £800,000; potatoes, £600,000; dairy produce, £117,000; wool, £816,000; hides, etc., £400,000; timber, £534,000.

Imports: £8,451,000 (Interstate: £6,932,600; overseas, £1,518,000). Food and drink: £1,780,000; metals and machinery, £1,570,000; clothing, etc., £1,529,000.

Shipping (entered and cleared): 2,000–2,500 vessels, 1·5–2·75 million tons (net).

Ports: Total trade (1925/6): Hobart: £9,390,000 (54·7% of total State); Launceston, £4,733,000 (27·6%); Burnie, £1,089,000 (6·3%); Devonport, £863,250 (5·0%).

Railways: Government lines (1926/7): 658 miles (633 miles, 3′ 6″; 25 miles, 2′ gauge). Private (1925/6): 143 miles. Profit on working: (State lines): £41,150; Net loss: £12,000=3·76% on capital cost.

Finance.—(1926/7) Revenue: £3,040,220 (£14. 3. 2 per caput); expenditure, £2,855,077 (£13. 5. 11). Public debt (net): £23,196,814 (£111. 8. 7) paying interest at 4·907%. Total taxation (State, Commonwealth and municipal): £14. 8. 0 per caput. Banks (private) (1926): cash reserves: £1,499,000; deposits, £6,145,600.

Social Conditions.—Education: (1925) State schools: 523 Primary, 5 High; 1,315 teachers; average attendance, 32,300. Private schools: c. 6,200 pupils. State expenditure on education: primary: £8. 13. 5 per scholar attending; higher, £16. 4. 11. Total expenditure on education, exclusive of buildings, £297,130 (£1. 7. 5 per caput of population).

Bank deposits: private banks (1926) £6,145,600; savings banks (1927/8): £5,149,798 (142,010 depositors; £36. 5. 3 per depositor). Expenditure on hospitals and charities (1925/6): £178,500 (16s. 5d. per head of population). (O. H. T. R.)

History.—Tasmania, or, as it was originally called, Van Diemen's Land, was discovered in 1642 by the Dutch navigator Tasman (*q.v.*), who named the territory after his patron, Van Diemen. In the 18th century the island was visited by French and English explorers, including Capt. Cook in 1777. The news that the French explorer, Baudin, had surveyed the south of the island in 1800 stimulated the British to forestall the French. In 1802 the "Cumberland," a small schooner, landed at King's island in Bass strait, and in 1803 Lieut. Bowen was sent by Governor King of New South Wales to form a settlement on the south coast of Van Diemen's Land. In 1807, Col. Paterson occupied Port Dalrymple on the north side of the island. During the same year Col. Collins, who had failed in an attempt to colonize the shores of Port Phillip, transferred his soldiers, convicts and officials to the neighbourhood of Hobart, and was appointed commandant of the infant settlement. The difficulties of the settlers were increased by the hostility of the blacks. The first collision took place at Risdon, a few days after the landing of Lieut. Bowen's expedition, and for this the white settlers were entirely responsible. Hostilities between the races were incessant from 1802 till 1830. In 1831 George Robinson induced the remnant of the blacks to leave the mainland and take refuge, first in South Bruni and subsequently in Flinders island, their numbers having then diminished from 5,000, the original estimate of the aboriginal population, to 203. The last pure-blooded Tasmanian died in 1876, at the age of 76.

The growth of population was extremely slow, and in 1808 a census showed that there were only 3,240 people on the island, all told. Soon settlers began to arrive, and as their number in the colony increased, an agitation arose for more political freedom and improved administration, in consequence of which, in 1822, courts-martial were replaced by courts of justice, and in 1825 the colony was made independent of New South Wales, Col. Arthur being appointed governor. In 1828 the Van Diemen's Land Company commenced sheep-farming on a large scale in the north-west district of the island under a charter granted three years before, and in 1829 the Van Diemen's Land Establishment obtained a grant of 40,000ac. at Norfolk Plains for agriculture and grazing. In 1834 Portland bay, on the mainland of Australia, was occupied by settlers from Van Diemen's Land, and in 1835 there was a migration, large when compared with the population of the island, to the shores of Port Phillip, now Victoria. At that date the population was 40,172, a large proportion being convicts, for in four years 15,000 prisoners had been landed. The colony was prosperous, but the free settlers were not at all satisfied with the system of government, and an agitation commenced in Van Diemen's Land, as well as in New South Wales, for the introduction of representative institutions and the abolition of transportation. This system was abolished in New South Wales in 1840, and in the island, which in the interim had been the receptacle for convicts from the United Kingdom, India and the colonies, in 1853. In the same year representative institutions were introduced and the colony was renamed Tasmania: three years later responsible government was granted.

The discovery of gold in Victoria had the effect of causing the value of exports to that colony to rise from £665,790 in 1851 to £1,765,316 in 1853, while the population diminished, young men and women of all classes migrating to the Australian mainland. In the sixties Tasmania embarked upon a new period of prosperity owing to the discovery in its western half of coal, in 1850, and gold in 1852. Later political history, until the colony became in 1901 part of the Commonwealth of Australia, was not important. The colony has a citizen defence force of about 1,700 officers and men, forming part of the Australian army; it furnished contingents both in the South African War and the World War.

See J. Fenton, *A History of Tasmania* (Hobart, 1884); H. Ling Roth and M. E. Butler, *The Aborigines of Tasmania* (2nd ed., Halifax, 1899); Royal Society of Tasmania, *Papers and Proceedings* (Hobart). *See* also AUSTRALIA.

TASMANIANS. The Tasmanians, who are now extinct, were of medium height, had black to dark brown skins; woolly hair; heavy brows; longish, oval or pentagonal, flattish and small sized (cranial content) heads; short broad noses and large teeth.

Culture.—They were food-gatherers, expert hunters and trackers of game, nomads, moving in small groups of the family type, with very little government but recognising the areas belonging to other groups as reserved and not to be interfered with except on risk of war. Hereditary or permanent chiefs do not seem to have been found. No marriage ceremony is recorded and there seems ground for holding that they were polygynous. They are typical representatives of the Early Stone and Wood Age. The stone implements are very crude in form and finish (akin to Mousterian products) and were made of phthanite, a fine grained sandstone. Fire was made with the groove and saw or with the drill. Stones with black and red bands were used for tallies or mnemonics for absent friends. All have been lost and their exact significance is not quite clear. They made rough drawings on bark, with charcoal, ornamented themselves, using red ochre for the hair and wore shell necklaces, fillets of gay flowers, or festoons of showy berries. Huts and wind-breaks were used as shelters. Skins were thrown over the back against rain but otherwise they were naked. Scarification was practised and they rubbed themselves with powdered charcoal and red ochre. They greased their bodies against rain. They made rafts generally of the bark of some species of Eucalyptus, which was rolled up into cigar shaped bundles, three going to a raft, broad in the middle and tapering to a point at each end. These were good fair weather craft but dangerous in storms. They used their spears for fishing but had neither bow and arrow nor boomerang.

Language.—There were five dialects, classified on a geographical basis in two main groups as eastern and western. Enough remains to show that they were all related and were dialectical variations from a common archetype. The language is said to have been musical and soft, vowels being peculiarly full and round. They had no *d, f, v, s,* or *z.* Words began generally with a consonant, *cr, pr* and *tr* being common, other combinations being rare. Words end with a vowel as a rule. Distinct forms were used for singular and for plural.

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TASSIE, JAMES (1735–1799), Scottish gem-engraver and modeller, was born at Pollokshaws, near Glasgow, on July 15, 1735, and died in London on June 1, 1799. During his earlier years he worked as a stonemason until he removed to Glasgow to attend the academy established by the brothers Foulis, the printers, and became one of its most distinguished pupils. Subsequently he visited Dublin and became acquainted with Dr. Quin, who had been experimenting in imitating antique engraved gems in coloured pastes. He engaged Tassie as an assistant, and together they perfected the discovery of an "enamel," admirably adapted by its hardness and beauty of texture for the formation of gems and medallions. Tassie went to London in 1766. After a hard struggle the beauty and artistic character of his productions came to be known. The empress of Russia commissioned a collection of about 15,000 examples; all the richest cabinets in Europe were thrown open to him for study and reproduction; and his copies were frequently sold by fraudulent dealers as the original gems. He exhibited in the Royal Academy from 1769 to 1791. In 1775 he published the first catalogue of his works, followed in 1791 by two volumes quarto, enumerating nearly 16,000 pieces.

Tassie also executed many large profile medallion portraits of his contemporaries. They were modelled in wax and were then cast in white enamel paste, the whole medallion being sometimes executed in this material; while in others the head only appeared in enamel, against a background of ground-glass tinted by paper placed behind. At his death, in 1799, Tassie's works numbered about 20,000 pieces.

His nephew, WILLIAM TASSIE (1777–1860), also a gem-engraver and modeller, succeeded to the business. His portrait of Pitt, in particular, was very popular, and circulated widely. He bequeathed to the Board of Manufactures, Edinburgh, a valuable collection of casts and medallions by his uncle and himself.

See Gray's *James and William Tassie,* 1895.

TASSO, BERNARDO (1493–1569), Italian poet, father of Torquato Tasso (*q.v.*), was born at Venice on Nov. 11, 1493, of a noble family of Bergamo. He was attached to the service of the prince of Salerno, and married a Neapolitan lady, Porzia de' Rossi. When his patron came into conflict with the Spanish Government of Naples Bernardo was proclaimed a rebel and his property sequestrated. In 1556 his wife Porzia died under mysterious circumstances. Next year he entered the service of the duke of Urbino, and became a considerable figure in the literary circle of his court. He wrote a long, complicated and dull romantic poem in octave stanzas, entitled *Amadigi* (Venice, 1560). Bernardo died at Ostiglia on Sept. 4, 1569.

TASSO, TORQUATO (1544–1595), Italian poet, son of the preceding, was born at Sorrento on March 11, 1544. He was brought up at Naples, where he lived with his mother and his only sister Cornelia, and was educated by the Jesuits. He was a precocious child and famous in Naples for his learning when, at ten years old, he joined his father in exile in Rome. In 1557 he accompanied his father to the court of Urbino. Torquato, a handsome and brilliant lad, now became the companion in sports and studies of the young heir, Duke Francesco Maria della Rovere. He met there many of the most famous scholars of the day, including Aldus Manutius and the critic Speroni. At Venice, whither his father went to superintend the printing of the *Amadigi* (1560), he found himself the pet and prodigy of a distinguished literary circle. He was then sent to study law at Padua, but his distaste for the subject led Bernardo to allow his son to exchange the study of law for that of philosophy and poetry at Padua, and then at Bologna. In 1561 he published some poems, and before the end of 1562 produced a narrative poem, *Rinaldo,* in twelve cantos which proposed to combine the regularity of the Virgilian with the attractions of the romantic epic. Tasso, who was still only 18 years old, sought to give the adventures of Roland a classic form. He was now famous. In 1565 he became attached to the learned court of Ferrara, at first in the service of the Cardinal Luigi d'Este.

The years between 1565 and 1570 seem to have been the happiest of Tasso's life, although his father's death in 1569 caused him profound pain. He was the idol of the most brilliant court in Italy. The princesses Lucrezia and Leonora d'Este took him under their protection. He was admitted to their familiarity, and there is some reason to think that neither of them was indifferent to him personally. In 1570 he travelled to Paris with the cardinal. Frankness of speech and a certain habitual want of tact caused a disagreement. He left France next year, and took service under Duke Alfonso II. of Ferrara. The most important events in Tasso's biography during the following four years are the publication of the *Aminta* in 1573 and the completion of the *Gerusalemme Liberata* in 1574. The *Aminta* is a pastoral drama of very simple plot, but of exquisite lyrical charm. It was represented at Ferrara in the summer of 1573, at the critical moment when modern music, under Palestrina's impulse, was becoming the main art of Italy.

The *Gerusalemme Liberata* occupies a larger space in the history of European literature, and is a more considerable work. Yet the commanding qualities of this epic poem, those which revealed Tasso's individuality and which made it a classic, beloved by the people no less than by persons of culture, are akin to the lyrical graces of *Aminta.* It was finished in Tasso's 31st year, and was read to the duke and to Princess Lucrezia in the summer of 1575.

As in the *Rinaldo,* so also in the *Jerusalem Delivered,* he aimed at ennobling the Italian epic style by preserving strict unity of plot and heightening poetic diction. He chose Virgil for his model, took the first crusade for subject, infused the fervour of religion into his conception of the hero Godfrey. But his own natural bias was for romance. Godfrey, a mixture of pious Aeneas and Tridentine Catholicism, is not the real hero of the *Gerusalemme.* Fiery Rinaldo, Ruggiero, impulsive Tancredi, and the chivalrous Saracens with whom they clash in love and war, divide our interest and divert it from Goffredo. The action of the epic turns on Armida, the beautiful witch, sent forth by the infernal senate to sow discord in the Christian camp. She is converted to the true faith by her adoration for a crusading knight, and quits the scene with a phrase of the Virgin Mary on her lips. Brave Clorinda, donning armour like Marfisa, fighting in duel with her devoted lover, and receiving baptism from his hands in her pathetic death; Erminia seeking refuge in the shepherd's hut—these lovely pagan women, so touching in their sorrows, so romantic in their adventures, so tender in their emotions, rivet our attention, while we skip the battles, religious ceremonies, conclaves and stratagems.

Tasso's self-chosen critics suggested every course but the right one, which was to publish the *Gerusalemme* without further dispute. Tasso, already overworked by his precocious studies, by exciting court-life and exhausting literary industry, now grew almost mad with worry. His health began to fail him. He complained of headache, suffered from malarial fevers, and wished to leave Ferrara. The *Gerusalemme* was laid aside in manuscript for a time. He opened negotiations with the court of Florence for an exchange of service. This irritated the duke of Ferrara, who feared that the Medici might get the coveted dedication of that already famous epic. Therefore he bore with the poet's humours. Meanwhile Tasso became the subject of delusions—thought that his servants betrayed his confidence, fancied he had been denounced to the Inquisition, expected daily to be poisoned. In 1576 he quarrelled with a Ferrarese gentleman, Maddalo, who had talked too freely about some love affair; in the summer of 1577 he was relating his sorrows once more to the princess Lucrezia, when he imagined a servant was listening and rushed on him, knife in hand. He was shut up in a room in the palace, and the duke then took him to his country seat of Belriguardo. The often told story, immortalized by Goethe, that a compromising *liaison* with Leonora d'Este came to light, and that Tasso agreed to feign madness in order to cover her honour, must be dismissed. The poet's own temperament and the critics of his *Gerusalemme Liberata* had aggravated his ill-health. He was now placed in a Franciscan convent at Ferrara. He escaped at the end of July, disguised himself as a peasant and went on foot to his sister Cornelia at Sorrento.

He seems to have found peace and healing with his sister, but after a time missed the court circle, and asked to return to Ferrara. There his old irritability returned. In the summer of 1578 he ran away again; travelled through Mantua, Padua, Venice, Urbino, Lombardy. In September he reached Turin on foot, and was courteously entertained by the duke of Savoy. Wherever he went, "wandering like the world's rejected guest," he met with the honour due to his illustrious name. But life was intolerable to him outside Ferrara. In February 1579 he returned at an ill-chosen moment. Alfonso was about to contract his third marriage, this time with a princess of the house of Mantua. The princesses did not want to see him. The duke was engaged. Tasso broke into terms of open abuse, and was sent off without ceremony to the madhouse of St. Anna. There he remained for seven years until July 1586. After the first few months of his incarceration, during which he was treated with the harshness then usual towards the insane, he obtained spacious apartments, received his friends, and went abroad attended by friends. Except for occasional odes or sonnets—some written at request and only rhetorically interesting, a few, like the famous canzone asking for the intercession of Lucrezia and Leonora, inspired by his keen sense of suffering and therefore poignant—he neglected poetry.

Long ago his papers had been sequestrated. Now, in 1580, he heard that part of the *Gerusalemme* was being published without his permission and without his corrections. Next year the whole poem was given to the world, and in the following six months seven editions appeared. The prisoner had no control over his editors; and from the masterpiece which placed him on the level of Petrarch and Ariosto he never derived one penny of pecuniary profit. The fame of the poem rapidly spread throughout Europe; within twenty years of its publication it was translated into English in the well-known version, itself a masterpiece, of Sir Edward Fairfax, *Godfrey of Bulloigne, or the Recoverie of Jerusalem* (1600). A rival poet at the court of Ferrara, Battista Guarini, undertook to revise and re-edit his lyrics in 1582. In 1585, two Florentine pedants of the Della Crusca academy declared war against the *Gerusalemme.*

In 1586 Tasso left St. Anna at the solicitation of Vincenzo Gonzaga, prince of Mantua. He followed his young deliverer to the city by the Mincio, basked awhile in liberty and courtly pleasures, enjoyed a splendid reception from his paternal town of Bergamo, and produced a tragedy called *Torrismondo,* the first sketch of which dates from 1574. But in the autumn of 1587 we find him wandering once more, through Bologna and Loreto to Rome, where he stayed in the house of an old friend, Scipione Gonzaga, now patriarch of Jerusalem. Next year he wandered off to Naples, where he wrote his unfinished poem on *Monte Oliveto.* In 1589 he returned to Rome, but fell ill. The patriarch in 1590 again received him. But Tasso's restless spirit drove him forth to Florence. The Florentines said, *"Actum est de eo."* Rome once more, then Mantua, then Florence, then Rome, then Naples, then Rome, then Naples—such is the weary record of the years 1590–94. We have to study a veritable Odyssey of malady, indigence and misfortune.

His health grew feebler and his genius dimmer. In 1592 he gave to the public a revised version of the *Gerusalemme,* called the *Gerusalemme Conquistata.* All that made the poem of his early manhood charming he rigidly erased. The versification was degraded; the heavier elements of the plot underwent a dull rhetorical development. During the same year a poem on the Creation in blank verse, called *Le sette Giornate,* saw the light.

In 1594 Clement VIII. and his nephew, Cardinal Aldobrandini of St. Giorgio, invited Tasso to Rome. There he was to assume the crown of bays, as Petrarch had assumed it, on the Capitol. Worn out with illness, Tasso reached Rome in November. The ceremony of his coronation was deferred because Cardinal Aldobrandini had fallen ill. But the pope assigned him a pension; and, under the pressure of pontifical remonstrance, Prince Avellino, who held Tasso's maternal estate, agreed to discharge a portion of his claims by payment of a yearly rent-charge. Fortune came too late. Before the crown was worn or the pensions paid he ascended to the convent of St. Onofrio, on a stormy April 1 in 1595. Seeing a cardinal's coach toil up the steep Trasteverine Hill, the monks came to the door to greet it. From the carriage stepped Tasso, the Odysseus of many wanderings and miseries, the singer of sweetest strains still vocal, and told the prior he was come to die.

He passed away on April 25, 1595, and the cell he occupied became a place of pilgrimage for his admirers. The last twenty years of his existence had been ineffectual. At the age of thirty-one the *Gerusalemme,* as we have it, was accomplished. The world, too, was already ringing with the music of *Aminta.* More than this Tasso had not to give to literature. But those succeeding years of derangement, exile, imprisonment, poverty and hope deferred endear the man to us. (J. A. S.; X.)

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TATA, SIR DORABJI JAMSETJI (1859–), Indian capitalist, was born at Bombay on Aug. 27, 1859, being the elder son of the famous Parsee industrial pioneer, Jamsetji Nasarwanji Tata. Upon leaving Cambridge, he entered his father's business and pursued his father's great conceptions until they culminated in striking advances in Indian industrial development and also in the establishment in 1905 of the Indian institute of scientific research at Bangalore. *See* TATA SONS, LIMITED.

TATA, JAMSETJI NASARWANJI (1839–1904), Parsee merchant and philanthropist, was born at Nosari, in the state of Baroda, in 1839, and went as a boy to Bombay, where he was educated at the Elphinstone College. In 1858 he entered his father's office, and began a commercial career of the highest eminence, beginning with cotton mills at Bombay and also at Nagpur, and ending with the formation of a company to work the iron ores of the Central Provinces on modern principles. He also introduced a silk industry after Japanese methods into Mysore. But his greatest benefaction is the endowment of a research institute at Bangalore. He died at Nauheim, in Germany, on May 19, 1904.

TATA, SIR RATAN (1871–1918), Parsee financier and philanthropist, was born at Bombay on Jan. 20, 1871, the son of the famous Parsee merchant Jamsetji Nasarwanji Tata (*q.v.*). He was educated at St. Xavier's college, Bombay, and entered his father's firm. On the death of the elder Tata in 1904 Ratan Tata and his brother, Dorabji Jamsetji Tata (b. 1859), inherited a very large fortune, much of which they devoted to philanthropy and to the establishment of industrial enterprises. See TATA SONS, LIMITED.

In England he founded (1912) the Ratan Tata department of social science and administration at the London School of Economics, and in the same year established a Ratan Tata fund at the University of London for studying the conditions of the poorer classes. He died at St. Ives, Cornwall, on Sept. 5, 1918.

TATAR REPUBLIC, an Autonomous Socialist Soviet Republic, created in 1920, in the Russian Republic and bounded on the south by the provinces of Ulianovsk and Samara, on the west by the Chuvash A.S.S.R. and the Marii Autonomous Area, on the north by Vyatka province and the Votyak Autonomous Area, and on the east by the province of Perm and the Bashkirian A.S.S.R. Area 67,241 square kilometers. Pop. (1926) 2,622,890. The republic is drained by the Volga and Kama and their tributaries, the Vyatka, joining the Kama in the east, and the Svyaga flowing northwards to the Volga in the west. Forest—pine, fir and juniper in the north, and birch, ash, lime, alder, willow and elm in the south—occupies about 17% of the republic, and in the north there is some marsh land. Of the land favourable to cultivation, 78% is tilled, agriculture being the main occupation of the people. Black earth is found in the south-west, along the valley of the Svyaga and in a few other places, the remaining soils being grey forest, clays and sands. The climate is continental, five months of the year having an average temperature below 0° C, and the rainfall averages 16 in. per annum in good years, but may fail periodically, resulting in such famines as those of 1911 and 1921, these being caused by insufficient spring rain; summer and autumn rains are more reliable. The prevailing winds are from the south-west, and often bring dust storms that cover the crops. In June and July thunderstorms with destructive hail are a frequent source of damage.

Agriculture and Industries.—These difficult conditions, giving harvests for export in some years and reducing the region to famine in others, are an indication of the need for more intensive forms of agriculture. Up to 1920 there was no many-field system and the peasants mainly used old-fashioned instruments. The tragic holocaust of the famine year was specially severe in the Tatar area, and since that time about 5% of the fields are being tilled on more intensive lines, and there has been greater care in the choice of seeds and crops. Attempts are being made to encourage maize, potato and beet cultivation, and to diminish the sowing of buckwheat, which gives a very unreliable harvest. Some better instruments are gradually replacing the traditional ones. In 1926 there was a good harvest and over 300,000 tons of grain were available for export. Rye (48·8%), and oats (19·2%) are the chief crops. Others are buckwheat, millet, grasses, lentils, flax and hemp. The mineral wealth is not great.

Factory industries are mainly centred on Kazan (*q.v.*) which was the only town in 1926 with a population of over 16,000. The chief future for factory industry lies in food production, but this cannot be developed to an export industry until railway and road communication is improved. The leather industry dates back to the Bolgar empire, and the Morocco and Russia leather of the Tatar Republic finds a ready market even beyond the U.S.S.R. The manufacture is at present mainly carried on in numerous small factories and in peasant artels. There is some flour-milling, two factories produce agricultural machinery, three work in hemp and jute and one in linen goods. The present supply of wool is insufficient for factory production. Glass, bricks, lime, alabaster and silicate are produced. There are four printing presses producing Tatar magazines, papers and books. In pre-war times the koustar or peasant industries of the region flourished. The Government is taking measures to restore these industries, since they are a means of giving the peasant sufficient income to prevent the wandering in search of employment that has been such a feature of Russia, and they also provide for the workless and landless peasant. Among the varied peasant products, sleighs, tarantasses and carts are famous and are in demand in Siberia. Tatar guitars, dulcimers and violins are noted.

Language and Education.—A great difficulty of the republic is its low rate of literacy, possibly 25% among men, certainly less among women. The position is difficult, partly because the budget of the republic at present shows a marked deficiency and school premises and materials are not available. The greatest difficulty, however, is the variety of languages. The Tatar population numbers 48·3%, Great Russians 43·1%, Chuvash 4·9%, Mordva 1·4% and various other nationalities 2·3%. Assimilation has hardly existed in the past and it is quite common for a village to have a group of Tatars in one section, of Finns in another and of Great Russians in another, each using its own language and following its own customs. Under the Tsarist régime education was mainly Russian. Since the foundation of the republic, Tatar is the official language of the administration and in 1925 there were many more Tatar schools, but the training of teachers is a difficulty, moreover the Tatar population is rural, and the greater proportion of the town population is Russian, and as there is a possibility of education in rural districts for about 30% of the children and in towns for about 70%, the problem is complex.

History.—From the 5th century onwards there was a strong immigration of Bulgarians into the region; they formed an important khanate, Bolgari or Bolgary, 60 m. S. of Kazan being the centre; its ruins are still to be seen. This kingdom reached its zenith in the 10th century, but was ruined by the Mongol invasion of the 13th century. Much intermixture between the Bolgars and the Mongols and also between local Finnish tribes has given the Volga Tatars a distinctive character. After the fall of the Golden Horde, these northern Tatars formed a khanate with Kazan as its centre, and there began the immigration into the region of refugee tribes, Mordva, Chuvash, Meschyeraks and Bashkirs. After the capture of Kazan in 1552, a policy of colonial Russian settlements on the Volga, with lines of forts to protect them from attacks by the natives was pursued. The problem facing the Tatar A.S.S.R. is the establishment of co-operation among these varied elements. (R. M. F.)

TATARS (the common form Tartars is less correct), a name given to nearly three million inhabitants of the Russian empire, chiefly Muslim and of Turkish origin. The majority—in European Russia—are remnants of the Mongol invasion of the 13th century (*see* MONGOLS), while those who inhabit Siberia are survivals of the once much more numerous Turkish population of the Ural-Altaic region, mixed to some extent with Finnish and Samoyedic stems, as also with Mongols. The name is derived from that of the Ta-ta Mongols, who in the 5th century inhabited the north-eastern Gobi, and, after subjugation in the 9th century by the Khitans, migrated southward, there founding the Mongol empire. Under the leadership of Batu they moved westwards, driving with them many stems of the Turkish Ural-Altaians towards the plains of Russia. The present Tatar inhabitants of European Russia, contain very little admixture of Mongolian blood, but belong to the Turkish branch of the Ural-Altaic stock, only Batu, his warriors, and a limited number of his followers being Mongols, while the bulk of the 13th century invaders were Turks. On the Volga they mingled with remnants of the old Bulgarian empire, elsewhere with Finnish stems, and with remnants of the ancient Italian and Greek colonies in Crimea, and Caucasians in Caucasus. The name of Tatars, or Tartars, given to the invaders, was afterwards extended to different stems of the same Turkish branch in Siberia, and even the bulk of the inhabitants of the high plateau of Asia and its N.W. slopes, described under the name of Tartary.

The Tatar inhabitants of the Russian empire formed three large groups—those of European Russia and Poland, those of Caucasus, and those of Siberia. (1) The Kazan Tatars, descendants of the Kipchaks settled on the Volga in the 13th century, where they mingled with survivors of the old Bulgarians and partly with Finnish stems. They speak a pure Turkish dialect; they are middle-sized, broad-shouldered and strong, and mostly have black eyes, a straight nose and salient cheek bones. They are Mohammedans; polygamy is practised only by the wealthier classes. They are excellent agriculturists and gardeners, very laborious, and have a good reputation for honesty. (2) The Bashkirs who live between the Kama, Ural and Volga are possibly of Finnish origin, but now speak a Tatar language and have become Mohammedans. (3) The Astrakhan Tatars are agriculturists and gardeners. The Kundrovsk Tatars still continue the nomadic life of their ancestors. (4) The Crimean Tatars, who occupied the Crimea in the 13th century, have preserved the name of their leader, Nogai. The mountain Tatars closely resemble those of Caucasus, while those of the steppes—the Nogais—are decidedly of a mixed origin from Turks and Mongols.

(5) The Tatars of Caucasia, who inhabit the upper Kuban, the steppes of the lower Kuma and the Kura, and the Aras. Of these the Nogais on the Kuma show traces of an intimate mixture with Kalmucks. They are nomads, supporting themselves by cattle-breeding and fishing; few are agriculturists. The Karachais in the upper valleys about Elburz live by agriculture. (6) The mountain Tatars, divided into many tribes, are scattered throughout the provinces of Baku, Erivan, Tiflis, Kutais, Daghestan, and partly also of Batum. They are certainly of a mixed origin, and present a variety of ethnological types. All who are neither Armenians nor Russians, nor members of any distinct Caucasian tribe, are often called Tatars. Although most fervent Shi-ites, they are on very good terms with their Sunnite neighbours. Polygamy is rare and their women go to work unveiled.

The Siberian Tatars occupy three distinct regions—a strip running west to east from Tobolsk to Tomsk, the Altai and its spurs, and South Yeniseisk. They originated in the agglomerations of Turkish stems which in the region north of the Altai reached some degree of culture between the 4th and the 8th centuries, but were subdued and enslaved by the Mongols. They are difficult to classify, for they are the result of somewhat recent minglings of races and customs. (7) The Baraba Tatars take their name from one of their stems (Barama), live in Tobolsk, a few in Tomsk, by agriculture, either in separate villages or along with Russians. (8) The Cholym or Chulym Tatars on the Cholym and both the rivers Yus speak a Turkish language with many Mongol and Yakut words, and are more like Mongols than Turks. (9) The Abakan or Minusinsk Tatars occupied the steppes on the Abakan and Yus in the 17th century, after the withdrawal of the Kirghizes, and represent a mixture with Kaibals (whom Castrén considers as partly of Ostiak and partly Samoyedic origin) and Beltirs—also of Finnish origin. Their language is also mixed. They are known under the name of Sagais. (10) The Tatars of the northern slopes of the Altai are of Finnish origin. They comprise some hundreds of Kumandintses, the Lebed Tatars, the Chernevyie or Black-Forest Tatars and the Shors, descendants of the Kuznetsk or Iron-Smith Tatars. They are chiefly hunters and have maintained their Shaman religion and tribal organization into *suoks.* They live partly also on cedar-nuts and honey collected in the forests. Their dress is that of their former rulers, the Kalmucks, and their language contains many Mongol words. (11) The Altai Tatars, or "Altaians," comprise—(*a*) the Mountain Kalmucks who have nothing in common with the Kalmucks except their dress and mode of life, while they speak a Turkish dialect, and (*b*) the Teleutes, or Telenghites, a remainder of a formerly numerous and warlike nation who have migrated from the mountains to the lowlands, where they now live along with Russian peasants.

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TATA SONS, LIMITED. This is an Indian house founded by the late Jamsetji N. Tata, a Parsi merchant and industrial pioneer.

The conduct of these enterprises of national importance is vested in the hands of Messrs. Tata Sons Ltd., of Bombay, under the chairmanship of Sir D. J. Tata, and the combined capital of their undertakings is estimated at £50,000,000 providing employment for an industrial community of nearly a quarter of a million people.

Perhaps one of the most prominent of the industrial concerns founded and managed by or associated with the firm of Messrs. Tata Sons Ltd. is the Tata Iron and Steel Co. Ltd. It took 20 years to realize this project of manufacturing iron and steel in India on western lines and on an extensive scale and to evolve a workable process of smelting India's iron ore. It cost nearly £14,500,000 to raise the works from the site of a veritable wilderness into a well ordered and up-to-date city, appropriately re-named after its great founder—Jamshedpur—the first and only steel city in India. The works have a capacity of nearly 800,000 tons of pig-iron and over 600,000 tons of finished steel per annum. Pig-iron, ferro-manganese, rails, plates, and sheets, corrugated and galvanized sheets, agricultural implements, sulphate of ammonia and sulphuric acid are some of the principal manufactures, with associated companies manufacturing electric cables, wire products and tin plate.

This hydro-electric group consists of four companies—the Tata Hydro-Electric Power Supply Co. Ltd., the Andhra Valley Power Supply Co. Ltd., the Tata Power Co. Ltd., and the Kundley Power Co. Ltd., the aggregate capital of which may be put at nearly £15,000,000. The equipment is planned to generate about 321,000 E.H.P. between the four companies, with the probability of an additional increase later on, to supply motive power to the factories, the tramways and the railway lines in Bombay and surburban extensions and to provide electricity for lighting and domestic purposes.

The contribution of the Tata house to the cotton mill industry, which made Bombay a great industrial centre commenced when the first of a group of mills—the Empress Mills—was inaugurated at Nagpur in 1877, which in time revolutionized the cotton industry in India. These mills even to-day challenge comparison with the best textile mills of Lancashire. Other mill companies have since been floated and Messrs. Tata Sons Ltd., have now under their charge, besides the Empress Mills, three others—the Svadeshi Mills, the Ahmedabad Advance Mills and the Tata Mills. The four mills have over 300,000 spindles and 7,500 looms, and bleaching, dyeing and finishing equipment. A capital of nearly £7,500,000 is involved in these mills under the management of Messrs. Tata Sons Ltd.

Besides the above, the activities of the Tata house extend to many other undertakings, such as collieries, cement factories, construction and building companies, insurance and trading companies, and an oil mill as well as a large hotel. (K. P. M.)

TATE, SIR HENRY, 1st Bart. cr. 1898 (1819–1899), English merchant and founder of the National Gallery of British Art, was born at Chorley, Lancashire, in 1819. He became a prosperous sugar-broker in Liverpool, and about 1874 removed to London, where he greatly increased the operations of his firm and made "Tate's Cube Sugar" known all over the world. He gave £42,000 to the Liverpool University College, founded in 1881; and a still larger sum to the Liverpool hospitals. When he came to London, he presented four free public libraries to the parish of Lambeth. He owned one of the best private collections of modern pictures in England. This he offered to the Nation with £80,000 for a building if the government would provide the ground; and in 1892 this offer was accepted. A new gallery, controlled by the Trustees of the National Gallery, was built on the site of Millbank Prison. The gallery was opened on July 21, 1897, and a large addition to it was completed just before the donor died. Tate died at Streatham on Dec. 5, 1899.

TATE, NAHUM (1652–1715), English poet laureate and playwright, was born in Dublin in 1652. He was the son of Faithful Teate (as the name was spelt), who wrote a quaint poem on the Trinity entitled *Ter Tria.* Nahum Tate was educated at Trinity college, Dublin, graduating B.A. in 1672. He wrote one or two original plays and a long series of adaptations from Shakespeare and the Elizabethan dramatists. Tate's name is chiefly connected with these mangled versions of other men's plays and with the famous *New Version of the Psalms of David* (1696), in which he collaborated with Nicholas Brady. A supplement was licensed in 1703. Some of these hymns, notably "While Shepherds watched," and "As pants the hart," rise above the general dull level, and are said to be Tate's work.

Tate was commissioned by Dryden to write the Second Part of *Absalom and Achitophel.* The portraits of Elkanah Settle and Thomas Shadwell, however, are attributed to Dryden, who probably also put the finishing touches to the poem. Of his numerous poems the most original is *Panacea, a poem on Tea* (1700). In spite of his consistent Toryism, he succeeded Shadwell as poet laureate in 1692. He died within the precincts of the Mint, Southwark, London, where he had taken refuge from his creditors, on Aug. 12, 1715.

TATI, a district of British South Africa attached administratively to the Bechuanaland protectorate. Area about 2,500 sq.m. The railway from Cape Town to Bulawayo crosses the territory with a station at Francistown, the principal settlement. Francistown stands 3,254 ft. above the sea and is 126 m. S.W. of Bulawayo by rail. The town of Tati, on the river of that name, is 18 m. S.E. of Shashi river railway station. Tati owes its importance to the presence of gold, first discovered by the German traveller, Karl Mauch, in 1864. Mining began in 1868, but it was not until 1895 that work on a large scale was undertaken. The mining rights are vested in a company, called the Tati Company, Ltd. (*See* BECHUANALAND and RHODESIA.)

TATIAN (2nd cent. A.D.), Christian apologist, missionary and heretic. Such knowledge as we have of his life is derived from (1) his own *Oratio ad Graecos* (*see* § 3); (2) Irenaeus, *Adv. Haereses,* i. 28, i.; (3) Rhodon, quoted in Eusebius's *Hist. Eccl.* v. 13, 1; (4) Clement of Alexandria, *Strom.* i. 1, 11; (5) Eusebius, *Chronicon anno* A.D. 171; (6) Epiphanius, *Panarion,* i. 3, 46. Convenient collections of these passages may be found in E. Schwartz's *Tatiani Oratio ad Graecos, Texte und Untersuchungen,* iv. 1, pp. 51–55; and in A. Harnack's *Geschichte der altchristlichen Literatur,* i. pp. 485–96. From these data the following outline of his life can be reconstructed. He was a Syrian[1] (Clem. Alex. and Epiphanius) born in Mesopotamia (*Or.* 42) and educated in Greek learning, in which he became proficient (*Or.* i. and 42). He was initiated into the Mysteries, though into which is not stated (*Or.* 29), but after this became acquainted with the Old Testament, and was converted to Christianity.

Tatian then went to Rome, where he was a hearer of Justin, and together with the latter incurred the enmity of a certain philosopher Crescens. As this fact is mentioned both in Justin's *Apology* and in Tatian's *Oratio ad Graecos,* and the *Apology* can be dated with fair security about A.D. 152 (*see* JUSTIN MARTYR), the conversion of Tatian must have been before this date. After the death of Justin he became a heretic—according to Eusebius's *Chronicon* in 173. Among his pupils were Rhodon, and, perhaps Apelles (*see* Victorinus Reat. schol. 44, in *Ep. Hieronymi ad Avitum,* ep. 124) and Clement of Alexandria (*Storm.* i. 1, 11). He made a missionary journey to the East and worked in Cilicia and Pisidia, using the Syrian Antioch as the centre of his efforts (Epiphan.). The heresy which Tatian either founded or adopted was that of the Encratites. Their main doctrines were the evil nature of matter, an absolute forbidding of marriage, abstinence from wine and perhaps from meat. It would also seem that Tatian believed in the existence of aeons, one of whom was the Demiurge of the world. He denied the salvation of Adam. It is also stated that in his celebration of the Mysteries (*i.e.,* the Eucharist), he used only water. (*See* Tertullian, *De Jejun,* 15; Hippolytus, *Philos.* 8, 4, 16 and 10, 18; Jerome in *Amos* ii. 12 and Iren., *Adv. Haer,* i. 28, iii. 23.)

Writings.—According to Eusebius (*Hist. Eccl.,* iv. 29), Tatian wrote many books; of these the names of the following have survived:—(1) *Περὶ ζῴων* (mentioned in *Or.,* 15); (2) *Περὶ δαιμόνων* (mentioned in *Or.,* 16); (3) *Λόγος πρὸς τοὺς Ἕλληνας*; (4) *Προβλημάτων βιβλίον* (Eus., v. 13, 1—a quotation from Rhodon) an attempt to deal with the contradictions to be found in the Bible; (?5) *Πρὸς ἀποφηναμένους τὰ πρὸς θεοῦ* (mentioned in *Or.,* 40 as a book which Tatian intended to write, but there is no evidence that he carried his plan into effect); (6) *Περὶ τοῦ κατὰ τὸν Σωτῆρα καταρτισμοῦ* (Clem. Alex., *Strom.,* iii. 12, 80); (7) The *Diatessaron;* (?8) a recension of the Pauline epistles. Of these books only two—the *Diatessaron* and the *πρὸς τοὺς Ἕλληνας*—are extant.

The *Λόγος πρὸς τοὺς Ἕλληνας* (*Oratio ad Graecos*) (*see* edition by J. C. T. Otto, in *Corp. apol. chr. saec,* Jena, 1851) belongs to Tatian's Catholic period. He has the double purpose in view of exposing the weakness of the pagan view of the universe and of commending the Christian explanation. The omissions in the *Oratio* are even more remarkable than its statements. There is at the most not more than an allusion to Christ, who is never mentioned by name, and though there are frequent allusions to the regaining of life, which is accomplished by union with the Logos, there is no reference to the doctrines of the incarnation or of the atonement. The *Oratio* was probably written in Greece about A.D. 150.

TATRA MOUNTAINS, a name usually reserved for the highest group of the central Carpathians, viz., the Vysoké Tatry, which rises abruptly as an isolated igneous group, partly in Slovakia and partly in Poland, from a high plateau of about 2,600 ft. to altitudes exceeding 8,400 ft., and extends between the rivers Váh, Poprad, Dunajec and Arva. The mountains have a west-east length of about 40 m. and a width varying from 9–15 m., notable peaks being Gerlachovka (8,737 ft.), the highest in the Carpathians, Lomnický (8,642 ft.) and Kriván (8,190 ft.). In everything except glaciers the range bears the Alpine imprint. Small spas, well-equipped with hotels, summer resorts and centres for winter sports exist, the most frequented being Smokovec (3,250 ft.), Štrba Lake (4,000 ft.) and Tatranská Lomnica (2,500 ft.), while electric and rack-railways lead to the most interesting districts.

South of the valley of the Váh runs a lower parallel range of similar structure, the Nízské Tatry, reaching its maximum heights in the peaks of Dumbier (6,707 ft.) and Králová Hola (6,373 ft.). (W. S. L.)

TATSIEN-LU, a town in the territory of Kham (Chwanben), west of China, situated over 8,000 ft. above sea-level. It is a great mart for Tibet, and from Tatsien-lu the two trade routes, the Ayalam and the Janglam diverge, the former making for Ladakh and the latter for Kashgar. Pop. est. 20,000.

TATTA or **THATO,** an ancient town of British India, in the Sind province of Bombay, 7 m. from the right bank of the main channel of the Indus and 13 m. from a station on the North-Western railway: pop. (1921) 8,470. Tatta was the capital of the Samma dynasty in Lower Sind in the 16th century, and long continued to be the centre of trade in the country, to which it sometimes gave its name in early European travels. Its former importance reflected its location at the apex of the Indus delta. An English factory was established here in 1758, but soon withdrawn.

TATTERSALL'S, London horse auction mart, founded in 1766 by Richard Tattersall (1724–95), who had been stud groom to the second duke of Kingston. The first premises occupied were near Hyde Park Corner, in what was then the outskirts of London. Two "Subscription rooms" were reserved for members of the Jockey Club, and they became the rendezvous for sporting and betting men. "Tattersall's Committee" and "Tattersall's Ring" are the descendants of these subscription rooms but are not in any way connected with the horse-mart. The former is a strong, but unofficial, organization that looks after the purity of the turf from the point of view of the bookmaker and bettor alike; and the latter is the name given to the principal betting enclosure on any race-course on which meetings are held under Jockey Club or National Hunt rules. By a House of Lords decision Tattersall's Ring is not a "place" within the meaning of the Betting Act, 1853.

TATTLER, a North American wading bird (*Heteractitis incanus*), about 11 in. long, slaty grey above and white barred with grey below. It breeds on the Pacific coast north from British Columbia, wintering in the Hawaiian Islands and the Galápagos.

TATTOOING: *see* MUTILATIONS.

TAUCHNITZ, the name of a family of German printers and publishers. Karl Christoph Traugott Tauchnitz (1761–1836), born at Grossbardau near Grimma, Saxony, established a printing business in Leipzig in 1796 and a publishing house in 1798. He specialized on the publication of dictionaries, Bibles and stereotyped editions of the Greek and Roman classics. The business was carried on by his son, Karl Christian Phillipp Tauchnitz (1798–1884), until 1865, when the business was sold to O. Holtze. He left large sums to the city of Leipzig for philanthropic purposes. Christian Bernhard, Freiherr von Tauchnitz (1816–95), the founder of the firm of Bernhard Tauchnitz, was the nephew of the first-mentioned. His printing and publishing firm was started at Leipzig in 1837. The Library of British and American Authors, so familiar to travellers on the continent of Europe, was begun in 1841. In 1929 the collection numbered over 4,800 volumes. In 1868 he began the Collection of German Authors, followed in 1886 by the Students' Tauchnitz editions.

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[1] Tatian describes himself as an "Assyrian," and though the terms "Assyrian" and "Syrian" are used very loosely by ancient writers, it is probable that he was born E. of the Tigris, *i.e.,* not in Syria as we understand it. Epiphanius, in another passage, calls him an Assyrian.

TAULANTII, in ancient geography, an Illyrian people in the neighbourhood of Epidamnus (Thuc. i. 24). They were originally powerful and independent, under their own kings. One of these was Glaucias, who fought against Alexander the Great, and placed Pyrrhus (*q.v.*), the infant king of Epirus, whom he had refused to surrender to Cassander, upon the throne (Plutarch, *Pyrrhus*, 3). Later the Taulantii fell under the sway of the kings of Illyria.

TAULER, JOHANN (*c.* 1300–1361), German mystic, was born about the year 1300 in Strasbourg, and was educated at the Dominican convent in that city. From Strasbourg he went to the Dominican college of Cologne, and perhaps to St. James's College, Paris, ultimately returning to Strasbourg. In 1338–1339 Tauler was in Basel, then the headquarters of the "Friends of God" (*see* MYSTICISM), and was brought into intimate relations with the members of that pious mystical fellowship. He died on June 16, 1361.

Tauler's sermons were printed first at Leipzig in 1498, and reprinted with additions from Eckhart and others at Basel (1522) and at Cologne (1543). There is a modern edition by Julius Hamberger (Frankfort, 1864), and R. H. Hutton published Tauler's Sermons for Festivals under the title of *The Inner Way*. *See* Denifle, *Das Buch von geistlicher Armuth* (Strassburg, 1877); Carl Schmidt, *Johann Tauler von Strassburg* (Hamburg, 1841); S. Winkworth, *Tauler's Life and Sermons* (1857); R. A. Vaughan, *Hours with the Mystics*, 3rd ed., vol. i. pp. 214–307; Preger's *Gesch. der deutschen Mystik im Mittelalter*, vol. iii.; W. R. Inge, *Christian Mysticism*: R. M. Jones, *Studies in Mystical Religion* (1909).

TAUNG-GYI: *see* SHAN STATES.

TAUNTON, a municipal borough and market town of Somersetshire, England, on the river Tone, 44¾ m. S.W. of Bristol by rail, on the G.W.R. Pop. (1921) 23,223. Standing in the valley of Taunton Dean, the town is chiefly built on the south side of the river. Taunton is the county town of Somerset.

There is evidence of an early settlement near the suburb of Holway, and Taunton (Tantun, Tantone, Tauntone) was a place of considerable importance in Saxon times. King Ine erected an earthen castle here about 700, and a monastery was founded before 904. The bishops of Winchester owned the manor, and obtained the first charter for their "men of Taunton" from King Edward in 904, freeing them from all royal and county tribute. At some time before the Domesday Survey Taunton had become a borough with very considerable privileges, governed by a portreeve appointed by the bishops. Two members were returned to parliament from 1299 to 1885. The Saturday market dates from before the Conquest.

Its main streets converge upon a triangular space, where there is a market cross. The parish church of St. Mary Magdalene is a fine Perpendicular building. Remnants of Norman work are preserved in the chancel arch, and of Early English work in the north aisles and transepts. The tower is also a notable feature. Little is left of an Austin priory established in the reign of Henry I. by William Giffard, bishop of Winchester, who also built the castle, now a museum for prehistoric, Roman and medieval antiquities. At the Restoration it was dismantled and its moat filled in. Among the schools is a grammar school founded in 1522 by Richard Fox, bishop of Winchester.

TAUNTON, a city of Massachusetts, U.S.A., one of the county seats of Bristol county; 35 m. S. of Boston, at the head of ocean navigation on the Taunton river, 14 m. above Fall River. It is served by the New York, New Haven and Hartford railroad and several steamship lines. Pop. (1920) 37,137 (27% foreign-born white, largely from the Atlantic islands, Portugal, Canada and Ireland) and 39,255 in 1925 (State census). Within the corporate limits of the city (which has an area of 44·25 sq.m.) are six villages. The old "common," fringed with lofty elms, is the centre of the business section of the modern city, and about a mile from "the Weir," at the harbour. Its manufacturing industries are extensive and varied, including large cotton mills, britannia-ware factories and stove foundries. The aggregate output in 1925 was valued at $31,744,082. The city's assessed valuation for 1927 was $41,380,020. Taunton was founded in 1638, and became the frontier town of Plymouth Colony. Myles Standish was engaged on the original survey. The town was incorporated in 1639, taking the name of the English home of many of the settlers. It was a base of operations during King Philip's War. In 1686 it refused to comply with the demands of Sir Edmund Andros for a tax levy. In 1774, after the passage of the Boston Port Bill, a red flag inscribed "Liberty and Union" was raised on the Common in token of sympathy with Boston. During the Shays Rebellion the court-house was twice besieged by insurgents, who were dispersed on both occasions by one of the judges, Gen. David Cobb. Industrial development began with the establishment of ironworks in 1656. Brick-making and ship-building were important early industries, and for some time Thomas Coram, founder of the London Foundling hospital, was one of those engaged in the latter. In the adjoining town of Berkley is the famous Dighton Rock, with inscriptions long attributed to the Norsemen, but now known to be the work of Indians. Taunton was chartered as a city in 1864. It was one of the first cities in the United States to operate its own electric-lighting plant, which it acquired in 1897.

TAUNUS, a wooded mountain range of Germany in the province of Hesse-Nassau. It lies between the Rhine and the Main on the south and the Lahn on the north, and is some 55 m. long. Its southern edge stands 5 to 10 m. back from the Main, but slopes steeply to the Rhine, and from Bingen downwards forms precipitous crags, many of which are crowned with picturesque ruins. It has an average elevation of 1,500 ft., but the loftiest peaks occur in the east, where the Grosser Feldberg (2,887 ft.), Kleiner Feldberg (2,714 ft.) and Altkönig (2,618 ft.) dominate the Wetterau and the valley of the Main. Above the Rheingau (the slopes to the Rhine between Biebrich and Bingen), the altitude averages 1,500 to 1,700 ft. The geological core of the system consists of (?Archean) argillaceous schists, capped by quartzite (Devonian) and broken through in places by basalt. On the northern side, which sinks on the whole gently towards the Lahn, the higher greywacke formation (Devonian) attains a considerable development. The hills are generally well wooded, with firs and beeches. The lower slopes are, where possible, planted with vineyards, orchards and chestnut and almond groves. The vineyards of the Rheingau are specially famous, and yield many famous brands of wine. The Taunus is also famous for its mineral springs and health resorts.

There are ruins of the castle of Kuno (above Falkenstein); of a fortress at Königstein; a Cistercian abbey at Eberbach; and two concentric lines of pre-Roman fortifications at Altkönig. The chief historical monument, however, is the Saalburg, a Roman fort serving as a centre of communications along the *limes* or fortified frontier-line drawn from Rhine to Main by Domitian (*see* LIMES GERMANICUS).

At Niederwald (*q.v.*) is the gigantic "Germania" statue in commemoration of the 1870 War. The steep crags of the western end of the Taunus, where they abut upon the Rhine, are rich in the romantic associations of the great river. Here are the rock of the siren Lorelei; the old castles of Stahleck and Pfalz; and the quaint mediaeval towns of Kaub and St. Goarshausen.

TAUPO, a township of East Taupo county, New Zealand, in the south-west of the Hot Spring district of North Island. It attracts many visitors both as a health resort and on account of the magnificent scenery and remarkable volcanic phenomena of the surrounding district. It lies on the north-east shore of lake Taupo, the largest lake in the island, having an extreme length of 26 m. and a shore-line, not counting minor indentations, of about 100 m., and lying 1,200 ft. above sea-level. The river Waikato, which reaches the west coast not far from Manukau

Harbour near Auckland, here leaves the lake. The district abounds in geysers, springs, mud volcanoes and other phenomena.

TAURI, the earliest known inhabitants of the mountainous south coast of the Crimea (Herodotus iv. 103). Nothing is certain as to their affinities. They probably represent an old population perhaps connected with some Caucasus stock. They are not likely to be Celts. They were famous in the ancient world for their maiden goddess, identified by the Greeks with Artemis Tauropolos or Iphigeneia (*q.v.*), whom the goddess was said to have brought to her shrine at the moment when she was to have been sacrificed at Aulis. Orestes sought his sister, and almost fell a victim to the Tauric custom of sacrificing to the maiden shipwrecked strangers, a real custom which was the ground of the whole myth. His adventures were the subject of plays by Euripides and Goethe. Towards the end of the 2nd century B.C. we find the Tauri dependent allies of the Scythian king Scilurus, who from their harbour of Symbolon Portus or Palacium (Balaclava) harassed Chersonese (*q.v.*). Their later history is unknown. (E. H. M.)

TAURINI (tou-rē′nē), an ancient Ligurian people, although the name may be of Celtic origin, who occupied the upper valley of the Padus (Po). In 218 B.C. they were attacked by Hannibal, with whose friends the Insubres they had a long-standing feud. They later became subject to the Romans, and the colony of Augusta Taurinorum (Torino, Turin) was founded in their territory (probably by Augustus after the battle of Actium). Both Livy (v. 34) and Strabo (iv. p. 209) speak of the country of the Taurini as including one of the passes of the Alps, probably the Mont Genèvre or Col d'Argentière.

TAUROBOLIUM, properly the shooting of a bull, hence a rite of baptism by bull's blood, usually in connexion with the worship of Cybele (q.v.), though not limited to it. Of oriental origin, its first known performance in Italy was in A.D. 134. Prudentius describes it in *Peristephanon* (x., 1066 et seq.): the person undergoing the ceremony, clad in a toga worn *cinctu Gabino,* with golden crown and fillets on his head, takes his place in a trench covered by a grating, on which a bull is slain.

The taurobolium was often performed as a measure for the welfare of the emperor, empire, or community, its date frequently being March 24, the *Dies Sanguinis* of the annual festival of the Great Mother and Attis (qq.v.). But its usual motive was the purification or regeneration of an individual, who was occasionally spoken of as *renatus in aeternum,* reborn for eternity, in consequence of the ceremony (*Corp. Insc. Lat.* vi. 510–512); more commonly the effect was considered to endure for 20 years.

BIBLIOGRAPHY.—*See* Showerman, *The Great Mother of the Gods* (1901); Hepding, *Attis, seine Mythen und sein Kult* (1903), p. 168 et seq., 201; Cumont, *Le Taurobole et le Culte de Bellone, Revue d'histoire et de littérature religieuses,* vi., No. 2 (1901); H. Graillot, *Culte de Cybèle.*

TAURUS ("the Bull"), in astronomy, the second sign of the zodiac denoted by the symbol ♉. It is a constellation of very great antiquity, the Pleiades (*q.v.*), and Hyades, two of its constituent star clusters, being possibly referred to in the Old Testament; while Aldebaran, its brightest star, is mentioned by Hesiod and Homer. The Greeks fabled this constellation to be the bull which bore Europa across the seas to Crete, and was afterwards raised to the heavens by Jupiter. Aldebaran is the principal object in the Hyades, named after the seven daughters of Atlas and Aethra—Ambrosia, Coronis, Eudora, Pasithoë, Plexaris, Pytho and Tycho—fabled by the Greeks to have been transformed into stars by Jupiter for bewailing the death of their brother Hyas. Many of the Hyades (but not including Aldebaran) form an associated group of stars with a common motion. This group was investigated by L. Boss and has furnished much important astronomical information (*see* STAR). The constellation contains the "crab nebula," so named from its claw-like protuberances.

TAUSEN, HANS (1494–1561), the protagonist of the Danish Reformation, was born at Birkende in Funen in 1494. The quick-witted peasant lad ran away from the plough at an early age, finally settling down as a friar in the Johannite cloister of Antvorskov near Slagelse. After teaching for a time at Rostock and Copenhagen, he was again sent abroad by his prior, visiting the newly founded University of Leyden and making the acquaintance of the Dutch humanists. He was already a good linguist, understanding both Latin and Hebrew. Later he translated the books of Moses from the original. In May 1523 Tausen went to Wittenberg, where he studied for a year and a half, when he was recalled to Antvorskov. In consequence of his adherence to Lutheran doctrines he was first imprisoned in the dungeons of Antvorskov and thence transferred, in 1525, to the Grey Friars' cloister at Viborg in Jutland, where he preached from his prison to the people assembled outside, till his prior, whom he won over to his views, lent him the pulpit of the priory church.

Several young men in Viborg had studied at Wittenberg, and the burghers had already expelled their youthful bishop Jörgen Friis. Tausen no longer felt safe among the Franciscans; he discarded his monastic habit, and placed himself under the protection of the burgesses of Viborg. At first he preached in the parish church of St. John, then in the market-place from the church tower. When the Franciscans refused to allow him to preach in their large church, the mob broke in by force. A compromise was at last arranged, whereby the friars were to preach in the forenoon and Tausen in the afternoon. The bishop sent armed men to the church to arrest Tausen, but the burghers drove them back. In Oct. 1526 King Frederick I., made Hans Tausen one of his chaplains, and charged him to continue "to preach the holy Gospel" to the citizens of Viborg, who were to be responsible for his safety. Tausen found a fellow-worker in Jörgen Viberg, better known as Sadolin, whose sister, Dorothea, he married. He was the first Danish priest to marry. He was also the first to use Danish instead of Latin in the church services.

On the death of King Frederick, Tausen, at the instance of Rönne, was, at the *Herredag* of 1533, convicted of blasphemy and condemned to expulsion from the diocese of Sjaelland, whereupon the mob rose in arms against the bishop, who would have been murdered but for Tausen's intervention. Rönne then permitted Tausen to preach in all his churches on condition that he moderate his tone. On the final triumph of the Reformation Tausen was appointed bishop of Ribe (1542), an office which he held for 20 years.

See Suhr, *Tausens Levnet* (Ribe, 1836); *Danmarks Riges Historie,* vol. ii. (Copenhagen, 1897–1905).

TAUSSIG, FRANK WILLIAM (1859–), American economist, was born at St. Louis, Mo., on Dec. 28, 1859. He was educated at Harvard university (A.B., 1879; Ph.D., 1883), where he started teaching in 1882, becoming professor of political economy ten years later. He made a particular study of finance and was during 1917–19 chairman of the U.S. tariff commission. In March 1919 he was called to Paris to advise in the adjustment of commercial treaties. He was in 1904–05 president of the American Economic Association and for many years edited the *Quarterly Journal of Economics.* His principal books are: *Wages and Capital* (1896); *The Tariff History of the United States* (rev. ed., 1923); *Principles of Economics* (1911); *Some Aspects of the Tariff Question* (1915); *Inventors and Money Makers* (1915); and *International Trade* (1927).

TAUT, BRUNO (1880–), German architect, was born in 1880 at Königsberg. After practical experience as a mason, he studied architecture and was for five years a colleague of Theodor Fischer. He was for some time municipal architect in Magdeburg, but subsequently removed to Berlin to work principally in collaboration with Max Taut (b. 1884) and Franz Hoffman (b. 1884). He traces the beginning of the industrialization of building back to Karl Friedrich Schinkel (1781–1841) through the Crystal Palace and the Eiffel Tower to Otto Wagner (1841–1918), although other authorities have pointed to Monier as the first to use ferro-concrete where previous engineers had used simple iron and glass. His works include a glass and iron building at the building exhibition, Leipzig (1913); a glass house at the Werkbund exhibition, Cologne (1914); the Stadt und Land Hall, Magdeburg (1922), the outside of which is beautifully designed in flat curves, while the hall itself, the segment of a circle, is ornamented by the constructional features of the roof; a housing-block at Schillerpark (1925), the effect of which is made by the emphasized rectangles of the façade; and the "Gehag" garden city (Berlin-Zehlendorf) in conjunction with Häring and Salvisberg, which admirably illustrates his requirements of domestic architecture. His publications include: *Die Stadtkrone* (Jena, 1919); *Alpine Architektur* (Münich, 1920); *Der Weltbaumeister* (Münich, 1920); *Die Auflösung der Städte* (Münich, 1920); *Die Neue Wohung* (Leipzig, 1924); *Bauen* (Leipzig, 1927); *Ein Wohnhaus* (Stuttgart, 1928).

See G. A. Platz, *Baukunst der neuesten Zeit* (1927).

TAUTOMERISM: *see* ISOMERISM.

TAVERNER, JOHN (*c.* 1495–1545), English composer, was born in Lincolnshire, possibly at Tattershall, about 1495, and, according to some accounts, became organist of Boston church. The bishop of Lincoln recommended him to Wolsey for an appointment at Cardinal college, Oxford, where he was made master of the children, and also acted as organist at St. Frideswide's, the chapel of the college. During this period he wrote his church music. He was then convicted of heresy and thrown into an underground prison with his companions, escaping with his life only through the cardinal's indulgence to him as a musician. It has been assumed that he was identical with the John Taverner who assisted at the burning of the Rood in 1539, and other fanatical doings at Boston. All that is definitely known, however, is that he was still at Cardinal college, writing songs for Wynkyn de Worde's song-book ("My Harte my Minde," "Love wyll I," for three voices, and "The Bella" for four), in the year 1530, and that he died and was buried at Boston in 1545. A two-part song, "In Women no Season is Rest or Patience," is in the British Museum, but, apart from this and the Wynkyn de Worde specimens, only his church music has been preserved. Of this there is a complete collection, with biographical notes, in the Carnegie edition of *Tudor Church Music*, i., iii. It includes eight masses; 28 motets (some incomplete); three magnificats and a Te Deum; a Kyrie known as the "Leroy," and shorter pieces.

See the article "Taverner," by Rev. E. H. Fellowes, in Grove's *Dictionary*, 3rd ed., on which the present article is based.

TAVERNIER, JEAN BAPTISTE (1605–1689), French traveller and pioneer of trade with India, was born in 1605 at Paris, where his father Gabriel and uncle Melchior, Protestants from Antwerp, pursued the profession of geographers and engravers. He had already travelled much in Europe, and was well acquainted with the principal European courts, when he started from Regensburg with two French fathers, M. de Chapes and M. de St. Liebau, for the Levant. In their company he reached Constantinople early in 1631, where he spent eleven months, and then proceeded by Tokat, Erzerum and Erivan to Persia. His farthest point in this first journey was Isfahan; he returned by Baghdad, Aleppo, Alexandretta, Malta and Italy, and was again in Paris in 1633. In September 1638 he began a second journey (1638–43) by Aleppo to Persia, and thence to India as far as Agra and Golconda. His visit to the court of the Great Mogul and to the diamond mines was connected with the plans realized more fully in his later voyages, in which Tavernier traded in costly jewels and other precious wares, among the greatest princes of the East. The second journey was followed by four others. In his third (1643–49) he went as far as Java and returned by the Cape; in his last three journeys (1651–55, 1657–62, 1664–68) he did not proceed beyond India. In 1669 he received letters of nobility and in 1670 purchased the barony of Aubonne, near Geneva.

Tavernier's narratives of his travels are: *Nouvelle Relation de l'Intérieur du Sérail du Grand Seigneur* (4to, Paris, 1675), based on two visits to Constantinople in his first and sixth journeys; *Le Six Voyages de J. B. Tavernier* (2 vols., 4to, Paris, 1676) and *Recueil de Plusieurs Relations* (4to, Paris, 1679).

The closing years of Tavernier's life are obscure. He left Paris for Switzerland in 1687, in 1689 he passed through Copenhagen on his way to Persia through Muscovy, and in that year he died at Moscow.

See Charles Joret, *Jean Baptiste Tavernier d'après des Documents Nouveaux* (1886, bibliography), and an English translation of his account of his travels in India, by V. Ball (1889).

TAVISTOCK, a market town in the Tavistock parliamentary division of Devon, England, in the valley of the Tavy, on the western border of Dartmoor; 16½ m. N. of Plymouth, on branch lines of the G. W. and S. railways. Pop. of urban district (1921) 4,316. There are some remains (including a portion in the square, now used as a public library established in 1799) of the magnificent abbey of St. Mary and St. Rumon, founded in 961 by Orgar, earl of Devon. After destruction by the Danes in 997 it was restored, and among its famous abbots were Lyfing, friend of Canute, and Aldred, who crowned Harold II. and William, and died archbishop of York. The abbey church was rebuilt in 1285, and the greater part of the abbey in 1457–58. The church of St. Eustachius dates from 1318, and possesses a lofty tower supported on four open arches. Kelly college, near the town, was founded by Admiral Benedictus Marwood Kelly, and opened in 1877 for the education of his descendants and the orphan sons of naval officers. Mines of copper, manganese, lead, silver and tin are in the neighbourhood, and the town possesses a considerable trade in cattle and corn, and industries in brewing, wool-combing and iron-founding. The mining industry has declined, but there is a trade in arsenic.

The early history of Tavistock centres round the abbey of St. Rumon. Both town and abbey were sacked by the Danes in 997, but were shortly afterwards rebuilt, and the latter at the time of the Conquest ranked as the wealthiest house in Devon, including the hundred and manor of Tavistock among its possessions. It returned two members to parliament as a borough from 1295 until deprived of one member by the act of 1867, and finally disfranchised by that of 1885.

See *Victoria County History, Devonshire;* A. J. Kempe, *Notices of Tavistock and its Abbey* (1830); R. N. Worth, *Calendar of Tavistock Parish Records* (Plymouth, 1887).

TAVOY, a town and district in the Tenasserim division of Burma. The town is on the left bank of the river of the same name, 30 m. from the sea. Pop. (1921) 27,480. It carries on a considerable coasting trade with other ports of Burma, and with the Straits Settlements whither is sent the bulk of the tin ore for which the district is important, as well as much of the rubber. The chief industry is silk-weaving, but there are also rice and timber mills.

The district has an area of 5,308 sq.m. It lies between Siam and the Andaman sea of the Bay of Bengal, enclosed by mountains on three sides, viz., the main chain of the Bilauktaung on the east, rising in places to 5,000 ft., which, with its densely wooded spurs, forms an almost impassable barrier between British and Siamese territory; the Nwahlabo in the centre, which takes its name from its loftiest peak (5,000 ft.); and a third range, under the name of Thinmaw, between the Nwahlabo and the sea-coast. The Tavoy is navigable for vessels of any burden. It is interspersed with many islands, and with its numerous smaller tributaries affords easy and rapid communication. The climate is on the whole pleasant. The annual rainfall averages over 200 inches. Pop. (1921) 156,786, showing an increase of 21,493 in the decade. The staple crop is rice. Forests cover an area of nearly 5,000 sq.m., of which considerable areas are "reserved." The leading industries of the district are now rubber planting and tin mining, both of which are of recent development.

Tavoy, with the rest of Tenasserim, was handed over to the British at the end of the first Burmese war in 1824.

TAXACEAE: *see* GYMNOSPERMS.

TAXATION, that part of the revenue of a state which is obtained by compulsory dues and charges upon its subjects, as distinct from revenue from property of its own.

Where the charge by the State or public authority bears a direct relation to the service rendered direct to the payer, and is on a contractual basis, as though between individuals, the amounts paid are usually classified as fees and charges, rather than taxes.

Definitions and Classifications.—Taxes are classified for various purposes in different ways, *e.g.*, direct and indirect; beneficial and onerous; local and national; proportional, regressive and progressive; taxes *in rem* and *in persona*. It is necessary to consider some of these distinctions if the general literature of the subject is to be understood.

The distinction between direct and indirect taxation is mainly an administrative one. It is a classification for convenience sake, adopted upon a rough observation of conspicuous, or apparently conspicuous, differences in the mode of levying taxes, and nothing more. The division, nevertheless, cannot be passed over without mention, as it is not only a common one in economic writing, but it figures largely in budget statements, financial accounts and finance ministers' speeches—especially in the United Kingdom and France. In the United Kingdom the distinction has been made familiar by free-trade discussions. Direct taxes are those finally borne by the actual payer, but where the legislation does not intend the tax to fall upon the payer, and expects him to pass it on, in price, or otherwise by altering the terms of a bargain, it is indirect. Thus income tax is classed as direct, although often paid by a tenant on behalf of his landlord and specifically deducted from rent, but beer duty paid by the brewer, and passed on in price to the publican, and by him to the consumer, is indirect; a motor licence duty paid by a private owner is direct, though it appears to be indirect where it is charged upon a vehicle for public hire and is an expense of carrying on a business which is expected to be recovered from fares. But petrol tax is obviously indirect. The distinction has little actual economic basis, because the effect of the tax in retarding production or consumption may be such as to throw the burden elsewhere, and the customer may, in consequence of the higher price, drink less beer, and the brewer, through selling less, make lower profits.

The distinction between direct and indirect taxes has not always been drawn upon present lines. By direct taxes the physiocrats meant any taxes levied immediately upon the "product net" out of which fund alone could taxes be paid. A levy of taxes anywhere else was indirect because the burden would be shifted from one to another until it rested there. This distinction fell into disuse as their theory of the location of wealth was discarded. Later writers took into account the difficult question of economic shifting. The French have not been in the habit of classifying customs duties as indirect. In the United States at the time of the Civil War the courts declared the income tax not to be "direct" in the sense intended by the constitution, but this decision was overborne in 1895.

"Local" and "national" refer not so much to the administrative body which formally imposes and collects a tax, as the body which is responsible for the decision to impose it. Income tax is collected locally, but it is a national tax, alike in weight over the whole area. Poor rates are local because they vary from district to district, but though the jurisdiction over them is local, it is regulated under general acts. But abroad, local revenues are sometimes raised by being "geared on" to a national tax; the differing local requirements are represented by varying percentage supplements to the national income tax, and collected with it. In other cases, such as Germany, the national tax is for the most part passed on in percentage grants to States and communes. Customs duties are national, but the octroi is local.

Taxation is "proportional" if the payment any person is required to make varies directly with the amount of income or wealth the payer possesses, "regressive" if the burden becomes a less percentage of income or wealth as the latter increases, and "progressive" if it becomes a greater percentage. Thus local rates are said to be regressive, because the average amount paid by a householder with £5,000 a year is a less percentage of his income than that paid by one with £500 a year. But the income tax and estate duties are now almost universally progressive.

Taxes *in rem* are laid or assessed upon a thing or physical object, regardless of the circumstances of its owner, *e.g.*, a motor licence, or a house tax; while taxes *in persona* pay due regard to the financial status and domestic circumstances of the payer, *e.g.*, income tax and death duties.

Fundamental Principles.—Adam Smith's famous canons or maxims were:—

1. The subjects of every State ought to contribute towards the support of the Government as nearly as possible in proportion to their respective abilities, *i.e.*, in proportion to the revenue which they respectively enjoy under the protection of the State.

2. The tax which each individual is bound to pay ought to be certain and not arbitrary. The time of payment, the manner of payment, the quantity to be paid, ought all to be clear and plain to the contributor and to every other person.

3. Every tax ought to be so levied at the time or in the manner in which it is most likely to be convenient for the contributor to pay it.

4. Every tax ought to be so contrived as both to take out and keep out of the pockets of the people as little as possible over and above what it brings into the public treasury of the State.

Ability to Pay.—The principle of "ability to pay" is not nearly so simple in application as it appears at first sight. Formerly it was thought to lead logically to proportional taxation (*see* above), but now it is generally agreed to require progression. It is now considered to be best tested by the total wealth of an individual, or else by his income over a certain unit of time. The unit varies with different classes of people, *e.g.*, weekly wage earners against business owners. With high rates of taxation, income may have to be carefully dissected to take out elements that are not pure income (for example, the wasting asset in an income from a diamond mine, or the capital element in an annuity). The nature of the income, whether it is precarious, or, on the other hand, independent of the work and health of the recipient, is more generally regarded, and a difference in the burden is made, while there is also a growing tendency to consider whether the income is burdened with inevitable family claims. These different elements have been recognized only in recent years, and taxation, formerly mostly "objective" and equal for every pound of income to every man, has become highly "subjective" or personal to individual loss. A few years ago a bachelor in Great Britain with £1,000 per annum from investment paid the same tax as a man with a salary of £1,000 and a wife and family of children and a number of dependent relatives.

Adam Smith's principles have thus been elaborated in British practice, especially as regards the first and the refinements of the principle of ability; for the other canons are really only common-sense administrative rules, and do little as a guide to the proper amounts of taxation to be levied between different classes. A recent addition to the category of "ability to pay" is the special ability or "windfall" principle, which postulates that a special addition to the regular flow of wealth or income, not counted upon by the individual in regulating his expenditure and mode of life, has a greater capacity to bear taxes without hurting him than a similar amount which forms a regular part of his receipts. Thus a higher rate of tax upon a legacy received from a distant relation than on a similar amount from a near relation (from whom one had "legitimate" expectations) has been justified on this principle, and so also have various increment taxes. The excess profits duty in war time was based mainly on the principle that in a time of general hardship anyone who found himself enjoying larger profits than in peace time was specially lucky and could well make a special contribution to the Exchequer.

Successful personal taxation is a great test of advanced administrative methods. It is always a failure where Government is not strong and uniform in its nation-wide application. In modern times so much wealth is only loosely attached to individuals—the profits of companies which are not distributed as dividends, or the wealth of corporate bodies—and taxation of these nonpersonal elements has to be reached by the same system. (*See* Income Tax.)

Ad Valorem Duties.—Adam Smith's second maxim (of uncertainty) is perhaps most nearly violated in modern times by the practice of imposing *ad valorem* and not fixed or specific duties on commodities. Specific duties applied to classes of goods of widely varying quality are obviously a higher proportionate tax upon the goods of poor quality and low price than upon the best quality. A duty of 1d. per cigar would be a very heavy tax upon a cheap cigar, and a very light one upon a Corona. This can be represented as a regressive tax upon the poor and favouring the rich, and also as very disturbing to production. If it is to raise a substantial duty over the whole class, it may even be so high as to lead to substitution in the lower grades of quality, a process which may easily raise the costs of production of the higher grades. The *ad valorem* duty is the natural escape, but the successful administration of a highly complex tariff requires a better and more skilled and honest staff of valuers or assessors than many countries are prepared to admit or afford. Although, therefore, an *ad valorem* tax is theoretically a certain tax, and the same levy must always be made upon this same quality, defects of administration may make it arbitrary and uncertain.

Adam Smith's third maxim is an administrative rule. In practice to-day taxes are levied at that point in the productive process, or the course of distribution, which is most convenient. Where "bonded" warehouses are available, duty payments may be postponed until there is actual withdrawal for use. It is generally considered that taxes on raw materials infringe the fourth maxim. If taxes are imposed at the first process, capital is locked up in the tax, and the payer has to secure interest upon it, and the user must get interest upon interest until the price of the final article has rolled up compound interest on the tax. Taxes on raw materials are almost universally condemned, but the reasoning behind these objections is not, from an economic point of view, particularly sound. A more important infringement of the fourth rule is the indivisibility of a tax. "Where a charge upon a commodity is not of such a figure as to be easily divisible among the ordinary units of retail consumption, so that it can be passed on to a consumer of the articles in the form of an increased price, it may remain fixed upon those who first pay it, at least for a time. This is supposed to have actually happened with the increase of the beer duty in the British budget of 1894 by 6d. per barrel—a sum which would not when divided by the pints in a barrel amount to the smallest coin." It is, therefore, the object of the financial authority to impose a tax on the commodity which may find a proportional equivalent in the price of a minimum quantity usually demanded—thus a penny on a gallon of beer would have no workable equivalent on the half pint.

Relations Between Direct and Indirect Taxation in Great Britain.—Much discussion has centred on the relations between direct and indirect taxation, and for many years it was thought, for no very clear reason, that the Government should "hold the balance even" between their respective yields. In 1840 in the United Kingdom indirect taxation was 73%, in 1870, 61%, in 1880, 60%, in 1895, 62%, and in 1906, 50%—for many years it hovered round this figure. To-day there is much less regard paid to the proportions, since direct taxes have developed to a marked extent, and there is a recent tendency to look at them as part of a common system, and all taxes taken together are reduced to a percentage of total income at each grade of income to determine the effect. Indirect taxes are justified in this view for their administrative convenience in reaching the incomes of the poorer classes who are only with difficulty brought within direct taxes, such as income tax, and death duties, and who otherwise would have political power and control over expenditure without any share in the responsibility.

The causes of the trend towards more direct taxation may be summarized in a three-fold classification:—

(1) *Natural Administrative Development.*—It is most natural for countries in their early stages of development to rely almost entirely upon indirect taxation, and in proportion as they become more highly differentiated in function or densely populated, and industrialized so as to be more completely of the type of western civilization—in that proportion is it found more administratively possible to resort to direct taxation. A country that is sparsely peopled has ill-developed administrative machinery. In agriculture it is always difficult to assess incomes, and it often takes many years after the adoption of an income tax to attain a high degree of administrative efficiency. A country in an early stage of development has to rely very largely upon a scattered and not too skilled administration, perhaps with no tradition of industry and probity. Such a country has one or two main outlets for its produce, and means of ingress for imports, confined to one or two chief ports, and by concentrating administration at these places, the gateways, as it were, of the country, it is possible to levy toll on things going in and out. Consumption taxes or taxes upon produce are the rule. These taxes are most easily checked at the points of ingress and egress.

(2) *Social and Political Reasons.*—Democracy has a growing power politically to put the major burden upon a minority. A landowning majority tends to put the weight upon manufacture and wages. Seligman says the indirect taxes of the 19th century were the outgrowth of the effort on the part of the commercial classes to escape the burdens which the landowners were desirous of placing upon them. Socialistic theories desire to equalize incomes, and heavy taxation of the rich is one important method. But this cannot be achieved by ordinary indirect taxes.

(3) *Economic Causes.*—The principle of ability to pay has led in recent times to progression (*see* below) through the economic principles of diminishing utility and equal sacrifice. This can only be attained by direct taxes.

According to calculations by Sir Herbert Samuel, before the Royal Statistical Society in 1903, the income of £150 a year bore ·1% of direct and 4·8% of indirect taxes. In 1918 this was ·1% and 10·9% respectively. For the £500 income the 1903 figure was 5·6% direct, 3·1% indirect, 8·8% total, and the 1918 figures 12% direct, 6·1% indirect, total 18·1%. The 1903 income of £5,000 bore 8·7% direct, 0·8% indirect, total 9·6%, but in 1918 the £5,000 income bore 42·2% direct, 1·3% indirect, 43·5% total. The £50,000 income bore 10·2% direct, ·08% indirect, total 10·2% in 1903, and 63·7% direct, ·1% indirect, total 63·9% in 1918.

It is true to say that the smaller incomes during the last 100 years have been so systematically relieved from taxation that, if a workman chose not to drink alcohol or to smoke, his taxation was almost negligible.

The report of the Colwyn Committee on Taxation deals exhaustively with the comparative burdens per head at different dates. The following is a selection of the conclusions (Report pp. 94–5) which differs in small details from the foregoing:—

Total Taxation: Percentage of Income

Income	Income wholly earned			Income half earned half investment		
	Direct	Indirect	Total	Direct	Indirect	Total
	%	%	%	%	%	%
1913–14						
100	..	5·4	5·4	1·2	5·4	6·6
150	0·2	4·2	4·4	1·4	4·2	5·6
500	2·6	1·8	4·4	5·3	1·8	7·1
5,000	6·0	0·7	6·7	8·9	0·7	9·6
50,000	8·3	0·1	8·4	13·5	0·1	13·6
1918–19						
100	..	9·9	9·9	1·2	9·9	11·1
150	0·2	8·8	9·0	1·4	8·8	10·2
500	7·0	3·2	10·2	10·3	3·2	13·5
5,000	35·9	0·7	36·6	38·5	0·7	39·2
50,000	50·5	0·1	50·6	58·1	0·1	58·2
1925–26						
100	..	11·9	11·9	1·1	11·9	13·0
150	..	11·6	11·6	1·1	11·6	12·7
500	2·0	4·2	6·2	4·2	4·2	8·4
5,000	21·9	1·3	23·2	28·2	1·3	29·5
50,000	44·2	0·2	44·4	57·5	0·2	57·7

The Progressive Principle of Taxation.—No change of opinion has been so great or so complete in the past fifty years as that upon progression. Adam Smith was, except in one or two passages, an exponent of proportion. Probably he went as far as was necessary in an age when regression was more commonly held as a defensible system. The nineteenth-century view is M'Culloch's oft-quoted remark, "When you abandon the plain principle (of proportion) you are at sea without rudder and compass, and there is no amount of injustice you may not commit."

In 1922 Sir Robert Giffen wrote, "As to progressive taxation based on the assumption that equality requires a larger proportionate charge upon a big income than on one of a smaller amount, the practical application of the principle, if true, would be impossible. A great deal more would need to be known than is now known as to the effect of taxes on different classes, and the aggregate amount of different incomes, before such a tax could be undertaken. If there is a greater proportionate charge already on the larger incomes, nothing more need be done, and we cannot know that there is not.

The doctrine of the minimum of subsistence was advanced by Bentham in the form of leaving untouched a certain minimum of income sufficient to provide the necessaries of existence.

There is no magic about the *minimum of subsistence.* It is not an absolute. "I well remember, when I was serving on the Dawes Committee on German Reparations, and we were considering the question of comparative national ability to bear burdens, with the necessary comparisons of total national incomes, the various nations agreed that the *minimum of subsistence* for each population should first be deducted, as it was only the balance of income that was capable of bearing a special burden. This minimum per head was, therefore, explored by the various representatives. The Americans were amazed at the figure suggested by the French and the Italians, and surprised even at the British; it seemed to them incredible. The Italians could not admit the British suggestion, and as for the American idea—when applied to Italy it blotted out the whole national income." (Sir Josiah Stamp, *The Christian Ethic as an Economic Factor.*)

The philosophical or mathematical basis of progression as a just principle has been debated since Montesquieu, and writing in 1894 Seligman was able to point to the growing Continental practice, and also the support of marginal theory in economics "as indicative of a great change." The principle is based on the diminishing satisfaction given by utility of money or wealth as a whole to its possessor, with every increase in it, satisfying less and less urgent wants, so that to take a shilling from the 10,000th £ is not so hurtful as to take a shilling from the 100th £. Taxation in Germany was frankly progressive from 1891. In Great Britain a mild element (degression) existed in the Income Tax, and some progression in death duties, from 1894, but the first instalment of real progression came in 1909 with the super tax. In France the principle was not admitted until much later.

The Incidence of Taxation.—Some of the most important issues in regard to incidence and ultimate effects are considered in the article INCOME TAX, ECONOMIC ASPECTS OF. But one of the fundamental principles in connection with all taxation of a flow of particular kinds of wealth (*e.g.,* taxes on mining royalties, on dividends from diamond mining, or on ground rents) is that of amortization or capitalization. It rests upon two economic principles, first that a tax on results (profits) or surplus (economic rent) does not enter into price and become recouped in sales, but stays as a deduction from the particular profits taxed; second, that all such "flows" have a capital value in the market, and the market (*caeteris paribus*) is indifferent to gross yields and looks at net yields only. Thus A and B have each £100 coming from sources X and Y, and its capital value in the market is £1,500 in each case. But a 10% tax is put on X and A receives £90 only—he can only get £1,350 in the competitive market, and at once bears the capitalized (or amortized) burden of future taxation. Every purchaser takes care to buy himself "free" of the burden and to get the same rate of yield as he would from untaxed sources. It is not necessary to wait for the actual imposition of the special tax—its preparation has the same effect, and even a hint of imposition begins to influence market price. Of course a general income tax leaves no untaxed alternatives open to the investor and there is, therefore, no amortization.

An important "negative" case is the special exemption from a general tax, *e.g.,* a "tax exempt security." Here the capitalized value of the tax escaped is a present to the owner at the time of the exemption, and every new holder has to give *pro tanto* more. If the tax exemption is a condition of a government offer, obviously the government gets a subscription on more favourable terms in lieu of the tax they prefer. The problem of tax exempt securities is peculiarly an American one.

The principle may apply to other forms of differential taxation, *e.g.,* land values, which are not upon immediate income, but fall on future prospects. Where taxes are levied on commodities, the broad principle of an alternative untaxed supply is important. A customs duty on imports balanced by an excise on home production, throws the whole tax (B) as an addition to cost price (A) and the final effect depends upon "elasticity of demand"—if the public will not buy the old quantities at the higher price (A+B) the effect may be to reduce sales which will pass off at a rather lower level C, intermediate between A and (A+B). But, where there is no duty on the home product, the general or broad result is that the foreign exporter needs to add the tax B to his price, the home producer can secure something approximating to A+B, and his trade expands at the expense of the foreigner. This result, again, is materially qualified by elasticity of demand, internal competition, and the degree to which the foreign exporter was making large differential profits which can be cut into before he will relinquish the market. The principle of substitution is operative to a marked extent in controlling incidence. A high tax on tea may encourage the substitution of other beverages. The incidence of death duties is indeterminate—it is described by the Colwyn Committee as follows:

> On practical grounds, we think it is impossible to say that the incidence of the estate duty is uniform.
>
> If a testator has consciously stinted his expenditure and saved more year by year than he would otherwise have done, regarding the difference solely as a piling up of the tax against the day of his death, it is hard to deny that the incidence is upon him during his life.
>
> On the other hand, the feelings and action of the testator have not been influenced in any direction by the prospect of the duty, the successor is the only person who suffers and the only person to whom the incidence can well be assigned. . . . When one compares the income tax with the estate duty, regarding the latter as a kind of postponed income tax, one sees clearly the solidarity of the interests of predecessor and successor. The income tax, in a concealed way, hits the taxpayer's son as well as the taxpayer himself, and may hit him just as severely. But the damage is separated by a time-gap. In the case of the estate duty the time-gap is bridged, and the damage is at once apparent. On the whole, we think we have good support for giving primary but not exclusive place to the notion that the incidence of the duty is on the predecessor.

The incidence of local rates on building rentals was highly debated for many years and is not finally determinable. At one time, it was said that all such taxation was thrown off upon ground rents, which could, and would, be *pro tanto* higher if local rates did not exist. But the reasoning upon which this was based would have applied almost equally to a reduction in the price of a "hair cut." It has to be realized that a large part of local rating is payment for value received (by the tenant) and also that local rating acts as a very rough (unshiftable) income tax.

Ulterior Objects of Taxation.—It will be seen that while taxation may be in the first instance to raise revenue, it has inevitably certain "effects" in so doing. The economic community cannot be exactly the same as it would have been without the taxation. This leads to endeavours to secure "effects" by the machinery of taxation, the resultant revenue (if any) being a secondary consideration. Taxation becomes an "engine of social or national policy." At any rate, it actually modifies the primary task of raising a given amount of revenue into a task of achieving that main object with a combination of desired ulterior objects. These objects may be grouped under three classes, (1) the discouragement of the use or consumption of things having disadvantageous personal or social effects, (2) the encouragement of particular trades, and (3) the equalization of wealth, and remedying of social inequality. Under the first, the temperance reformer sees virtue in making the price of alcoholic liquors so high that a given expenditure can do little personal harm; others would consider diminution of smoking a satisfactory result of tobacco duties, a tax on cats is desired to keep down their numbers, and not actually for revenue. In the second class, of course protective duties are avowedly designed to promote home production in the particular trades affected—whether there is a net national advantage after allowing for trades which use the product, for depression in exporting trades which would pay for the imports, for comparative efficiency, etc., in the trades themselves, is, of course, the complicated issue known as the "fiscal question."

Under the third head, progressive taxation of incomes and death duties is not pursued merely because it is the easiest or fairest way to raise a necessary burden or discharge a disagreeable duty—it takes on the character of a deliberate equalization of wealth, as a goal to be aimed at, with an almost retributive character. The limits to which this can be carried without reducing the size of the national dividend, are increasingly important. (*See* Capital Levy and Income Tax.)

The Main Problems of Post-war Taxation.—The man in the street would declare that the main problem is to reduce it. But given the necessity or inevitability of raising a certain sum, certain real problems remain.

1. *Jurisdiction and Double Taxation.*—The civilized world has accepted the ideas of subjective taxation, according to the capacity of the individual, before it has given up that of objective taxation, or the levying of tax upon a source of wealth wherever it is found. The two are in conflict, but the conflict does not much matter where the two are in the same tax or political jurisdiction. But where the object, say, is a ranch in the Argentine, and the owner a resident in England, then the Argentine government think most of the protection and benefits they are affording the ranch and without which the ranch would be unproductive, and think too of the wealth "withdrawn" from their country, while the British think of the wealthy private resident in their midst, who, compared with his neighbours, can "afford" in justice a high rate of tax. The people interested in the "ranch," as an object, may be the tenant, who has an occupational and capital interest, the owner who receives a rental and interest on capital, the mortgagee, and possibly a ground landlord—these may all be in different stations in life, properly taxable at very different levels, and resident in four different jurisdictions. Still more complex is the origin and destination of business profit—buying, and perhaps some manufacture done in Australia, blending and selling in Africa, the directing seat of control in London, the shareholders in America. How determine where profit is made? The widely distributed character of modern ownership accentuates the problem of double taxation. Neither Government is willing to give up an existing source of income. The matter is the subject of expert enquiries since 1920 by the League of Nations, the International Chamber of Commerce, and the various Governments. As an ultimate goal the choice of the individual as the crux of taxation rather than the physical object is now clearly preferable, and consequently the taxation of the resident on his whole resources wherever they come from, and the "reciprocal exemption of the non-resident" in the country of "origin" of the wealth or income is the generally approved principle in theory.

2. *Taxation of Collective Wealth in a Progressive System.*—Focussing attention upon the individual and his available resources leads to difficulty at a time when he has proximate resources held in collective form—*e.g.*, the reserves and undistributed profits of companies. When these companies are small groups of two or three persons, the distinction between personal ownership and collective ownership is very thin, yet very real. The aggregate of individuals' fortunes or incomes tends to be less than the aggregate of wealth or incomes finally accruing to individuals, to an increasing extent; it is not necessary to postulate the desire to evade highly progressive taxation as the cause.

3. *The Borderline Between Income and Capital Gains.*—The ease with which, under modern financial forms, income and capital are convertible into each other, and at the same time the fact that capital accretions may be due *either* to additions of unused income, *or* to new monetary expressions of the same thing, leads to great difficulties in "drawing the line."

Taxation per Head of Population in the United Kingdom 1913–14, 1914–15, and 1920–21 to 1925–26. Motor Vehicle Duties Excluded.
(*From the Colwyn Report on Taxation and the National Debt*)

	1913–14	1914–15	1920–21	1921–22	1922–23	1923–24	1924–25	1925–26
	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
Direct taxation per head	2. 1. 0	2. 9. 7	14. 17. 0	11. 2. 3	10. 18. 7	9. 18. 1	9. 19. 5	9. 11. 6
Indirect taxation per head	1. 10. 4	1. 12. 11	7. 0. 2	6. 15. 0	6. 3. 11	5. 17. 10	5. 2. 2	5. 2. 11
Percentage relation of indirect to direct taxation	74·0	66·4	47·2	60·7	56·7	59·5	51·2	53·7

4. The devolution of fortunes by gifts *inter vivos* instead of at death, bids fair to take a considerable corpus of "descending" wealth permanently out of the estate duty scheme.

5. The determination of "profits" as between two countries, where some of the trading operations are performed in the exporting and some in the importing country.

6. The establishment of customs tariffs which shall be fairly *ad valorem* without an unduly cumbrous and expensive administrative machine.

7. The reconciliation of "justice" in progressive taxation with social expediency and collective advantages in the accumulation of capital and preservation of incentive.

8. The choice of suitable articles of consumption for taxation which shall be wide enough to be productive of revenue and worth while, and which will not vanish through elasticity of demand or be repressive and regressive because they are necessary features in the poorest household budget.

9. At a time of very high expenditure the choice between finding objects of new taxation and putting fresh increments on successful existing taxes at a point at which those taxes are beginning to show their peculiar disadvantages to a marked degree. Akin to this is the super-imposition of various progressive types, which individually productive, eat into the yield of each other, *e.g.*, a combination of high income taxes, death duties, surtaxes and the Capital Levy (*q.v.*).

The Burden of Taxation.—In the last decade of the Victorian era a taxation budget in Great Britain in excess of £100 millions was regarded as the limit of prudent finance, with income tax at 8d. in the £. But the South African War, succeeded by social legislation, brought in clear view an annual budget of 200 million sterling, with an income tax of 1s. 3d. in the £, supertax and heavy death duties. In every budget debate it was asserted that the nation had reached the "limit of its taxpaying power," that it had "destroyed its war reserve," that it was "killing the goose that laid the golden eggs." Such jeremiads were uttered in the discussions of 1914 just before the World War. Every year of war enlarged the taxable horizon, and to-day the pre-war burdens, then so vast, seem trivial. There was much the same experience in other countries. To-day the annual payment in respect of the British debt to the United States alone requires a rate of income tax equal to the total for all purposes in pre-war times.[1] Of course taxation for the debt is the chief item in the post-war budget, equal in one case to nearly twice the total pre-war budget. In general, at a date sufficiently long after the close of the war for the position to have been consolidated, the debt situation can be even expressed as a percentage of 1913 and then as corrected by the 1921 wholesale price index number:—

	Debt in 1921 as percentage of pre-war debt 1913 = 100	"Corrected" debt in 1921 as percentage of debt in 1913 1913 = 100
Italy	+ 704·9	122·3
Belgium	+ 739·9	..
France	+ 919·0	266·2
United Kingdom	+1,079·8	596·6
Germany	+5,812·7	304·2

The proportions between local and central or national taxation vary greatly. Before the World War, say 1900, the United Kingdom had 119 millions sterling national, 56 millions local; France 3,100 million francs national and about 800 millions local; Germany 886 million marks imperial, 525 State and 800 communal; the United States, 505 million dollars Federal, 189 State, 706 local (total 1,400). In 1913–14, the figures were: United

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[1] For the Paris agreement of 1929 *see* Reparations. (Ed. E.B.)

Kingdom 163 millions national, $93\frac{3}{4}$ local; France 4,134 million francs national, 943 millions local; Germany 1,960 million marks Imperial, 1,140 State and 1,378 communal (total 4,478 millions); United States 661 million dollars Federal, 304 million State and 1,155 local (total 2,180). After the war (1924) United Kingdom 718 millions sterling national, 250 millions local; France 22 milliards national, $2\frac{1}{2}$ milliards local; Germany in 1922 before the complete currency collapse, 447 milliards Imperial and about 200 milliards local; United States 3,355 million dollars Federal, 4,475 State and local, total about 7,830. (*See* Seligman: *Studies in Public Finance 1925*, p. 34.) These figures serve to show the great changes that have taken place in the relative positions of local and central taxation.

International Comparisons.—It is notoriously difficult to make statistical comparisons of the taxation burdens in different countries, so great are the differences in fiscal practices, but the following represents a very broad attempt (based upon figures before the Royal Statistical Society):—

Country	Unit of currency	1924–25			1913
		National income	Total taxation	Percentage ratio	Percentage ratio
		(000,000's omitted)		%	%
England . .	£	3,850	852	22·1	11·4
France . .	Franc	170,000	30,293	17·8	13·8
Italy . . .	Lira	100,000	20,000	20·0	8·6
Switzerland .	Franc	5,000	750	15·0	6·9
Austria . .	Gold crown	5,000	872	17·3	16·9
Hungary . .	Gold crown	3,600 4,000	596	14–17	13–14

In France tax rates were subsequently increased and the percentage ratio brought nearer to the English. In Germany the estimate of national incomes was not very reliable, but the figure has been reckoned at 20 per cent. The yield of the taxes levied by the Great Powers in Europe thus represents about one-fifth of their national income.

In the United States the ratio between taxation and national income has recently been calculated at 10·5%, which is less than the pre-war charge in England, France, Austria and Hungary. There is probably no country in Europe in which the taxation is at present as low as in the United States.

But the computations of a more experienced American writer, Professor Seligman, are rather different. He reaches the following results, as the ratio of taxation to income *per capita:*—

	1900–01	1913–14	1918–19	1924–25
United States . .	7·76	6·68	10·03	11·06
United Kingdom .	9·99	11·29	23·93	24·77
France . . .	14·96	14·11	12·44	20·01
Germany . . .	7·99	10·51	17·42	29·21

"The far higher taxation in France carried through in 1925 and the gradual reduction in Great Britain" are reversing the relative positions of the two countries, and it is possible that in the near future "the most severe tax burdens in Europe will be suffered almost equally by France and Germany. . . ." (*Studies in Public Finance 1925*, I. Corporation Tax Burdens, p. 43.)

The European Burden.—Why is it that taxation in Europe amounts to such a large proportion of the national income? The reason is twofold: (a) State expenditure is still high; (b) the national income has not yet reached the pre-war level. "If we analyse expenditure, we find that in most countries debt service has risen enormously, and that certain terminal charges, such as war pensions and reconstruction outlay weigh heavily on the budgets; but that, on the other hand, appropriations for civil administrations and defence on the basis of pre-war prices are generally lower than in 1913." (Per Jacobsson in *Europa Year Book 1926.*) The Colwyn Committee on Taxation reported—that in reference to the post-war period up to the end of the last completed tax year, it could be said definitely that the burden of taxation was heavier in Great Britain than in any other European country, and very much heavier than in the United States.

It is small wonder, therefore, that taxation has come to be a dominant factor in economic life, although its importance in actually altering the standard of life, and reducing production and initiative can easily be exaggerated. The Colwyn Committee on Taxation reported that the burden of indirect taxation appeared formidable when viewed as a whole, but on analysis, it was found that the duties on food were now light except for the sugar duty, which they considered relatively high. The high level of the duties on luxuries appeared to be justifiable at present, considering the large amount of revenue required, and the risk of interfering too much with savings, if heavier direct taxation were adopted.

"The burden of direct taxation, while we do not wish to belittle it, is less crushing than is frequently represented. It does not, with trivial exceptions, enter directly into prices, and its indirect effects are not such as substantially to affect the general price-level." It has a materially adverse influence on capital accumulation, but this does not hold good, so far as the receipts are applied to payments on account of the internal debt. Again, it has widely diffused psychological effects, and has been responsible for a good deal of discouragement, while trade has been suffering from long-drawn-out depression due to wider causes; on the other hand, some of the psychological effects have been actually beneficial. The Colwyn Committee said that present taxation—even in conjunction with the loss of material wealth due to war expenditure, which lies behind the national debt—was not one of the main causes of industrial difficulty. (J. S.)

For details of the taxation systems of different countries *see* the articles under GREAT BRITAIN, UNITED STATES, FRANCE, GERMANY, etc.

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TAXATION, LOCAL. (The following article deals with the levying of taxes by authorities other than the central national authority.)

LOCAL TAXATION IN ENGLAND AND WALES

The principal function of the local authorities of England and Wales—these authorities comprise county councils, town councils, urban district councils, rural district councils, parish councils, and other bodies—is to provide and maintain the services which the State (*i.e.*, the Central Government), without whose consent they cannot undertake any function, has either directed or authorized them to provide and maintain. The collection of money to pay for those services is ancillary to this principal function. The money so collected is, so far as it is collected by the State and contributed by it to local authorities, sometimes described as "national taxation applied to local purposes" or (less contentiously) as "national taxation applied in meeting part of the cost of services administered by local authorities." The whole of the money collected by local authorities themselves to pay for these services is sometimes described as being (or being obtained from) "local taxation"; more frequently the expression "local taxation" is applied only to that part of the money which is collected by local authorities, for public local purposes, by means of local rates; and it has been contended that whenever a local rate is described as "taxation" there should be some cautionary note to the effect that a local rate combines in varying degrees the elements of (i.) a compulsory payment for a service or services indispensable to the individual ratepayer and unobtainable by him, by his own effort, at a smaller price than is paid by him in the local rate, and (ii.) a compulsory payment for a service or services not indispensable to the individual ratepayer or obtainable by him, by his own effort, at a smaller price.

General Scheme of Local Finance.—The general scheme of local finance contemplates that the current expenditure of each financial year (including, in addition to the maintenance of the several services, interest on and provision for the repayment of money borrowed on capital account) shall be met out of revenue.

The number of local authorities in England and Wales having financial transactions is about 11,000. A list of the principal services maintained by them is given in column 1 of the following table (Table A). Column 2 shows (in thousands of £'s), as illustrating the relative importance of the several services from the point of view of local finance, the amount spent out of current revenue by the local authorities on each of those services in a recent year (1925–6). Columns 3, 4 and 5 indicate how large a proportion of that expenditure was met from sources not being State contributions or local rates, from State contributions, and from local rates.

Table A

Services maintained by local authorities	Current expenditure of local authorities on each service	Specific income (other than from local rates) of local authorities in respect of each service		Balance of current expenditure falling (for the most part) to be met out of local rates
		Fees, tolls, dues, rents and other receipts not being contributions from the state	Contributions from the State	
1	2	3	4	5
	Amounts (*in thousands of £'s*) for year 1925–26			
Group I.—*Services which are, for the most part, maintained without recourse to local rates or state contributions:*				
Water supply	17,017	15,818*	84	1,115†
Gas supply	16,683	16,749	23	*Cr.* 89†
Electricity supply	20,394	21,461	64	*Cr.* 1,131†
Tramways, light railways and omnibuses	23,657	23,511	67	79†
Harbours, docks, piers, canals and quays	14,160	14,209	22	*Cr.* 71†
Sundry minor trading services and corporation (general) estates	5,128	5,857	23	*Cr.* 752†
Private street works and other works of private improvement	2,111	2,103	..	8†
Totals for services in Group I.	*99,150*	*99,708*	*283*	*Cr.* *841*†
Group II.—*Services maintained by local authorities with the help of large contributions from the state:*				
Education Elementary	59,631	920	32,514	26,197
Education Higher	15,876	2,632	6,532	6,712
Hospitals, sanatoria, dispensaries, etc.:				
For tuberculosis	2,996	136	1,656	1,204
For venereal diseases	401	8	290	103
Maternity and child welfare	1,852	359	705	788
Port sanitary service	93	5	37	51
Mental deficiency	1,033	104	459	470
Housing:				
State-aided housing schemes	18,311	8,837	7,868	1,606
Other housing schemes	1,485	1,272	2	211
Small dwellings acquisition	1,424	1,585	..	*Cr.* 161
Highways and bridges (including scavenging but excluding lighting)‡	48,786	2,648	13,988	32,150
Police and police stations	20,039	879	9,586	9,574
Registration of electors	821	14	411	396
Small holdings and allotments	2,423	1,425	996	2
Totals for services in Group II.	*175,171*	*20,824*	*75,044*	*79,303*
Group III.—*Services which are, for the most part, maintained out of local rates:*				
Relief of the poor (excluding maintenance of lunatics in county and borough asylums)¶	34,627	1,740	1,210	31,677
Lunatics in lunatic asylums	8,318	1,760	1,074	5,484
Medical officers of health, sanitary inspectors and health visitors	1,304	3	409	892
Sewers and sewage disposal	9,037	883	368	7,786
Collection and disposal of house refuse	6,765	476	23	6,266
Hospitals for fever, diphtheria, small-pox and certain other diseases	3,270	208	5	3,057
Public baths and wash-houses	1,738	842	14	882
Public parks and open spaces	4,388	1,154	179	3,055
Certain minor health services	2,274	493	16	1,765
Administration of justice	1,314	631	25	658
Public lighting (lighting streets, etc.)	3,895	50	3	3,842
Fire brigades (engines, etc.)	2,078	244	12	1,822
Public libraries and museums	1,710	252	6	1,452
Land drainage and embankment and river conservancy	970	275	67	628
Sundry minor services	4,151	2,992	212	947
Totals for services in Group III	*85,839*	*12,003*	*3,623*	*70,213*
Group IV.—*Sundry items appertaining to services mentioned above but not apportioned between them.*	12,950	6,383§	5,733§	834
Total current expenditure and current receipts of the local authorities of England and Wales (year 1925–26)	373,110	138,918 223,601	84,683	149,509

*Including sums levied, as water rates and otherwise, exclusively on consumers of water, for water supplied to them.

†These balances have been arrived at by setting gains in some localities against losses in others.

‡Includes alike the trunk roads between great cities, streets and minor roads in and between villages.

¶Includes destitute poor of many kinds, *e.g.*, those suffering from sickness, accident or infirmity, and their dependents, as well as those in receipt of relief by reason of unemployment or under-employment.

§These unapportioned receipts were not applicable wholly or mainly to the sundry overhead charges, amounting to £12,950,000, entered in column 2 but were applicable generally in aid of expenditure on services mentioned in column 1.

The table shows *inter alia* that, contrary to a widely-held popular belief, the current income of local authorities from local rates is much smaller than their current income from other sources.

Current Income Other Than from Rates and Government Grants.—There is (as already indicated) some difference of opinion as to whether the receipts—or some of the receipts—of local authorities from fees, tolls, dues, rents and other sources not being either rates for public local purposes or contributions from the State, should or should not be deemed to be derived from "taxation." Broadly stated, public opinion seems at the present time to regard them as being essentially of the nature of receipts for services rendered or commodities sold to individuals *qua* individuals and not as essentially of the nature of taxation. Support for this opinion may be found in the fact that analogous receipts by the Post Office and by public utility companies from individuals for services rendered to them are not generally regarded as in the nature of "taxation."

Government Grants to Local Authorities.—The system of giving Government grants to local authorities originated in the years 1833–35. In the form in which it developed during the period up to 1888, it was a system of grants attached to specified items of expenditure, and the grants, while in terms described as in relief of local rates, in fact so operated as to stimulate expenditure on those items and to involve Parliament and the Government departments in the supervision in detail of some parts of the work of local authorities. This system, except so far as it related to elementary and industrial schools (most of which were at that time in the hands of voluntary bodies), was swept away by the reforms embodied in the Local Government Act of 1888, and, in lieu of it, there was set up a system whereby Parliament "assigned" to the county and county borough councils established by that act the revenues arising from certain national taxes and, at the same time, required those councils (in effect) to make payments to themselves and other local authorities in substitution for the discontinued grants. The assigned revenues were made distributable to the councils through a special account, called "the local taxation account," on bases which were so designed as not to stimulate local expenditure. The yield of the assigned revenues was at the outset greater than the amount of the discontinued grants and there was an expectation that it would so develop as to keep pace with the normal growth in local expenditure. In fact, the exigencies of national finance soon arrested the development of the assigned revenues system; annuities of fixed amount were substituted for most of the assigned revenues; periodical revisions which had been contemplated by the authors of the system did not take place; and the system, although still (1928) maintained in form, is regarded as having become obsolescent. It now exists side by side with a great variety of *ad hoc* Government grants which reproduce many of the features of the pre-1888 system. Indeed, the number of these grants is so great and the conditions subject to which they are given are so various that it is impracticable to do more than briefly indicate the main facts.

The growth in the amount of Government grants relatively to the growth of the amount of local rates is shown in Table B.

TABLE B

Year	Government grants to local authorities	Amount of local rates in respect of all services—grant-aided and other	Total rates and grants	Proportion of such total received from grants
	Amounts, in thousands of £'s			%
1867–8 .	878	16,504	17,382	5·1
1885–6 .	3,659	26,143	29,802	12·3
1905–6 .	19,870	58,256	78,126	25·4
1925–6 .	84,684	148,598	233,282	36·3

Many factors have contributed to the increase in the percentage shown in the last column of this table. Among them may be mentioned: the imposition by the State of new duties (*e.g.*, education, housing) upon the local authorities; the insistence by the State upon the attainment of a higher standard of local administration than is deemed to be attainable without the giving of State assistance; the substitution, under the Agricultural Rates Acts, 1896 and 1923, of Government grants for proportions of the rates formerly payable by the occupiers of agricultural land; the progressive development of means of communication between the several localities, accompanied by the growth of a public opinion that certain services, formerly deemed to be predominantly of local interest, have become predominantly of national interest; and the prevalence of the doctrine that, at least in the case of the cost of such predominantly national services, the incidence of national taxation is, as between persons of equal income resident in different localities, more equitable than the incidence of local rates.

It will be seen on reference to Table A that the amount of the Government grants in aid of the cost of the services constituting Group II. in that table was not far short of the expenditure falling to be met out of rates in respect of that group.

At the present time (1928) the proportion of the Government grants to local authorities which is distributable through the local taxation account has fallen to less than one-sixth of the whole amount of those grants. Upwards of five-sixths of that amount has been made by Parliament distributable either (i.) on the basis that (subject to certain safeguards) the grant to a local authority in respect of a service shall be some prescribed proportion (or part) of the expenditure by the local authority on the service, or (ii.) on some other basis which makes an increase in the amount of the grant depend directly or indirectly upon an increase in the expenditure on the service by the local authority. This system, it is said, inflicts hardship upon the localities not able to afford increases of expenditure and is over-generous to and stimulates expenditure in localities well able to afford such increases. Moreover, like the pre-1888 grant system, it involves Parliament and the Government departments to an increasing and undesired extent in the supervision in detail of some parts of the work of local authorities.

Rates for Public Local Purposes.—For the purposes of local rates for public local purposes, England and Wales have been divided by Parliament into rating areas, each of which is rated separately for the cost of the services administered therein by local authorities, so far as that cost is not met out of the receipts from fees, tolls, dues, rents, etc., and the Government grants already mentioned. The expression "local rates for public local purposes" includes all rates levied by local authorities, except (i) certain land-drainage rates and unusual rates—amounting in all to less than ½% of the total amount so levied—and (ii.) water rates levied only on consumers of water in respect of water supplied to them; and in the following part of this article the word "rates" must be read as meaning "local rates for public local purposes" unless the context otherwise requires.

The number of rating areas is (in 1928) 1,804. This total comprises 29 metropolitan boroughs (including the cities of London and Westminster), 83 county boroughs (including cities such as Birmingham, Liverpool and Manchester), 255 municipal boroughs not being county boroughs, 783 other urban districts, and 654 rural districts. In each of these rating areas the council of the borough or district—a popularly elected body—is the rating authority, charged, to the exclusion of every other body, with the statutory duty of making and levying rates of sufficient amount to meet not only its own expenses, so far as they are payable out of rates, but such part of the expenses of every other local authority exercising jurisdiction within the area as may be payable out of the rates of the area.

Rates are leviable on persons and not on property; but they are leviable only on persons occupying lands or buildings within the area rated or owning tithe rentcharge charged on such lands and buildings or enjoying rights of sporting or fishing in connection therewith. The short description of such persons is "the ratepayers," and the short description of such lands and buildings is "rateable hereditaments" or, more simply, "hereditaments."

In order that the total amount of the rate levied by the rating authority may be fairly apportioned among and assessed upon the several ratepayers in the rating area, Parliament has imposed upon the rating authority the duty of preparing periodically a statement, called a "valuation list," in which each rateable hereditament in the rating area is shortly described, a "rateable value" is assigned to it, and the name of its occupier stated.

It is the duty, enforceable by penalty, of every occupier (and, in certain cases, of every owner or lessee) to assist the rating authority by furnishing such particulars relating to the hereditament as may be reasonably required for the purpose of ascertaining its rateable value. With the help of such particulars, and in the light of their own local knowledge and experience, supplemented, if need be, by paid professional advice, the rating authority decide the rateable value to be assigned to the hereditament. The entries made by the rating authority in the list are liable to revision by a separate authority called the assessment committee, which must, subject to certain conditions, hear any person or body aggrieved by any entry in or omission from the list. There is, also subject to conditions, a right of appeal from the assessment committee to the local Court of Quarter Sessions and, ultimately, on points of law, to the Superior Courts. In certain cases, matters in dispute may be dealt with by arbitration. The task of promoting by conference, and otherwise, uniformity of valuation throughout the several rating and assessment areas in each administrative county is entrusted to a county valuation committee representative of the various parts of the county.

The outline of the system of valuation for rating purposes given in the six preceding paragraphs relates, as from April 1, 1929 to the whole of England and Wales except London. In London an analogous but not identical system is in force.

The various kinds of rateable hereditaments are described in column 1 of the following table (Table C). Column 2 shows, according to a summary of estimates made by the rating authorities, the percentage of the total amount of rates levied in England and Wales in the year 1927–8 which was levied upon the ratepayers in respect of each of those kinds of property:

TABLE C

(Column 1) Properties in respect of which rates were levied on ratepayers	(Column 2) Percentage of total amount of rates levied (1927–28) in respect of each class of property	
Agricultural land		2·4
Mines and quarries	2·0	
Steel and iron works; Blast-furnace works; Smelting works	1·0	
Ship-building or ship-repairing works	0·3	
Mills and manufactories; Chemical works; Dyeing and Cleaning works (including laundries); and Workshops separately assessed and not elsewhere included	7·8	
Breweries and distilleries	0·3	
Land used as a canal or towpath for a canal; and Land covered with water other than reservoirs of waterworks	0·4	
Railways (including stations and appurtenances)	3·9	
Harbours, docks, piers, quays and wharves (except land covered with water included above)	0·6	16·3
Gas undertakings	1·4	
Electricity undertakings	1·4	
Waterworks	1·5	
Tramway undertakings	0·5	
Cemeteries and other burial grounds	0·2	
Sewers and sewage works and sewage farms	0·2	
Warehouses separately assessed	2·2	
Licensed houses (for the sale of beer, wine, spirits, etc.)	2·6	
Tithes and tithe rentcharges	0·7	
Land (not elsewhere included) separately assessed, including woodlands, parks, sports' grounds and rights of sporting	0·5	
Dwelling-houses, shops, offices, and all other classes of rateable property not mentioned above	70·1	81·3
Total (all classes)		100·0

When a rating authority has decided upon the amount to be raised by a rate, it brings that amount into comparison with the total rateable value of all the hereditaments in the rating area and, by means of this comparison (after appropriate adjustments, *e.g.*, in respect of amounts which cannot in fact be collected), estimates the amount which a rate of one penny per pound of the total rateable value of those hereditaments will produce. The total amount to be levied by means of the rate is then divided by the estimated produce of the penny rate, giving, as the quotient, the amount per pound of rateable value of the rate. The rateable value of a hereditament multiplied by this amount per pound (commonly called "the rate in the £") gives the amount payable by the ratepayer. That amount is in due form demanded, usually for a rating period of six months, from him by the rating authority, and thereupon becomes payable by him. In order to reduce the cost of collecting the rates, owners of property may in certain cases be required by the rating authority to pay to it rates otherwise payable by their tenants.

The average amount, per pound of the annual assessable value of all the rateable property in England and Wales, of all the rates collected therein, varied between 11s. 8¾d. and 12s. 10¾d. a year in the period of five years from 1923–4 to 1927–8. These amounts in the £ are equivalent to £3 13s. 3d. and £4 5s. respectively per head of the population of the country. The variation in the several localities from these national averages is very great. Thus, in 1927–8, the extreme range in the urban rating areas was from 7s. 6d. in the £ in a seaside pleasure resort to 34s. 4d. in the £ in a coal-mining area. In rural rating areas the range was similar but on a somewhat lower level.

The congeries of systems, outlined in the preceding paragraphs, which together constitute the local taxation system of England and Wales, have been evolved in the course of centuries; the several parts of the system, and the system as a whole, are the outcome of many local customs, experiments, adjustments, conflicts and compromises—all ultimately expressed in general or local acts of Parliament or in votes of Parliament providing for grants from national taxation.

Abatements from Net Annual Value.—The causes which resulted in occupiers of lands and buildings (and not the owners thereof) being assessed to local rates and to the adoption of the net annual value of property occupied as the basis or standard of assessment, to the exclusion of any other basis, are stated in Professor Cannan's *History of Local Rates.* That basis has, however, been modified from time to time in cases where, by reference to the two canons of (i.) the ability of the ratepayer to pay and (ii.) the benefit derived by him from rate expenditure, the strict application of the basis of net annual value seemed likely to lead or had led to injustice. Thus, for the purposes of the Lighting and Watching Act of 1833—an Act which enabled parish authorities to undertake the lighting of streets and the provision of fire engines—it was deemed unjust to rate the occupiers of agricultural land on the same basis as the occupiers of dwelling-houses, and therefore Parliament (in effect) provided that, while the last mentioned occupiers should pay in proportion to the whole of the net annual value of the dwelling-houses, occupiers of agricultural land should pay in proportion to one-third (now one-quarter) only of the net annual value thereof. A similar plan was adopted in the case of the Public Health Act of 1848 (and is now embodied in the Public Health Act of 1875) under which, while the occupiers of dwelling-houses and similar properties contribute to rates for sanitary expenses in proportion to the whole of the net annual value of the property in their occupation, certain occupiers (*e.g.*, occupiers of agricultural land and land used as a railway or canal), who are deemed to derive but little advantage from sanitary expenditure, contribute (in effect) to that expenditure in proportion to one-quarter only of the net annual value of the land. The same plan was applied to certain rates (*e.g.*, rates for the relief of the poor, education and rural highways) in the Agricultural Rates Acts of 1896 and 1923 and the Rating and Valuation Act of 1925, with the result that occupiers of agricultural land have been liable to contribute, in respect of that land, to those rates in proportion to one-quarter only of the net annual value of the land.

The abatements made under the above-mentioned Acts of 1896 and 1923 were in respect of long-established rates, and consequently, if those abatements had stood alone, they could not have been made without increasing immediately the amount of rates payable by other classes of ratepayers; and with a view of mitigating (in 1896) or avoiding (in 1923) such an increase, grants in respect of the abatements were made from national taxation.

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The Rating and Valuation (Apportionment) Act, 1928, and the Local Government Act, 1929, provided for a very great extension, as from Oct. 1, 1929, of this system of abatements. Occupiers of agricultural land and agricultural buildings (not being dwelling-houses) are wholly exempted, in respect of such land and buildings, from all rates for public local purposes, and occupiers of industrial and freight-transport hereditaments, in respect of the parts of those hereditaments which are occupied and used for industrial and freight-transport (railway undertakings, light railways, canals and docks dealing with merchandise) purposes, contribute to local rates in proportion (generally) to one-quarter only of the net annual value thereof. The necessary provision for the "derating" measure was made in the Finance Act of 1928. These provisions are bound up with provisions for a reform of part of the existing system of Government grants (including the abolition of the Local Taxation Account) and for a great increase in the amount of those grants with the transfer to councils of counties and county boroughs of the functions at present exercised by Poor Law authorities, and with various reforms in the machinery of local government.

The provisions of the Local Government Act and the basis on which the new government grants to local authorities are calculated are explained *s.v.*, LOCAL GOVERNMENT.

BIBLIOGRAPHY.—The question of the real incidence of local rates as distinguished from the primary or apparent incidence was in 1897 referred to financial and economic experts by the Royal Commission on Local Taxation, which was then sitting. The replies were published in *Parliamentary Paper* [*C-9,528*] in 1899. That volume includes at page 55 a bibliography for the period 1833–97.

Professor Cannan's *History of Local Rates in England in relation to the proper distribution of the burden of taxation* (1927) shows *inter alia* how local rates came to be assessed on occupiers of lands and buildings to the exclusion of the owners thereof and how the basis or standard of assessment came to be the annual value of lands and buildings to the exclusion of income from other sources.

Grice's *National and Local Finance in England, France, Belgium and Prussia* (1910) traces *inter alia* the growth of systems of Government grants in aid of the cost of services administered by Local Authorities. It should be read in connection with the *Final Report of the Departmental Committee on Local Taxation in England and Wales* [*Cd. 7,315*], which was issued in 1914, and with the *Statement* (prepared by H.M. Treasury) *of Government grants to Local Authorities in Great Britain, showing as far as possible the purposes for which they are paid and the bases of distribution in each case* [*Cmd. 3,157*], which was issued in 1928.

The above-mentioned Report of 1914 deals *inter alia* with proposals to replace the rating system in whole or in part by a rate on land (or site) values, or by a local income tax, or by other revenue.

The Annual Local Taxation Returns (*England and Wales*), published (like all the official statements mentioned herein) by H.M. Stationery Office, exhibit in detail the working of the local taxation system. The Returns for each year are summarised in the Annual Report of the Ministry of Health and are summarized for a series of years (generally 1913–14 and each of the latest 14 years) in each issue of the Annual Statistical Abstract of the United Kingdom. That Ministry also prepares an annual publication showing the rates in the £ levied in each urban area and in certain typical rural areas.

A Stationery Office paper, *Rates levied by Local Authorities* (*England & Wales*) shows for 1927–28, the amount of rates levied in respect of each of the principal classes of rateable property in each rating area.

See also *Ryde on Rating* (Butterworth & Co.) and supplements.

(X.)

LOCAL TAXATION IN OTHER COUNTRIES

Some knowledge of the local government system of a country is obviously essential to the understanding of its method of local taxation. This is not the place for an attempt to explain, however briefly, local government systems, but it does seem necessary to allude to one or two characteristics which have a bearing upon the local taxation and in which the systems of other countries differ essentially from that of Great Britain.

Europe.—The primary area of local government on the continent of Europe may be most conveniently described by the French word "commune." Almost invariably, the whole area of a country is divided into communes and these, whether urban or rural, whether large or small, have usually the same status and the same powers and duties. The only exception to this rule is that, in Germany and some other countries, certain of the larger towns are made independent of any other local authority, as is the English county borough of the county. The secondary area of local government, answering to the English county, is known as a "department" in France, as a "circle" in Germany, as a "province" in Belgium, Holland, Italy and Spain, and by various titles in other countries. It has usually a more organic connection with the commune than has the English county with the minor authorities; is more generally entrusted with control over these latter, especially in finance; and is looked upon rather as an agglomeration of communes for the wider purposes of administration than as having a separate existence of its own.

These two types of areas have each their elected local authorities with powers of local self-government, but side by side with these is to be found, almost invariably, a system of State local government, which may be carried on either by a completely distinct set of authorities or by employing officials of the local authority also as agents of the State. By this means the administration of the police is almost always completely withdrawn from the sphere of local self-government, the term "police" frequently signifying, not merely "security police" but the making and enforcing of any regulations (such as public health or building by-laws) whose infraction involves penal procedure. Moreover, in the more completely centralized countries other matters than police are regulated locally by the central Government or its agents—as for instance, education in France, where, although local taxation is called upon to contribute to a certain extent to the expense, the whole cost of the salaries of teachers is borne by the central Government and does not appear in the local budgets.

It follows from this that it is seldom possible to draw the same hard and fast line on the continent, as in England, between the purposes or the objects of national and local taxation; and that the whole conception of local taxation is different. It is, indeed, held in some quarters that a system of local finance should, as far as possible, include all kinds of impositions which are found in the State system and be, in effect, a reduced reproduction of that system, in order that all taxpayers and all revenues may be called upon to contribute to the local charges. In no country is this principle fully carried out, but there is almost everywhere a very close connection between the respective local and national systems. This is especially the case in Germany since the World War. The various States of the German Confederation (or "Reich") have each the power to organize their own system of local government and finance, subject, however, to certain general rules laid down in the national constitution and by subsequent national legislation. The general effect of these rules is that, in the hierarchy of Reich, States, provinces, circles and communes, the higher authority has the prior right to any sources of public revenue and the communes have to do the best they can with what remains to them after the superior authorities have made provision for their needs.

The principal basis of the local taxation systems of the countries of the continent of Europe is to be found in the addition, to certain of the national taxes, of so many hundredths for local purposes ("additional centimes"), the whole of the tax being collected by the national authority and the produce of the "additional centimes" being paid over to the respective local authorities. Thus, the demand note in respect of the land tax in France shows, in a specific instance, that 48% is what is called the "principal" (*i.e.*, the amount levied for national purposes), that 40% consists of "additional centimes" for the purposes of the department (which corresponds to the English county) and 12% for the purposes of the commune, which is the minor local authority.

The number of centimes which may be added to any specific national tax by each type of local authority is definitely regulated by law—sometimes, as in France, by the annual finance act, sometimes for a period of years or until fresh regulations are laid down. The French national taxes to which centimes may be added for municipal purposes are the four "direct contributions" ("direct" taxes in the continental sense meaning taxes which are levied upon a person in consequence of his name being inscribed on a cadastre or register), viz., the land tax, the land and buildings tax, the tax on the rentals of houses and apartments, and the licence tax on trades and professions. In Germany, before the World War, the addition of centimes to the income tax was the main source of revenue to the communes. This is no longer permitted, the total yield from the income tax being now taken by the Reich, which refunds a certain proportion to the States and communes. The communes are still allowed to add percentages to the State taxes on land and buildings and on professions, in which the Reich has no part. In most of the other countries of Europe the same system is to be found to a greater or less extent.

In all European countries, the communes, whether or not they may add centimes to the national taxes, are given the power to levy certain taxes on their own account. Local taxes on land and buildings are very usual. So, too, is a dog or an entertainment tax. Other instances of local taxes are—in Belgium, on visitors, street façades, construction or reconstruction of buildings, sale of liquor and tobacco; in France, on dwellings and offices, horses, carriages and motor-cars, sports grounds, domestic servants, pianos and organs, billiard tables, clubs; in Germany, on unearned increment, acquisition of land, musical instruments, sale of beer; in Switzerland, by way of bicycle, motor, hunting and fishing licences; in Czechoslovakia, on house rents, lodgers, vacant land, advertisements. In Estonia there are no less than 30 heads of taxation which are open to the local authorities, and in Hungary the towns may levy taxes on any object which is not taxed by the State. In Spain, in addition to a number of local taxes of various kinds, a municipality may levy a general tax on every resident based on his financial condition. In spite, however, of the variety of local taxes of a miscellaneous character, their yield is everywhere a small proportion of the total revenue of the local authorities.

The levy of a local income tax is of greater importance and deserves special mention. The countries in which such a tax (independent of any national tax) forms one of the chief sources of revenue are Denmark, Finland, Holland, Norway, Sweden, and some of the cantons of Switzerland. In Holland, in 1924, there were only five communes which levied no kind of income tax for local purposes. In that year 60 communes added percentages to the national income tax, 85 levied a local non-progressive income tax, 309 levied a similar tax as well as adding percentages to the national tax, and 625 levied a local progressive income tax. The assessment of each taxpayer, in Holland, to the local income tax (if any) is fixed by State officials at the same time as that to the national income tax, and the tax is collected by State officials and paid over to the communes on a certificate by the minister of finance. Power can, however, be given by royal decree to a commune, for a period of not more than five years, to deal with the local income tax through its own officials. It has already been mentioned that the power which the German communes formerly possessed of levying a local income tax by means of additions to the national tax has been taken from them. The system was, however, so complete until the changes made subsequently to the World War that reference should be made to it.

Formerly the "octroi"—local customs duty on articles of consumption—was one of the main sources of revenue to the municipalities on the Continent, but it has now been abolished in the majority of countries and is of importance only in Italy and France. In the latter country, an act of 1897 encouraged the communes to suppress their octrois by opening out to them other methods of local taxation, and later acts have pursued the same policy. As a consequence many French towns have abolished the octroi altogether, while others have contented themselves with reducing the rate of duty or the number of articles subject to it. The total number of octrois in France, which was 1,552 in 1913, was reduced to 1,100 by Jan. 1, 1926, and continues to diminish. Apart from the addition of centimes to national taxes and the direct imposition of local taxes, such charges as those on frontagers for street cleaning or on occupiers of houses for the removal of refuse are often found reckoned as items of local taxation.

In many countries the system of assigned revenues, in conjunction with that of local taxation, is in force and in Germany in particular, since the war, this system has been largely extended. Government grants, also, are frequently given for specific purposes. It may further be mentioned that local taxation is, on the Continent much more than in England, relieved by the income arising from municipal landed property, especially forests, and that in some countries the profits from the municipal supply of gas or electricity and from other municipal undertakings, such as tramways, slaughter-houses, markets, funerals or quarries, add substantially to the local revenue. The larger (county or provincial) authorities, as a rule, obtain their funds by percentage additions to certain specified national taxes and by the method of assigned revenues. They may also, sometimes, levy taxes themselves, but in this they are never given the same scope as the communes. Thus, in Belgium, taxes on dogs and bicycles are levied by almost all the provinces, and on motor-cars and persons employed in industries by several. In Spain is to be found the exceptional system of the provinces making additions, for their own purposes, to municipal taxes. In some countries the method of obtaining provincial revenue is by precepts on the communes.

Whereas the local authorities in continental countries possess a greater variety of sources of revenue than in England, they are, generally speaking, much more restricted as to the amount of revenue which they may raise by taxation and that not only by definite statutory provisions as to the number of centimes which may be added or the subjects of local taxation. In many continental countries the annual estimates of every local authority require the approval of a higher authority and, even where this is not the case, the levy of a new tax will almost always require such approval. In Denmark approval is required only when the local taxation exceeds a certain amount; in Sweden and in several of the Swiss cantons control of this description is little more than formal, and in Estonia and Finland the local authorities possess almost entire freedom within the limits of the law. On the other hand, both in France and Germany, and in the countries which closely follow either the French or the German model, the higher authorities in the hierarchy of government exercise a general control over the finances of the lower. This control may not, indeed, be limited to the refusal to sanction taxation proposals of the local authority. The system of *inscription d'office,* which is recognized in France, Holland, Poland, Hungary and some of the German States, enables the superior authority to insert in the communal budget items for obligatory functions, which may involve additional taxation.

In some countries a department or official of the central Government exercises this control directly over all local authorities; in others this applies only to the highest grade of local authority, which may itself control the lower. Thus, in France, the prefect, who is an official of the central Government, controls both the department (=county) to which he is appointed and every local authority within it. In Holland the annual budget of the communes requires the approval of the provincial executive, from which there is an appeal to the Crown. In Spain there is in each province a body representing the central Government, whose approval is required for the levying of all local taxes. In Czechoslovakia the provincial authority sanctions the levying by the communes of any of the taxes on the recognized list, but the permission of the Government is required for the levying of any others.

Valuation and assessment for land, buildings or income taxes are usually the concern of the national authorities. Indeed, a French writer (M. Roger Bonnard) postulates it as one of the essential conditions of local impositions that they must be such that their assessment and levy can be carried out by the State services, since the majority of the local authorities are not in a position to exercise these functions. On the other hand, the contrary system is to be found. Thus, in Denmark, an assessment committee is directly elected annually in each commune and in the towns assesses for national as well as local taxes. There is an appeal from this committee to a county liabilities council as regards assessments on real property. Although, as a rule, the final accounts as well as the estimates of each local authority must be submitted to a superior authority, there is nowhere to be found the same systematic Government audit which is carried on in England and Wales under the Ministry of Health.

British Overseas Dominions.—Local government and local taxation in the self-governing Dominions of the British Empire resemble the British system rather than the continental, but in one respect the method of local taxation differs from both, in that it is very generally based on the capital value of land. Thus, in Australia the main source of municipal revenue consists of rates levied on the unimproved capital value of land in New South Wales and Queensland, on the annual value of land in South and Western Australia and, in Victoria, on either the one or the other at the option of the local authority. It is to be observed, however, that in Western Australia the annual value of a property, for purposes of taxation, must be taken as not less than 4% of the capital value of improved or 5% of unimproved property, and in South Australia also there is a similar check on the annual value, which approximates it to a capital value tax.

The position is much the same in the other Dominions, the precise selection between annual or capital value of land and buildings, or land value alone, being a matter, primarily, for legislation by the various provinces, and secondarily for the decision of the local authorities themselves. In most of the provinces of Canada buildings are taxed as well as land, while personal property and businesses are also in some cases subject to local taxation. In Nova Scotia, Ontario and Saskatchewan municipalities may levy a local income tax, but this power has not been widely exercised. Market dues, dog taxes, liquor, trade and vehicle licences are available to the local authorities in the Dominions generally. Grants from the central Government do not play so large a part in the Dominions as in Great Britain, nor is central control exercised to any great extent, except as regards restrictions on the raising of loans. In British India provincial rates are levied on the annual value of land, while the principal sources of municipal revenue are octroi, taxes on houses and lands, animals, vehicles, professions and trades, tolls on roads and ferries, and water, lighting and conservancy rates.

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(G. M. H.)

LOCAL TAXATION IN THE UNITED STATES

State and local taxation in the United States varies greatly from State to State, and there are practically as many systems as there are States and territories. The State Constitutions provide the outline of the system. The States control by general laws all taxes levied by their political subdivisions, the counties, cities, towns, school and other districts; the State and local taxes may be therefore explained together.

The general property tax is the chief source of State and local revenue in the United States. It is used in every State and Territory. In all but a few States it affords revenue for the State and for all of its political subdivisions as well. In a few States the State Governments draw little or no revenues from this source depending on other taxes which are, however, sometimes only modified forms of the property tax. This tax has an unbroken historical existence from the earliest colonial days down to the present. It began when the people in the towns of New England or in the counties of Virginia and other southern colonies were confronted with the necessity of raising money for some common purpose such as the building of roads and bridges, or later the support of schools. The original idea was that each resident should contribute to the common fund in proportion to his ability. In measuring ability the simplest of rules were followed. Thus the assessors, officers appointed to apportion the taxes, counted up or "listed" the number of acres of land owned, as so many acres of arable land, so many of pasture, woodland and swamp, the number of cattle and houses, and "listed" also all other property such as houses, barns, furniture, etc. Since, obviously, one cannot add together such items as 20 ac. of land and five horses without some common denominator, values in money were attached to the "list." At first these values were quite arbitrary, but as time went on an effort was made to make the assessed or "listed" values correspond to the selling or market values of the property. People who earned a living from trades or professions were often "listed" or "rated" at arbitrary sums for their "faculty" or ability to pay, based on some rough estimate of their earnings. Sometimes heads or polls were similarly listed as property at an arbitrary value of, say, $100, the resulting tax being, perhaps $1.00.

As the tax developed it became, during the first part of the 19th century, a personal tax, the amount of which was to be determined in each case by the taxpayer's "estate," that is, in proportion to everything he possessed. But as time passed and the forms of ownership became complicated, as, for example, mortgages owned by one person, secured by another person's property, or stocks, bonds and contracts of many sorts, the tax became less and less personal. The present fundamental idea is that the tax is levied upon ownable things, rather than on the owners thereof. But traces of the old idea are still to be found. The result is that the tax, especially as used by the local governments, is primarily a tax on tangible property. That means that it is a tax on all real estate within the taxing jurisdiction and on such tangible personal property, as furniture, stocks of goods and merchandise, as can easily be found. In many States intangible personal property, such as money due to a person, stocks, bonds and the like, is taxable according to the letter of the law either as all other property is taxed or at lower rates. But inasmuch as such property, in practically all cases, merely stands for and represents other property which is fully taxed, its owners resist every attempt to assess it, and since it is intangible and hence easily concealed, very little is ordinarily placed upon the rolls.

Since probably 85% of this tax is on real estate and physical property of a similar visible sort, a description of the tax as applied to this class of property will be given. Each State is divided into assessment districts. In New England, originally, the township was the district, in Virginia it was the county, and in cities it was the old "ward." The nature and size of the assessment district is a matter determined by the framework of government and hence varies from State to State. In each district there is an assessor, or sometimes a board of assessment. Where the districts are small, as a single township, or a ward in a city, the assessor can complete the list or roll in a few weeks. But the work, to-day, requires considerable judgment and discretion and is best done when the district is large enough to warrant the employment of a full time assessor with a staff of trained deputies.

The Assessor's Work.—In a typically, fully equipped, large assessment district, this consists, first, in the preparation of a set of maps, or, in cities, of block books, showing each piece of real estate. The next step is to ascertain, from sales, and other sources, the fair market value of the property and by comparison of adjacent or otherwise similar properties to fix uniform or equal valuations. These valuations are then entered in the general assessment roll opposite a description of each piece of real estate or other property and each owner's name is noted. In most States every property owner is required to file a statement or declaration of his property. These declarations are not very important so far as the real estate is concerned for that is all on record in the assessor's office. But they serve, when checked by inquiry made by the assessor's field deputies, to give information as to the personal property.

The assessment roll, sometimes called the assessment list, or the assessment book, in which the taxed properties are entered at the values fixed by the assessor, is a formidable public document of many pages and often in many volumes, and when completed serves as the warrant for the collection of the taxes, and finally as a record of taxes paid. The roll is written anew each year and the entries are always revised for changes in ownership, new buildings, changes in personal property and the like, and, as often as may be necessary, is completely revised as to the land values. It is customary to assess all property for much less than its full market value, although in almost every State the words of the law direct the use of full value.

Review or "equalization" of the roll after the assessor has completed his work consists, in the main, in allowing taxpayers who feel that their property is too heavily assessed to have a hearing before some board, usually the county governing board or the city fathers, called a board of review or of equalization. After this review the roll passes to the auditor who extends the taxes, showing how much each person is to pay and then to the tax collector.

The rate of the tax is expressed as so many mills on the dollar of assessed value, or as so many cents or dollars and cents per 100 dollars. Thus a tax of 10 mills on the dollar is equivalent in the other form to $1.00 on the $100. The rate is arrived at in one of two ways. The most common method is to estimate first how much money will be needed to run the Government for the year, and then to divide that sum by the total of the assessment roll, thus getting the tax rate. But naturally the total to be raised is seldom fixed without attention to what the resulting tax-rate will be. The other method is to fix rates for each activity of government as: 5 mills for schools, 2 for roads, 1 for the hospital; or for each branch of government as: 5 mills for the county, 2 for the village or district, 5 for the State; and then to require or attempt to require that each activity confine its expenses to the amount of money these rates will yield. In some of the states where all branches of government, from the smallest school district or village through the towns and cities, and the counties up to and including the state itself, levy on the general property tax the rate applied to any one taxpayer is a combination of three or more tax levies, the state, the county, and as many local districts or divisions as include his property. Thus a common occurrence would be about 50 cents State tax, 50 cents county tax, 75 cents town or city tax, 25 cents primary school district tax, and 10 cents high school district tax. Many more may occur.

Cities sometimes make an assessment of the property within their boundaries in addition to and separate from the assessment made for the other branches of government. This is most often the case where the assessment roll for all other branches of government is a county roll. The valuations on the two rolls do not usually agree. In fact the city roll is apt to show higher values because the main reason for incurring this otherwise wasteful cost is to obtain a lower tax rate. This is a bit of camouflage, because if the tax I have to pay on a house worth $10,000 is $100, it makes no difference to me whether it is computed as $1.00 per hundred on $10,000 assessed value, or $2.00 per hundred on $5,000 assessed value.

Equalization of Assessments.—Equalization between districts becomes of great importance whenever several different branches of government levy heavy taxes on the same roll. Equalization between individuals in the same district is, as indicated above, generally left to a local board. At one time, when the State's government expenses were relatively small, the State's needs were apportioned roughly to the districts, which then collected enough money in addition to their own needs to cover this charge. But as the State activities grew and the State's share became large, let us say as much as 50 cents on each $100 of assessed value, it made a serious difference if one locality or district had a low valuation and another a high one. So State boards of equalization were established which raised or lowered any district assessment roll which seemed to be out of line with the others. This proved a crude remedy and to-day in many States there are State tax commissions among whose duties it is to supervise and direct the work of the local assessors all the time. The object of this supervision is to make the assessments uniform.

The general property tax is most successful where there are mainly neighbourhood charges to be apportioned among neighbours. But when, among the taxpayers, there are great corporations owning property, such as railroad lines, electric light and power plants, extending through many assessment districts, local piecemeal assessment becomes difficult. Hence has arisen the practice of taking the assessment of all public utility companies, financial institutions such as banks and insurance companies, and some other large corporations, out of the hands of the local assessors. These are then either assessed centrally as units by the State tax commission and the assessments apportioned to the districts, or the taxes from these sources are taken over entirely by the State. In the latter case the methods may be changed and the tax based on gross receipts or some other factor. When that is done the amount of the State taxes to be apportioned to the localities is smaller. In several States the taxes on the segregated classes of property supplemented by other taxes have been sufficiently large to reduce the State's share of the general property tax to nothing or to a very small amount.

Exemptions are an outstanding feature of the property tax. Property used for religious worship, for educational and charitable institutions, and cemeteries is universally free of taxation. Veterans of war are often given liberal exemptions, especially if possessed of only small amounts of property. Very often a small amount of household furniture, tools, etc., is allowed as an exemption to everybody.

Miscellaneous Taxes.—*Poll taxes* come next to the general property tax in age but are slowly passing into disuse. Among the origins of these taxes was the idea that all able-bodied men should go out for at least a few days each year and work on the roads. Those who could not or did not want to do so could pay a tax in lieu of work. But there was, also, the idea that everybody should pay a little, be it only a dollar a year, to support the Government under which he lived. Poll taxes have been used as above for roads, and also for schools, hospitals, in commutation of service in the militia and occasionally imposed on special classes such as "foreign miners." But the trouble and cost of collection and their inherent inequality has led to their abandonment in many places.

Licence taxes on selected businesses and occupations are extensively used. These are annual charges on the privilege of doing business of the kinds selected for taxation, and payment is shown by a "licence" which reads as if it granted a privilege. The classes of business selected are frequently those which use comparatively little property covered by the property tax. But that criterion is not carefully applied. In the southern States the licence taxes are very numerous and long tariffs of rates covering hundreds of classes of licenses are enacted.

Income taxes have come into use in several of the States. There are now eleven States with some kind of an income tax enacted mainly since 1911. In Wisconsin and Massachusetts the income tax was introduced as a sort of substitute for the taxation of intangible personal property under the property tax, which, as explained above, is not satisfactory anywhere. In those States the tax is centrally administered but the proceeds are distributed in part to the localities. In New York the income tax is a part of the programme of supporting the State Government with as little recourse to the general property tax as possible. Other States have income taxes which vary greatly in form and purpose. In general the rates are graduated but not very high, and the personal exemptions much smaller than in the federal income tax. In some States the tax falls on corporations as well as individuals.

Inheritance taxes, or corresponding death duties, are used in very nearly all the States and are State taxes, not local taxes. In a few States there are estate taxes which, like the federal tax described above, fall on the entire estate of the decedent. But in most States these taxes are on the distributive shares received by the heirs and other beneficiaries. In these cases they are at rates graduated in two ways. (1) They are graduated by the relationship to the deceased. Thus the widow, or husband, the children or the father or mother are taxed lightly and have large exemptions. The brother or sister and the nephews or nieces are in a class taxed more heavily than the direct heirs. Cousins often form a third class with still higher rates and finally the heaviest rates and smallest exemptions apply to bequests to strangers to the blood. (2) For each class of beneficiaries the rates increase with the amount of property received. Difficulties of the gravest sort have arisen in the administration of these taxes when the property left is scattered in several States. Gradually the following principles are coming to be, but are not yet fully, recognized: (1) real estate and tangible personal property are taxable where physically located; (2) intangible personal property is taxable only by the State in which the deceased had a residence.

Corporation or franchise taxes is a term applied to cover a great variety of taxes designed to reach more effectively than can be done otherwise, the tax-paying ability of the various classes of corporations. They are in general aimed at the value of the business as a going concern and take on many different forms.

State finances, county finances, municipal finances and district finances, and hence the taxes used, are closely related and interlocking. The State very often subsidises and supervises the schools and the main highways. The counties in many cases levy taxes for schools which are handed over to and expended by the school districts. The municipalities enjoy, possibly, a larger degree of independence than any other political subdivisions of the State, but that is only in the realm of strictly municipal activities. The total of taxes levied by any one class of taxing divisions does not correspond to the total expenditures of that class. Thus the State may be said to spend on its own activities very much less than it raises in taxes, for it subsidises many local expenditures. The counties subsidise the districts, but on the other hand receive subsidies from the State. The districts, school, road and other, and the municipalities are the final recipients of the subsidies from above, but levy some taxes of their own.

BIBLIOGRAPHY.—The best sources of further information concerning taxation in the United States are: A. *On statutory law.* The codes or general statutes of the United States and of the several States. In many States the revenue laws are separately published. A digest of the revenue laws of the States is published at intervals of ten years by the United States Census Bureau, last edition, "1922" printed 1924. The Federal Government publishes the "regulations" for each of its taxes in a series revised as need be, and also the "rulings" and "decisions." These and other federal publications mentioned below can be obtained from the Government Printing Office, Washington, D.C. There are a considerable number of annual taxpayers' guides and continuous "tax services," relating especially to the Federal income tax, obtainable through the book trade.

B. *Financial statistics.* The original sources are: the reports of the State auditors or controllers and of the State tax commissioners. Secondary, but authoritative sources are: the United States Bureau of the Census series of publications entitled Wealth, Debt and Taxation, published in complete form once every decade; the last edition was "1922" published, 1924. The Bureau also publishes annually a report on the finances of cities. Local taxes are frequently statistically summarized in the above State reports. The city taxation departments and the city auditors of the larger cities, also, usually publish annual reports. The New York City office is known as the Commissioners of Taxes and Assessments.

C. *Discussion, descriptions and studies.* Most of the American college textbooks on public finance and the tariff and many legal treatises on taxation contain more or less extensive descriptions of United States taxes. The annual volumes of the *Proceedings of the National Tax Association* (vol. xx. 1927) contain carefully prepared papers and discussions on American taxation by the best qualified experts, and also, each year, a record of the more recent changes in tax law. The National Tax Association also publishes a monthly bulletin.

D. *Decisions of the Courts* contain very important matters concerning taxation. (C. C. P.)

TAXICAB: *see* MOTOR-TAXICAB.

TAXIDERMY, the art of preserving the skin, together with the fur, feathers or scales, of animals; a skin so preserved may then either be retained as a specimen for study purposes, or else mounted for exhibition in museums and private collections, or used as an ornament. Formerly the setting up of animals used to be known as "stuffing," and, in most cases, this was actually what was done; the skin was simply stuffed with straw or wool until it looked something like the living animal. Nowadays, the stuffing process is quite extinct, the greatest care being taken to model the specimens so that they look as life-like as possible. The old fashioned "bird-stuffers" have been replaced by taxidermists, and the verb "to stuff," as applied to the art of taxidermy, is now obsolete; the modern taxidermist "mounts," or "models" a specimen, not "stuffs" it. The art does not appear to be a very ancient one, probably not more than 300 years old; this statement only applies to the stuffing or mounting of specimens, as, of course, the curing of skins, for use as wearing apparel, rugs, etc., must have been perfected in very early days. Taxidermy, in a crude style, was practised in England towards the end of the 17th century, as is proved by specimens in the Sloane Collection, which in 1753 formed the nucleus of the British Museum. At the Great Exhibitions held in the middle of the 19th century, many examples of British taxidermy were exhibited; at the Paris Exhibition of 1864 a special zoological section was prepared by Mr. Edwin Ward. The much higher standard of the exhibits in the great museums, and the demands of sportsmen for the proper treatment of their trophies, have transformed the "stuffing" of animals into an elaborate art.

All the early books published on this subject*, such as R. A. F. Réaumur's *Treatise* (1749) and the *Guides* and *Instructions* on collecting and preserving natural history specimens, by E. Donovan[1], W. Swainson[2], Captain Thomas Brown[3], are now quite out of date, and only interesting from an historical point of view. For work in the field the instructions issued by the British Museum of Natural History[4], and Rowland Ward's[5] Sportsman's Handbook, are of the greatest assistance to the sportsman and collector. As regards the actual mounting, the work is so intricate and requires such special training, that it is rarely undertaken with successful results by amateurs. A few works have been published dealing with this branch of taxidermy and the reader will find much that is helpful in William T. Hornaday's[6] account of American taxidermic methods.

Taxidermy may then be considered under two quite separate headings, (1) the skinning and preserving of specimens, (2) the mounting of such specimens in as life-like a style as possible. It should be noted that only a very small number of the animals skinned and preserved are set up, or mounted; the great majority go to swell the large study collections now maintained in museums.

Tools Used.—The knives and other tools used in skinning an animal are the following:—a series of scalpels, forceps and scissors, scissor-forceps, pliers, small bone-saw, brain-scoop, a variety of scrapers, a camel-hair brush, and a set of glovers' needles. As regards preservative for use on the raw skin, arsenical soap may be used as long as proper precautions are taken; Rowland Ward's Taxidermine is a useful and effective, non-poisonous preparation, as it may be used on both sides of the skin in cases where the fur is "slipping," that is, tending to come away from the pelt. In no circumstances should the skins be exposed to the direct rays of the sun, and alum, frequently used on large mammals, should never be employed on the skins of birds as it makes them brittle. If nothing better is to hand large skins can be cured with wood-ashes, the harder the wood, the better the ash; this is how many native-cured skins are prepared, and doubtless was how primitive man treated skins before soft-dressing them. Some good results have been obtained by using common salt; this process is one, however, which necessitates most careful attention, and is not to be recommended in moist climates, as the skins will not dry well and are liable to sweat. Skins of large beasts may be preserved by pickling; they are first thoroughly treated with salt and afterwards immersed in a barrel of brine. Reptiles and fish can be preserved with Taxidermine in the same way as mammals and birds, or they may be placed in spirit and brought home entire.

A most important point is the packing of skins for transport; the skins should be packed with plenty of naphthalene, and, in the case of large mammals, turpentine may be used to protect the skins against insects. The latter spirit should not be used indiscriminately on bird-skins, as it dissolves the fat in the skins and this will adversely affect the colour and condition of the plumage.

Procedure with Mammals.—With mammals, whether they are required for study or mounting purposes, operations must begin by measuring the dead animal while still in the flesh; head and body, tail, ear, and hind foot must be measured, in feet and inches for large beasts, in millimetres for medium-size and small mammals. Then comes the important item of writing the label for the skin; the measurements just taken should be entered on one side of the label, together with such field notes as may be desirable. On the other side the date and locality of capture, sex and

*The superior figures placed after authors' names have reference to books mentioned in the bibliography.

collector's number and name, must be recorded. A second label should be prepared giving the collector's initials and number, for attaching to the skull when freed from the body. In skinning a large animal, such as a tiger, care should be taken to conduct the whole operation in the shade; if no shade is available a tent should be pitched. The body is then slit up from the edge of the lower lip to the tip of the tail, and cross cuts are made from this median incision along the limbs to the feet. The skin should be removed as cleanly as possible, all fragments of fat or muscle, must be removed with the body, and not left on the skin; otherwise the hair will tend to slip at the spots where flesh remains inside. The nose, lips, eyes, paws, and ears require very careful and thorough skinning; the thick skin around the base of the whiskers should be scored so that the preservative can get well in, and the spongy tissue inside the pads of the feet should be cut away. The skin should then be well washed and hung up, hair-side out to dry. It should then be placed hair downwards on the ground, preferably on a mat, and gently pulled into correct shape and size. Then follows the application of the preservative, after which the skin is allowed to dry (out of the sun), and can then be folded up. Skinning a medium-sized, or small mammal is a slightly different operation, as here the only incision needed is a median one, along the abdomen; the limbs and head can be skinned out by simply turning the animal inside out. The limbs should be skinned as far down as possible and the bones of the feet severed from the carcase and left in the skin; occasionally the limb-bones are left in as well. The tail in most small mammals can be skinned by taking a firm grip of the base of the vertebrae and pulling the tail out of the skin; in medium-sized specimens it is frequently necessary to assist this operation with a ventral incision. The skin, after treatment with the preservative, is then moderately stuffed with wool, or wood-wool, according to the size of the animal, and a wool-covered wire inserted down the tail and up the body as far as the chest and head. After sewing up the body the specimen is pinned out to dry, with its fore and hind limbs stretched out parallel with the body, and the label tied on to the right hind foot. Care should be taken not to stretch a skin during these operations; an inexperienced person, with a heavy hand, can easily convert a five inch weasel into a ten inch one; on this account it is best to make the skin, as nearly as possible, the same size as it was before removal from the body, as indicated by the dimensions on the label. To skin the head of a horned animal it is necessary to make a transverse incision behind and between the horns, from the centre of this slit another cut is made down the back of the neck; the skin can then be removed leaving the horns on the skull.

Birds.—The skinning of birds is somewhat similar; the humerus, or upper wing-bone, is first broken; an incision is made either down the mid-line of the stomach, or under the wing, as far as the vent; the body is then skinned out by severing the legs, after stripping the bones, at the middle of the thigh-bones, and the wings are similarly treated, being severed at the fracture of the humerus. The head may often be approached through the skin of the neck; in some larger kinds it is necessary, however, to make a small dorsal incision in the neck. The eyes, muscles, and brain are then removed, and preservative and cotton-wool take their place. After cleaning the wings and treating the skin with preservative it is moderately filled with wool and sewn up. Care must be exercised in drying bird-skins, and paper bands, or cones, are frequently used to keep the feathers in position.

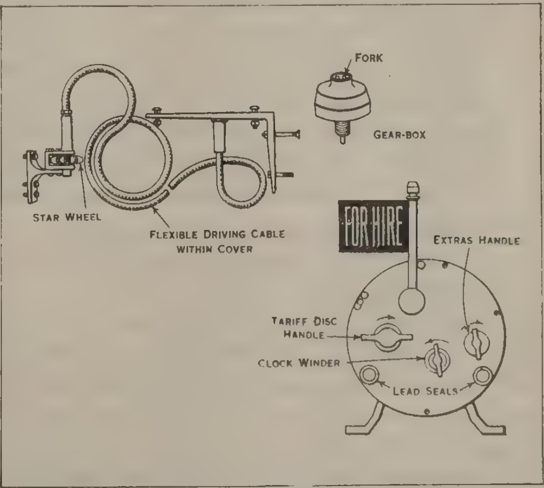
Reptiles.—Reptiles are treated much in the same way as mammals. With fish the incision is not made down the centre of the belly but along the less important side, from gill to tail. The skin can be manipulated neatly from each side of the incision; the fins should be severed from their attachments, but not too closely. Great care should be taken not to bend, or otherwise injure, the skin, during the removal of the body, as the scales are very fragile and easily detached. After treatment with preservative, the body should be filled with dry sawdust or sand, after which the specimen can be neatly sewn up; it may then be allowed to dry and the sawdust or sand removed in due course.

Mounting, in the second branch of taxidermy, that of mounting or modelling, it will be impossible in this article to give more than a brief outline of the intricate processes involved. A model, or "manikin," is built up to represent as nearly as possible the body of the animal, special care being lavished on the proper representation of the muscular system and veinage; the skin, which has been made as thin and pliable as possible, is then stretched over the model and sewn on in an invisible manner. Frequently additional realism is produced by covering the "manikin" with a thin layer of modelling composition, so that the skin may be moulded to the desired form.

BIBLIOGRAPHY.—*See* authors' names above. [1]*Instructions for Collecting and Preserving Various Subjects of Natural History* (1794). [2]*The Naturalists' Guide for Collecting and Preserving Subjects on Natural History and Botany* (1822). [3]*Taxidermist's Manual* (Glasgow, 1833). [4]*Handbook of Instructions for Collectors,* British Museum (Natural History) (1921). [5]Rowland Ward's *Sportsman's Handbook* (1923). [6]*Taxidermy and Zoological Collecting* (1901). (J. G. D.)

TAXIMETER, a registering apparatus which records the fare for the hire of a hackney carriage or motor taxicab. It is put into service by the movement of a handle, and is operated by one of the front wheels of the cab. The parts are indicated in the diagram. The star-wheel is driven from a hub-ring attached to the near-side front wheel of the vehicle. A flexible shaft leads away from the star-wheel to the gear-box fixed under the meter. This box enables the speed to be geared down, and also allows of the substitution of different gears with teeth suitable for the circumference of the tyre in use. Behind the meter is the clock winder. To put the meter into service the tariff disc handle is turned as far as it will go, and the flag pushed down. The meter will then register by time and distance. For the "stopped" position the tariff disc handle is again turned as far as it will go; registration is then only by time. When the "extras" handle is turned the "extras" will show in the aperture.

A double tariff meter is so constructed that the driver can turn on either the day or the night tariff, and the meter is arranged in such a manner that only half the normal distance is given for the same amount of fare. Another type is made to show a higher fare for the first mile, and then a lower basic rate subsequently.



BY COURTESY OF THE BRITISH TAXIMETER COMPANY, LTD.

THE EQUIPMENT OF THE DRIVE, GEAR CHANGE AND METER SHOWN FROM THE REAR

TAY, the longest river in Scotland. From its source in Ben Lui (3,708 ft.), a mountain on the borders of Perthshire and Argyllshire, it flows north-east to Logierait, where it curves to the south by east as far as Dunkeld; there it turns south-east to the mouth of the Isla, where it bends south-west to the vicinity of Scone. From this point it makes a sharp descent south-east beyond the county town, where it sweeps to near Newburgh in Fifeshire; here it faces the north-east again as far as Broughty Ferry, whence it flows straight eastwards into the North sea, off

Buddon Ness in Forfarshire, after a total run of 117 miles. During the first 11 m. it is known as the Fillan and discharges into Loch Dochart. From the lake it emerges as the Dochart (13 m.), which enters Loch Tay at Killin. Flowing through the loch for 14½ m. it issues at Kenmore under its proper name of Tay. With its tributaries it drains all Perthshire and portions of Forfarshire and Argyllshire, having a catchment basin of 2,400 square miles. In many parts the current is impetuous, and in flood has occasionally wrought much havoc. Its mean discharge of water every minute is estimated to be larger than that of any other stream in the United Kingdom.

Vessels make Dundee at all stages of the tide, and the estuary is navigable to Newburgh by vessels of 500 tons, and as far as Perth by ships of 200 tons. The navigation, however, is seriously obstructed by shifting sandbanks. The estuary varies in width from ½ m. at Cairniepier Ferry to full 3 m. at its mouth. The first railway viaduct across the firth, opened in 1877, was blown down along with a train in 1879. The second bridge, 2 m. and 73 yd. in length, was erected 60 ft. higher up stream and opened in 1887. The Tay is famous for salmon.

TAY, LOCH, the largest lake in Perthshire, Scotland. It is situated about the middle of the county and has a flattened ogee form, with a general trend from north-east to south-west. It is 14½ m. long from Killin at the head to Kenmore at the foot, from ½ m. to fully 1 m. wide. It receives at Killin the rivers Lochay and Dochart and discharges by the Tay at Kenmore. Ben Lawers (3,984 ft.) rises near the left bank. There are piers at Killin, Ardeonaig, Lawers, Ardtalnaig, Farnan and Kenmore, at which the steamers call during the tourist season. At the foot of the lake is an island containing the ruins of the priory which was founded in 1121 by Alexander I. in memory of his wife Sibylla, daughter of Henry I. She was buried here. Loch Tay enjoys great repute for its salmon-fishing.

TAYABAS, a municipality (with 48 *barrios* or districts) of the province of Tayabas, Luzon, Philippine islands, about 8 m. north of Lucena, the provincial capital. Pop. (1918), 14,983. Tayabas, which was the provincial capital from the middle of the 18th century until 1901, is situated on the slope of the extinct volcano, Banájao, and commands a fine view of the surrounding country. The chief agricultural products of the region are rice and coco-nuts. Hat-making has attained to considerable importance. In 1918, Tayabas had 8 manufacturing establishments, 6 rice mills, and 530 household industry establishments, with outputs valued at 26,400; 260,000; and 88,000 pesos respectively. Of the 16 schools, 15 were public. Tagalog and Bikol are the chief languages spoken.

TAYGETUS, the highest mountain in the Peloponnese, separating Laconia from Messenia, and traversed by the steep Langada Pass. The highest point is H. Elias (7,900 ft.).

TAYLOR, ANN (1782–1866) afterwards Mrs. Gilbert and **TAYLOR, JANE** (1783–1824), English writers for children, daughters of Isaac Taylor (1759–1829), were born in London on Jan. 30, 1782, and Sept. 23, 1783, respectively. In 1786 the Taylors went to live at Lavenham in Suffolk, and ten years later removed to Colchester. Jane was a lively and entertaining child, and composed plays and poems at a very early age. Their father and mother held advanced views on education, and under their guidance the girls were instructed not only in their father's art of engraving, but in the principles of fortification. Ann introduced herself to the publishers Darton and Harvey by a rhymed answer to a puzzle in the *Minor's Pocket Book* for 1799, and Jane made her first appearance in print in the same periodical with "The Beggar Boy." The publishers then wrote to Isaac Taylor asking for more verses for children from his family, and the result was *Original Poems for Infant Minds* (2 vols., 1804–5), by "several young persons," of whom Ann and Jane were the largest contributors. The book had an immediate and lasting success.

They followed up this success with *Rhymes for the Nursery* (1806), *Hymns for Infant Minds* (1808, 2nd ed. 1810), *Rural Scenes* (1806); *City Scenes* (1809); a less-known collection, *Signor Topsy Turvy's Wonderful Magic Lantern; or, The World Turned Upside Down* (1810), and *Original Hymns for Sunday School* (1812). In 1813 Ann married a Congregational minister, Josiah Gilbert, and Jane went to live at Ilfracombe with her brother Isaac. In 1816 Jane returned to Ongar, where the family had been settled for some years, and died there on April 13, 1824. Ann Gilbert died at Nottingham on Dec. 20, 1866. Both sisters wrote after their separation, but none of their later works had the same vogue.

The best edition of the *Poetical Works* of the sisters is that of 1877. There is an excellent edition (1903) of the *Original Poems and Others*, by Ann and Jane Taylor and Adelaide O'Keeffe, edited by E. V. Lucas, with illustrations by F. D. Bedford (1903).

Abundant information about Ann and Jane Taylor is to be found in: *Autobiography and Other Memorials of Mrs. Gilbert* (2 vols., 1874), edited by her son Josiah Gilbert; *Memoirs and Poetical Remains . . . of Jane Taylor* ed. by her brother, Isaac Taylor (2 vols., 1825), and the collection by the same editor entitled *The Family Pen: Memorials . . . of the Taylor Family of Ongar*, vol. ii. (1867); *see* also Mrs. H. C. Knight, *Life and Letters of Jane Taylor.*

A selection of *Prose and Poetry* by Jane Taylor was published, with introd. by F. V. Barry, in 1925.

TAYLOR, BAYARD (1825–1878), American author, was born of English and German stock in Chester county (Pa.), on Jan. 11, 1825. He published at Philadelphia in 1844 a little volume, *Ximena; or The Battle of the Sierra Morena, and Other Poems.* Remuneration for his poetry on a scale generous for the time and advance payments for travel letters by the publishers of the *Saturday Evening Post* and the editor of the *United States Gazette*, as well as a conditional engagement by Horace Greeley, made it possible for him to take (1844–46) the coveted trip to the Old World which was his university education. His study in Germany and his happy roaming through Scotland, England, France and Italy are described in his *Views Afoot* (1846), which went through a number of editions. After a brief period of country journalism Taylor moved to New York city. The year 1848 brought him several lucrative magazine and newspaper offers, the most important of which was with the New York *Tribune.* The excitement of the gold rush at this period was responsible not only for his passionate Californian ballads but for his trip to the Pacific coast as correspondent for the *Tribune,* which he recounted in *Eldorado* (2 vols., 1850). The wanderlust was in his blood. His trips to almost every part of the globe continued till the end of his life, and, although the popularity of his narratives of travel has diminished, his vivid pictures of remote places, such as *A Journey to Central Africa* (1854) or *Northern Travel* (1857), in their day won many readers.

For several years his lectures were equally in demand. Quiet was afforded him in his country home, Cedarcroft, in which he entertained hospitably and read and wrote copiously. Some of the works of his later period are *The Poet's Journal* (1862), *The Picture of St. John* (1866); the translation of *Faust* (1870–71); *Home Pastorals* (1875); and the novels *Hannah Thurston* (1863), *Joseph and His Friend* (1870), and *The Story of Kennett* (1866). As a novelist Taylor is undistinguished; as a poet he is at his best in the *Poems of the Orient* (1854) or his rich and sonorous rendering of *Faust* in the original metres.

In 1862 Taylor had entered the diplomatic service as secretary of the legation at St. Petersburg, and in the following year he became *chargé d'affaires* at the Russian capital. His disappointment at not being made minister there, which caused him to leave the service, was atoned for by his being made minister to Germany early in 1878. He died on Dec. 19, 1878.

Taylor's *Studies in German Literature* (1879) and *Critical Essays and Literary Notes* (1880) were published posthumously. Collected editions of his *Poetical Works* and of his *Dramatic Works* appeared in 1880. Besides co-operating with H. E. Scudder in the publication of the valuable *Life and Letters of Bayard Taylor* (1884), Mrs. Taylor wrote an interesting volume of reminiscence, *On Two Continents* (1905). A. H. Smyth has a good biography (1896), with bibliography.

TAYLOR, BROOK (1685–1731), English mathematician, was the son of John Taylor, of Bifrons House, Kent, was born at Edmonton in Middlesex on Aug. 18, 1685. He was educated at St. John's College, Cambridge, and studied mathematics under John Machin and John Keill. He obtained in 1708 a remarkable solution of the problem of the "centre of oscillation," which, however, remaining unpublished until May 1714 (*Phil. Trans.*, vol.

xxviii. p. 11), his claim to priority was unjustly disputed by John Bernouilli. Taylor's *Methodus Incrementorum Directa et Inversa* (London, 1715) added a new branch to the higher mathematics, now designated the "calculus of finite differences." Among other ingenious applications, he used it to determine the form of movement of a vibrating string, by him first successfully reduced to mechanical principles. The same work contained the celebrated formula known as "Taylor's theorem" (*see* INFINITESIMAL CALCULUS), the importance of which remained unrecognized until 1772, when J. L. Lagrange realized its powers and termed it *"le principal fondement du calcul différentiel."* In his essay on *Linear Perspective* (London, 1715, revised ed. 1719) Taylor set forth the true principles of the art in an original and more general form than any of his predecessors; but the work suffered from the brevity and obscurity which affected most of his writings.

Taylor was elected a fellow of the Royal Society early in 1712, sat in the same year on the committee for adjudicating the claims of Newton and Leibniz, and acted as secretary to the society from 1714 to 1718. From 1715 his studies took a philosophical and religious bent. Taylor died on Dec. 29, 1731, at Somerset House, and was buried at St. Ann's, Soho. As a mathematician, he was the only Englishman after Sir Isaac Newton and Roger Cotes capable of holding his own with the Bernouilli; but a great part of the effect of his demonstrations was lost through his failure to express his ideas fully and clearly. *See* also TAYLOR'S THEOREM.

See the lives of Taylor prefixed to his Contemplatio philosophica (ed. Sir W. Young, 1793), and to his *New Principles of Linear Perspective* (ed. Colson 1749).

TAYLOR, FREDERICK WINSLOW (1856–1915), American engineer, was born March 20, 1856, at Germantown, Pennsylvania. In 1875 he was apprenticed as pattern-maker and machinist in a small Philadelphia shop. As early as 1880 or 1881, while gang boss in the employ of the Midvale Steel Company, controversy with workers had led him to realize the necessity of accurate measurement of what constituted a day's work on any operation. This in turn led to a series of careful experiments resulting in important achievements in two fields; in mechanical engineering, the discovery with Maunsel White of a new method of tempering tool steel permitting metal-cutting operations at high speed (1898); and in the field of management, perfection of that system of shop management which later came to be known as scientific management. The remainder of his life was spent in forwarding the principles of this system, by practising the new profession of consulting engineer in management for many plants (1893–1901), lecturing, and writing.

He died on March 21, 1915, in the city of Philadelphia.

Taylor's writings include *Notes on Belting* (1893); *The Adjustment of Wages to Efficiency* (1896); *On the Art of Cutting Metals* (1906); *Shop Management* (1911); *The Principles of Scientific Management* (1911). *See* F. B. Copley, *Frederick W. Taylor, Father of Scientific Management* (1923); C. B. Thompson, *The Taylor System of Scientific Management* (1917).

TAYLOR, SIR HENRY (1800–1886), English poet and political official, was born on Oct. 8, 1800, at Bishop-Middleham, Durham. After a few months' service in the navy he obtained a clerkship ashore. From 1824 to 1872 he held important appointments in the colonial office, where he rendered active assistance to Sir James Stephen in drafting the Act of Emancipation. He died at Bournemouth on March 27, 1886. Taylor was the author of several plays, of which *Philip van Artevelde* was the most famous. His dramatic poetry is generally better than his lyrical work, but some of his lyrics, notably "If I had the wings of a dove" have found a place in many anthologies.

Taylor's *Autobiography* (2 vols. 1885) should be supplemented by his *Correspondence* (1888), edited by Edward Dowden. His *Works* were collected in five volumes in 1877–78.

TAYLOR, HENRY MARTYN (1842–1927), English mathematician, was born at Bristol on June 6, 1842. He was educated at Wakefield Grammar school and at Trinity college, Cambridge. He was appointed tutor in 1874, and remained on the mathematical staff at Cambridge until he retired in 1894. Taylor's work in mathematics was on geometry, but he is known chiefly for his effort to make scientific knowledge available to the blind. He lost his sight completely soon after he left Cambridge. He learnt Braille and transcribed a number of textbooks on mathematics, astronomy and geology. Hampered by the high cost of production of the books in Braille, he started a fund which the Royal Society accepted as a trust in 1913. Taylor died at Cambridge on Oct. 16, 1927.

TAYLOR, JEREMY (1613–1667), English divine and author, was baptized at Cambridge on Aug. 15, 1613. His father, Nathaniel, a barber, was a man of some education, for Jeremy was "solely grounded in grammar and mathematics" by him before he became a pupil of Thomas Lovering, at the newly founded Perse grammar school. Lovering is first mentioned as master in 1619, so that Taylor probably spent seven years at the school before he was entered at Gonville and Caius College as a sizar in 1626. He was elected a Perse scholar in 1628, and fellow of his college in 1633. He took holy orders in 1633, and, took the place of Thomas Risden for a short time as lecturer in St. Paul's. Archbishop Laud sent for Taylor to preach before him at Lambeth, and took the young man under his special protection. Taylor retained his fellowship at Cambridge until 1636, for Laud desired that his "mighty parts should be afforded better opportunities of study and improvement than a course of constant preaching would allow of," but he seems to have spent much of his time in London. In November 1635 he had been nominated by Laud to a fellowship at All Souls, Oxford, where, says Wood (*Athen. Oxon.*, Ed. Bliss, iii. 781), love and admiration still waited on him. He seems, however, to have spent little time there. He became chaplain to his patron the archbishop, and chaplain in ordinary to Charles I. After two years in Oxford, he was presented, in March 1638, by Juxon, bishop of London, to the rectory of Uppingham, in Rutlandshire. In 1642 he was appointed to preach in St. Mary's on the anniversary of the Gunpowder Plot, and apparently used the occasion to clear himself of a suspicion, which, however, haunted him through life, of a secret leaning to the Roman Catholic communion. This suspicion may have arisen from his intimacy with Christopher Davenport, better known as Francis a Sancta Clara, the learned Franciscan chaplain of Queen Henrietta; but was probably strengthened by his known connection with Laud, as well as by his ascetic habits. More serious consequences followed his attachment to the Royalist cause. The author of *The Sacred Order and Offices of Episcopacy or Episcopacy Asserted against the Aerians and Acephali New and Old* (1642) could scarcely hope to retain his parish, which was not, however, sequestrated until 1644. Taylor probably accompanied the king to Oxford. In 1643 he was presented to the rectory of Overstone, Northamptonshire, by Charles I. There he would be in close connection with his friend and patron Spencer Compton, 2nd earl of Northampton.

Taylor seems to have been in London during the last weeks of Charles I.'s life, and is said to have received his watch and some jewels which had ornamented the ebony case in which he kept his Bible. He had been captured while besieging Cardigan castle on Feb. 4, 1645. He found refuge, as private chaplain, with Richard Vaughan, 2nd earl of Carbery (1600–1686), whose hospitable mansion, Golden Grove, Carmarthenshire, is immortalized in the title of Taylor's great manual of devotion, and whose first wife was a constant friend of Taylor. The second Lady Carbery was the original of the "Lady" in Milton's *Comus*. Mrs. Taylor had died early in 1651. His second wife was Joanna Bridges, said on very doubtful authority to have been a natural daughter of Charles I. She owned a good estate, though probably impoverished by Parliamentarian exactions.

From time to time Jeremy Taylor appears in London in the company of his friend Evelyn, in whose diary and correspondence his name repeatedly occurs. He was three times imprisoned: in 1654–5 for an injudicious preface to his *Golden Grove;* again in Chepstow castle, from May to October 1655, on what charge does not appear; and a third time in the Tower in 1657–8, on account of the indiscretion of his publisher, Richard Royston, who had adorned his "Collection of Offices" with a print representing Christ in the attitude of prayer.

Much of his best work was produced at Golden Grove. In 1646 appeared his famous plea for toleration, Θεολογία Ἐκλεκτική, *A Discourse of the Liberty of Prophesying.* In 1649 he published the complete edition of his *Apology for authorized and set forms of Liturgy against the Pretence of the Spirit,* as well as his *Great Exemplar . . . a History of . . . Jesus Christ,* a book which was inspired, its author tells us, by his earlier intercourse with the earl of Northampton. Then followed in rapid succession the *Twenty-seven Sermons* (1651), "for the summer half-year," and the *Twenty-five* (1653), "for the winter half-year," *The Rule and Exercises of Holy Living* (1650), *The Rule and Exercises of Holy Dying* (1651), a controversial treatise on *The Real Presence . . .* (1654), the *Golden Grove; or a Manuall of daily prayers and letanies . . .* (1655), and the *Unum Necessarium* (1655), which brought upon him the accusation of Pelagianism. In reply to a request from Katherine Phillips (the "matchless Orinda"), he wrote his *Discourse of the Nature, Offices and Measures of Friendship* (1657). His *Ductor Dubitantium, or the Rule of Conscience . . .* (1660) was intended to be a standard manual of casuistry and ethics for Christian people.

He probably left Wales in 1657, and his immediate connection with Golden Grove seems to have ceased two years earlier. In 1658, through the kind offices of his friend John Evelyn, Taylor was offered a lectureship in Lisburn, Ireland, by Edward Conway, second Viscount Conway. At first he declined a post in which the duty was to be shared with a Presbyterian, or, as he expressed it, "where a Presbyterian and myself shall be like Castor and Pollux, the one up and the other down," and to which also a very meagre salary was attached. He was, however, induced to take it, and found in his patron's mansion at Portmore, on Lough Neagh, a congenial retreat.

At the Restoration, instead of being recalled to England, as he probably expected and certainly desired, he was appointed to the see of Down and Connor, to which was shortly added the small adjacent diocese of Dromore. He was also made a member of the Irish privy council and vice-chancellor of the university of Dublin. None of these honours were sinecures. Of the university he writes, "I found all things in a perfect disorder . . . a heap of men and boys, but no body of a college, no one member, either fellow or scholar, having any legal title to his place, but thrust in by tyranny or chance." Accordingly he set himself vigorously to the task of framing and enforcing regulations for the admission and conduct of members of the university, and also of establishing lectureships. His episcopal labours were still more arduous. There were, at the date of the Restoration, about seventy Presbyterian ministers in the north of Ireland, and most of these were from the west of Scotland, and hated episcopacy. The new bishop had nothing to offer the Presbyterian clergy but the bare alternative—submission to episcopal ordination and jurisdiction or deprivation. Consequently, in his first visitation, he declared thirty-six churches vacant; and of these forcible possession was taken by his orders. At the same time many of the gentry were won by his undoubted sincerity and devotedness as well as by his eloquence. With the Roman Catholic population he had no success. At the instance of the Irish bishops Taylor undertook his last great work, the *Dissuasive from Popery* (in two parts, 1664 and 1667), but, as he himself seemed partly conscious, he might have more effectually gained his end by adopting the methods of Ussher and Bedell, and inducing his clergy to acquire the Irish tongue. He died at Lisburn on Aug. 13, 1667 and was buried in the cathedral of Dromore.

Of a genuine poetic temperament, fervid and mobile in feeling, and of a prolific fancy, Taylor had also the sense and wit that come of varied contact with men. All his gifts were made available for influencing other men by his easy command of a style rarely matched in dignity and colour. With all the majesty and stately elaboration and musical rhythm of Milton's finest prose, Taylor's style is relieved and brightened by an astonishing variety of felicitous illustrations, ranging from the most homely and terse to the most dignified and elaborate.

The whole works of . . . Jeremy Taylor with a life of the author and a critical examination of his writings was published by Bishop Reginald Heber in 1822, reissued after careful revision by Charles Page Eden (1847–54). His most popular works, *The Liberty of Prophesying, Holy Living,* and *Holy Dying* have been often reprinted. *The Poems and Verse-translations of Jeremy Taylor* were edited by Dr. A. B. Grosart in vol. i. of the *Miscellanies of the Fuller Worthies Library* (1870). The first biographer of Jeremy Taylor was his friend and successor, George Rust, who preached a funeral sermon (in 1668) which remains a valuable document. His life has been written by John Wheeldon (1793), H. K. Bonney (1815), T. S. Hughes (1831), R. H. Willmott (1847), George L. Duyckinck (New York, 1860) and by Edmund Gosse (1904) in the "English Men of Letters" series. The chief authority is still Eden's revision of Bishop Heber's memoir, which includes much valuable correspondence. S. T. Coleridge was a diligent student and a warm admirer of Jeremy Taylor, whom he regarded as one of the great masters of English style. A series of comments by Coleridge are collected in his *Literary Remains* (1838, vol. iii., pp. 203–390).

TAYLOR, JOHN (1580–1653), English pamphleteer, commonly called the "Water-Poet," was born at Gloucester on Aug. 24, 1580. After fulfilling his apprenticeship to a waterman, he served (1596) in Essex's fleet, and was present at Flores in 1597 and at the siege of Cadiz. On his return to England he became a Thames waterman, and was at one time collector of the perquisites exacted by the lieutenant of the Tower. He was an expert in the art of self-advertisement, and achieved notoriety by a series of eccentric journeys. With a companion as featherbrained as himself he journeyed from London to Queenborough in a paper boat, with two stockfish tied to canes for oars. *The Pennyles Pilgrimage, or the Moneylesse Perambulation of John Taylor . . . how he travailed on foot from London to Edenborough in Scotland . . .* 1618, contains the account of a journey perhaps suggested by Ben Jonson's celebrated undertaking, though Taylor emphatically denies any intention of burlesque. He went as far as Aberdeen. At Leith he met Jonson, who good-naturedly gave him 22 shillings to drink his health in England. Other travels undertaken for a wager were a journey to Prague, where he is said to have been entertained (1620) by the queen of Bohemia, and those described respectively in *A very merry, wherry ferry voyage, or Yorke for my money,* and *A New Discovery by sea with a Wherry from London to Salisbury* (1623). At the outbreak of the civil war Taylor began to keep a public-house at Oxford, but when the Royalists surrendered the city he returned to London, where he set up a similar business at the sign of "The Crown" in Phoenix Alley, Long Acre. He was buried in the churchyard of St. Martin's-in-the-Fields on Dec. 5, 1653.

Sixty-three of Taylor's "works" appeared in one volume in 1630. This was reprinted by the Spenser Society in 1868–69, being followed by other tracts not included in the collection (1870–78). Some of his more amusing productions were edited (1872) by Charles Hindley as *The Works of John Taylor.* They provide some very entertaining reading. Mr. Hindley edited other tracts of Taylor's in his *Miscellanea Antiqua Anglicana* (1873).

TAYLOR, JOSEPH (*c.* 1586–1652), English actor, is mentioned in the folio Shakespeare of 1623 as one of the 26 who took principal parts in all of these plays. He was with the duke of York's company in 1610, but involved himself in a lawsuit with John Hemings by leaving them to join the Lady Elizabeth's in the next year. He appeared in the actor list of the latter company in *The Honest Man's Fortune* (1613) and *The Coxcomb* (1613). From 1616 he was one of the prince's company, but left them to join the king's men in 1619. He remained with them until he retired, playing several of Burbage's parts, including Ferdinand in *The Duchess of Malfi,* and Hamlet. There is a legend that he was trained by Shakespeare to play Hamlet. In many of Beaumont and Fletcher's plays he had a leading role, and he is one of the ten actors who signed the dedication of the first folio of these dramatists (1647). He led the king's men, with Lowin, after Hemings and Condell, and in 1630, after Hemings's death, obtained two shares in the Globe, and one in the Blackfriars theatres. In 1639 he was appointed yeoman of the revels. He died at Richmond, where he was buried on Nov. 4, 1652.

TAYLOR, ROWLAND (d. 1555), English Protestant martyr, was born at Rothbury, Northumberland; he took minor orders at Norwich in 1528 and graduated LL.B. at Cambridge in 1530 and LL.D. in 1534. Adopting reformed views he was made chaplain by Cranmer in 1540 and presented to the living of Hadleigh, Suffolk, in 1544. He was further preferred to a canonry of

Rochester (1547) and the archdeaconry of Exeter (1552). Apparently he advocated the cause of Lady Jane Grey, for on the 25th of July 1553, only six days after Mary's proclamation as queen, he was committed to the custody of the sheriff of Essex. He was released not long afterwards, and with the support of his parishioners offered strenuous resistance to the restoration of the Mass. He was consequently imprisoned in the King's Bench prison on March 26, 1554. He was sentenced on Jan. 22, 1555, and burnt on the 9th at Aldham Common near Hadleigh.

See Thomas Quinton Stow's *Memoirs of Rowland Taylor* (1833); *Dict. of Nat. Biogr.* lv. 463–4, and authorities here cited.

TAYLOR, TOM (1817–1880), English dramatist and editor of *Punch*, was born at Bishop Wearmouth, on Oct. 19, 1817. He was a fellow (1837) of Trinity college, Cambridge, and for two years professor of English literature at University college, London. He was called to the bar (Middle Temple) in Nov. 1846, and went on the northern circuit until, in 1850, he became assistant secretary of the Board of Health. On the reconstruction of the board in 1854 he was made secretary, and on its abolition his services were transferred to a department of the Home Office. He retired on a pension in 1876. Four burlesques of Tom Taylor's were produced at the Lyceum in 1844. He made his first hit with *To Parents and Guardians* (Lyceum, 1845). He also wrote some burlesques in conjunction with Albert Smith and Charles Kenny, and collaborated with Charles Reade in *Masks and Faces* (1852). Before the close of his life his dramatic pieces numbered over 100, amongst the best known of which are *Our American Cousin* (1858), produced by Laura Keene in New York, in which Sothern created the part of Lord Dundreary; *Still Waters Run Deep* (1855); *Victims* (1857); and the *Ticket of Leave Man* (1863).

Taylor wrote leaders for the *Morning Chronicle* and the *Daily News*. He was on the staff of *Punch* until 1874, when he succeeded Shirley Brooks as editor. He was a good amateur actor, an artist, and an art critic of *The Times*. He died at Lavender Sweep, Wandsworth, on July 12, 1880.

TAYLOR, ZACHARY (1784–1850), twelfth president of the United States, was born in Orange county, Virginia, Sept. 24, 1784. Within the year his father, Richard Taylor, an officer in the Revolutionary War, made a new home for his family in Kentucky where Washington appointed him collector of the port of Louisville, then on the border and Spaniards and Indians were still a menace. In this environment Zachary Taylor spent his youth, and gained what little schooling he was to enjoy from Elisha Ayres, a New England tutor, who was employed by the elder Taylor to ground his numerous family in the rudiments. In 1806 he volunteered during the difficulties caused by Aaron Burr's southwestern schemes and saw brief service. Two years later through the instrumentality of his relative, James Madison, and others, Zachary Taylor was given a commission by Jefferson as first lieutenant in the seventh infantry, the beginning of his military career of 40 years duration.

As captain and major he served through Harrison's Indian campaign and the War of 1812 in the northwest territory and at the close of the war temporarily left the army because reduction to peace-time strength had lowered his rank. However in 1816 President Madison reappointed him to his old rank and there ensued twenty years of garrison life at various posts, varied in 1832 by an expedition against Black Hawk. The outbreak of the Seminole War in 1837 found him an infantry colonel in the Northwest and soon orders came for him to take his command to the Everglades. In this bewildering warfare he spent three years gaining promotion to the rank of brigadier-general by brevet for his service in the battle of Kissimmee on Lake Okeechobee and receiving command of operations. He was able to make little impression against these Indian foes and in 1840 asked to be relieved. He was given command of the first department with headquarters in Louisiana, which enabled him to acquire a plantation at Baton Rouge and establish a home where he spent many intervals between tours of inspection. When Texas was acquired in 1845 it fell to him to protect the new possession and he was ordered by the War department to occupy the borders of Texas; by the spring of 1846 he had moved down to the mouth of the Rio Grande with a force of over 3,000 men and established Ft. Brown. The Mexican army was concentrated across the river with orders to drive the Americans out of the contested area; the result was a skirmish on the American side of the river, April 24, and war was immediately declared. Taylor found himself in a precarious situation because of the exposed position of his base of supplies at Pt. Isabel and while manoeuvring to protect this base he fought the Mexican army winning two victories at Palo Alto (*q.v.*) and Resaca de la Palma (*q.v.*) on May 8 and 9, 1846. These victories sent the Mexicans across the river to Matamoras. Taylor was unprepared to follow up his advantage so when he finally crossed the river and occupied Matamoras (May 18), the enemy had gone. The news of these victories was received with great appreciation throughout the country and various persons including Whig editors and politicians began to see the possibilities of a presidential candidate in the victorious general. Thereupon, because Gen. Winfield Scott, commander of the army, was so slow in preparing to take active charge, President Polk placed Taylor in command of the invasion of Mexico and appointed him major-general at first by brevet and then in full rank. After slow preparations at Matamoras he moved in August to the head of navigation on the Rio Grande where he established a depot at Camargo and then set out for his first objective, Monterey. September 21–24 witnessed a series of vigorous skirmishes, heroic assaults and grave errors. Taylor with little knowledge of military science or the use of artillery resolved to take the town by bayonet assault which caused considerable slaughter of his own men. But the fighting was so effective that on the third day the Mexicans agreed to surrender if they be permitted to retreat and be granted an eight weeks' armistice, subject to the approval of the respective governments. Taylor accepted these terms, and "Old Rough and Ready," was acclaimed once more throughout the land.

Vexations followed. The War department began to make suggestions as to the movements of his subordinates and the administration disapproved the armistice. These matters incensed Taylor who was becoming convinced that Polk and Marcy were trying to discredit him because of their political differences. He vetoed the plans for his subordinates, wrote a letter to Gen. Gaines criticizing the administration which later found its way into the press and brought down Marcy's rebuke, and moved on to Saltillo which he occupied Nov. 16, deciding to take possession of the territory between that point and the sea-coast where Tampico had fallen into the hands of the navy. While carrying out these plans he received a letter from Gen. Scott informing him that Scott was to lead an expedition into Mexico and, without divulging the plan, indicated that he would need most of Taylor's troops, requesting a meeting to perfect the details. Taylor upon receiving this note decided that instead of meeting Scott he would go as far away as he could, and accordingly went to Victoria which Quitman had lately occupied. When Scott learned of this move, he contented himself with ordering the greater part of Taylor's troops to the coast to embark for Vera Cruz while with the remainder Taylor was to defend the occupied territory in northern Mexico. Taylor protested to the War department and informed Senator Crittenden that he was a receptive candidate for the presidency. Reluctantly he led the remnant of troops left him by Scott back to Monterey, but instead of remaining there moved southward where word came that Santa Anna with 20,000 troops was advancing upon Taylor who had only a quarter of that number. The armies met at Buena Vista (*q.v.*), Feb. 22, 1847, and in spite of his lack of skill, his army inspired by his presence snatched a victory from defeat and the north of Mexico was saved. At home, the feeling was general that Taylor had been stripped of his troops by a jealous administration and left to perform the impossible. This ended his military activity but his political availability increased.

Shrewd politicians had become increasingly convinced of his potentialities as a candidate. The Whig party was especially in need of a strong candidate to retrieve the defeat of 1844. Very early in the war, Thurlow Weed of New York began pushing him and popular enthusiasm made his task easier. His correspondence was skillfully handled; he was reluctant, he maintained, and with truth, to be a seeker for the office; he had never voted and though a Whig in sympathy was not an avowed partisan. As a slaveholder also he was certain to gain votes in the South where there was a good deal of suspicion that northern influences dominated the Whig managers. These advantages were sufficient to ensure success and in the Whig convention on the fourth ballot, Taylor won the nomination from Clay, Webster and Scott. An opportune split in the Democratic party ensured his victory and on March 5, 1849 he was inaugurated.

Few presidents have had less knowledge of what was expected of them. The new executive expected to be a non-partisan president, leaving to Congress all legislative matters and confining himself to executing the laws. With Col. Bliss, his son-in-law, to phrase his thoughts, he, at first, was more or less influenced in his policies by Vice-Pres. Fillmore, but it was not long before the superior astuteness of Sen. Seward, Fillmore's rival in New York State, accomplished results. The new president became convinced that it was his duty to build up the Whig party by means of clever patronage, and deserving Whigs began to come into their own.

With these preliminary lessons learned, Taylor found his most perplexing problem to be the status of the newly acquired territory. As a soldier he was anxious to see stable government established. In order to hasten this he authorized Congressman King of Georgia to go to California and urge an application for statehood. When Congress met, Dec. 1849, the President had the pleasure of reporting that California was ready to become a State and that New Mexico would be soon. He recommended the admission of California and hoped that the slave issue would not be injected into the situation. When Southern representatives objected because California had prohibited slavery, he resented their protests. He declared himself willing to accept any law providing for admission, passed by Congress and warned Southern leaders that he would take the field if necessary to carry out such a law and hang any who resisted. His attitude was the natural reaction of a military executive to those opposed to the regular process of law and order. Consequently he was not in favour of conciliating those opposed and referred contemptuously to the Compromise measures of 1850 as the "Omnibus Bill." In other respects his administration was not proving a sinecure; charges were made against his secretary of war, Crawford, to the effect that he had used his official position to pursue a claim successfully before the secretary of the treasury by which he benefited financially. This charge involving the secretaries of war and the treasury as well as the attorney-general, deeply mortified Taylor who prided himself on scrupulous honesty and he determined to reorganize his cabinet. Then came the fatal July 4, 1850, when exposure to the heat and injudicious eating combined with worry, aggravated an attack of typhus fever, which caused his death five days later.

A combination of honesty, simplicity, determination and common-sense had brought him successfully through a variety of difficult situations and by a strange turn of the wheel carried him to the White House.

Taylor had six children, three of whom survived him. One daughter, Sarah Knox Taylor, gained his reluctant consent to marry a young subaltern, Jefferson Davis, in 1835, surviving the marriage but three months. His only son, Richard Taylor (1826–1879) graduated from Yale in 1845 and after a short service in his father's camp, became a sugar-planter and politician in Louisiana. At the outbreak of the Civil War he entered the Confederate army and served in various capacities, finally commanding an army which surrendered in May 1865.

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TAYLOR, an anthracite-mining borough of Lackawanna county, Pennsylvania, U.S.A., on the Lackawanna river. Pop. (1920) 9,876 (29% foreign-born white).

TAYLOR, a city of Williamson county, Texas, U.S.A., 35 m. N.E. of Austin, on the Missouri-Kansas-Texas and the Missouri Pacific railways. Pop. (1920) 5,965 (23% negroes) estimated locally at 7,500 in 1928. The city gins 40,000 bales of cotton in a normal year; has three chick hatcheries, railway shops and other manufacturing industries. Natural gas was turned into the city mains on Sept. 1, 1928. Taylor was founded in 1876, incorporated in 1882 and has had a commission-manager form of government since 1910. It was named after General Zachary Taylor.

TAYLOR'S THEOREM, the statement of a formula discovered by Brook Taylor (*q.v.*) in 1712, and published three years later in his *Methodus incrementorum directa et inversa* (1715). The formula provides for the expansion of a function of $x+h$ as follows:—

$$f(x+h) = f(x)+hf'(x)+\frac{h^2}{2!}f''(x)+\ldots$$

A related formula, published by the Scottish mathematician Colin Maclaurin (1698–1746) in 1742 and bearing his name, gives the expansion of a function of x in the following manner:

$$f(x) = f(0)+xf'(0)+\frac{x^2}{2!}f''(0)+\ldots$$

It often happens that the value of such expressions as sin$x$, tan$x$, log$x$, and e^x is required to a higher degree of accuracy than is given by available tables; for example, the value of tan 1·2 radians. In this case tan$x$ can be expanded by such formulae and its value can be found by substituting 1·2 for x. (*See* SERIES.) (D. E. S.)

TAYLORVILLE, a city of central Illinois, U.S.A., on the Sangamon river, 26 m. S.E. of Springfield; the county seat of Christian county. It is served by the Baltimore and Ohio, the Chicago and Illinois Midland and the Wabash railways. Pop. 5,806 in 1920 (92% native white); estimated locally at over 11,000 in 1928. There are four large coal mines near by.

TCHEREPNIN, NICOLAI (1873–), Russian composer, was born at St. Petersburg (Leningrad) on May 15, 1873. He first studied law, and it was not until 1895 that he decided to take up music. He then entered the conservatoire, where he took composition with Rimsky-Korsakov. In 1901 he was appointed conductor of the Belaeiev orchestral concerts in St. Petersburg and from 1908–14 he conducted for Diaghilev in Paris and elsewhere. In 1914 he returned to Russia and from 1918–21 was director of the conservatorium at Tiflis, after which he settled in Paris. His best known works are the ballets: *Le pavillon d'Armide* and *Narcissus*. *A Russian Fairy Tale* was produced by Madame Pavlova's company. In 1925 he wrote *The Romance of a Mummy*. Other works are: *Narcissus and Echo* and *The Enchanted Garden* (symphonic poems), two masses, and a string quartet.

His son ALEXANDER TCHEREPNIN, born in St. Petersburg in 1899, is a well-known pianist and composer, his principal works being: *The Frescoes of Ajanta* (ballet, produced by Pavlova, 1923), a piano concerto and sonatas, a concerto for flute and violin with small orchestra op. 33 (1925), and a string quartet, op. 36, entitled "Liebesopfer der heiligen Therese vom Kinde Jesu."

TCHERNAIEV, MIKHAIL GREGORJOVICH (1828–1898), Russian general, a member of a noble family, was born on Oct. 24, 1828. Educated at the Nicholas Staff college, he entered the army in 1847, and distinguished himself in the Crimean war and in the Caucasus. After serving as divisional chief of the staff in Poland, he went to Orenburg in 1858 as assistant to the commander of the line of the Syr-Darya, and the following year commanded an expedition to support the Kirghiz tribes on the borders of the Sea of Aral against the Khivans. He did duty on the staff of the army of the Caucasus for a time, and returned to Orenburg as chief of the staff. In 1864, having reached the rank of major-general, he made his famous march with 1,000 men across the steppes of Turkestan to Chimkent in Khokand, to meet another Russian column from Semipalatinsk, in Siberia, in conjunction with which he successfully stormed Chimkent, and then unsuccessfully attacked Tashkent, 80 miles farther south. Wintering at Chimkent, he captured Tashkent the following year. This was contrary to his instructions, and although he was received in St. Petersburg with enthusiasm, and presented with a sword of honour by the emperor, he was not again employed in the military service, and retired from it in July 1874. He bought, and edited with great success, the *Russkiy Mir* in Slavonic interests, devoting himself to the Panslavic idea. In the summer of 1876 he was appointed commander-in-chief of the Serbian army, but on entering Turkey was driven back by Osman Pasha, who followed him into Serbia defeating him at Zayechar and Yavor in July, and the campaign in Serbia proved disastrous. He rashly proclaimed Milan king of Serbia in September, and in October Aleksinats and Deligrad were in the hands of the Turks, and the road open to Belgrade. An armistice was concluded, and Tchernaiev resigned his command. In 1877 he visited Austria in connection with his propaganda, but was expelled, and lived for a time in France. In 1879 he organized a Bulgarian rising, but was arrested at Adrianople and sent back to Russia. He succeeded Kaufmann (*q.v.*) as governor of Turkestan in 1882, but his aggressive policy led to his recall two years later, when he was appointed a member of the council of war at St. Petersburg. In 1886 his opposition to the Central Asian Military railway caused him to lose his seat in the council. He died on the 16th of August 1898, at his country seat in the province of Mogilev.

TCHERNOV, VICTOR (VICTOR OLIENIN), co-founder and for many years the principal leader of the Russian socialist revolutionary party, was first associated with its predecessor, the "people's right" group. Until 1914 he occupied a centrist position in the party, but during the world war he differed from other leading members by reason of his anti-war attitude. He participated in the Zimmerwald conference of 1915. After the February 1917 revolution he held the position of minister for agriculture in the coalition government of May 1917, but soon withdrew owing to the opposition of the other coalition parties to his radical agrarian proposals. During 1917 he was unable to control his party or to get its various groups to adopt a single programme, and his position as leader of the "peasants' party" was largely stultified in consequence. Still, he was elected President of the All-Russian Constituent Assembly which opened on January 18th, 1918 and, after a single day's session, was dispersed by the Bolshevist Government. After this, Tchernov took an active and leading part in the anti-Bolshevist movement on the Volga. After the end of civil war, he readapted his centrist attitude and, as the editor of *Revolutionary Russia*, he continued his activity as one of the leaders of the Social-Revolutionary Party. He escaped from Russia in 1918 and has since been living in exile.

TCHIHATCHÓV, PIERRE ALEXANDROVICH (1812–1890), Russian naturalist and geologist, was born at Gatchina near St. Petersburg, in 1812. He entered the diplomatic service and was (1842–44) attached to the embassy at Constantinople; whence he visited Asia Minor, Syria and Egypt. In 1844, he was charged with a scientific mission to the Altai mountains. He died at Florence on the 13th of October 1890 (N.S.).

His publications include: *Voyage scientifique dans l'Altai oriental et les parties adjacentes de la frontière de Chine* (with atlas, 1845); *Asie Mineure; description physique, statistique et archéologique de cette contrée* (4 vols. with 3 atlases, 1853–69); *Le Bosphore et Constantinople* (1864, another ed. 1877); *Considérations géologiques sur les Îles Océaniques* (1878); and *Espagne, Algérie et Tunisie* (1880).

TCZEW (German DIRSCHAU), a town of Poland, in the province of Pomorze, on the left bank of the Vistula, 20 m. S. from Danzig, at the junction of the main railway lines Danzig-Bydgoszcz and Berlin-Königsberg. The river is here crossed by two fine iron bridges. The chief industries are railway workshops and the manufacture of sugar, cement and agricultural implements. In 1923 it was found impossible to deal with the whole timber export from Poland at Danzig alone. Part of the goods, therefore, were unloaded at Tczew. The project is therefore being considered of connecting the town with the sea by a canal. If this is realized, Poland will have two ports to supplement the city of Danzig.

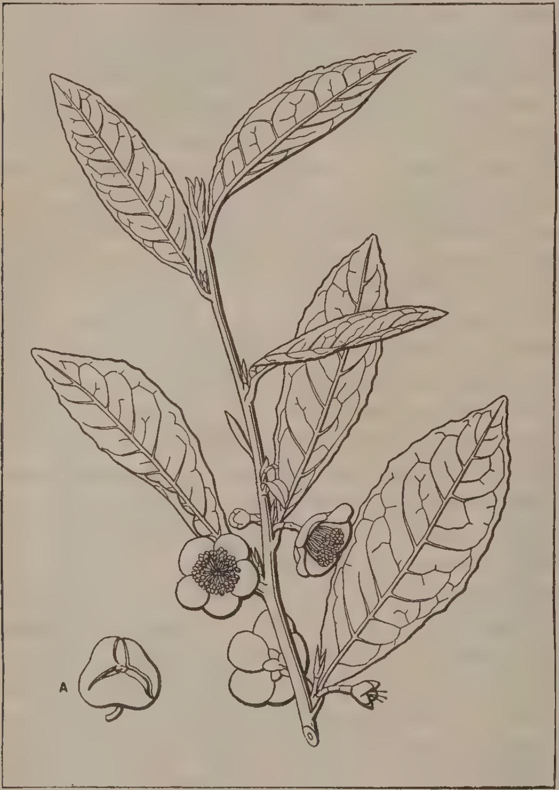
TEA, the name given to the leaves of the tea bush (Chinese *cha,* Amoy dialect *té*), prepared as a beverage. The term is by analogy also used for an infusion or decoction of other leaves, *e.g.,* camomile tea; and similarly for the afternoon meal at which tea is served.

The Discovery of Tea.—The early history of tea as a beverage is mainly traditional. According to Chinese legend, the virtues of tea were discovered by the Emperor Shên-nung, 2737 B.C., to whom all agricultural and medicinal knowledge is traced. A tradition exists in China that a knowledge of tea travelled eastward to and in China, having been introduced A.D. 543 by Bodhidharma, an ascetic who came from India on a missionary expedition. Bodhidharma vowed that he would contemplate the virtues of Buddha through 9 unsleeping years. At the end of 3 years he slept and in his anger at his weakness he cut off his eyelids and threw them on the ground beside him. After a further five years of contemplation he again felt drowsy and plucking some leaves from a nearby shrub he found stimulation to complete his 9 years. This shrub was called *cha,* or tea. The use of tea in China in the middle of the 9th century is known from Arab sources (Reinaud, *Relation des Voyages,* 1845, p. 40). From China a knowledge of tea was carried into Japan, and there, according to historical records, the cultivation was established during the 9th century.

The earliest mention of tea by an Englishman is probably that contained in a letter from Mr. Wickham, an agent of the East India Company, written from Firando in Japan, on the 27th June 1615, to Mr. Eaton, another officer of the company, resident at Macao, and asking for "a pot of the best sort of *chaw.*" It was not till the middle of the century that the English began to use tea, and they also received their supplies from Java till in 1686 they were driven out of the island by the Dutch. At first the price of tea in England ranged from £6 to £10 per lb. In the *Mercurius Politicus,* No. 435, of September 1658, the following advertisement occurs:—"That excellent and by all Physitians approved China Drink called by the Chineans *Tcha,* by other nations *Tay, alias Tee,* is sold at the Sultaness Head, a cophee-house in Sweetings Rents, by the Royal Exchange, London." Thomas Garway, the first English tea dealer, and founder of the well-known coffee-house, "Garraway's," in a curious broadsheet, *An Exact Description of the Growth, Quality and Virtues of the Leaf Tea,* issued in 1659 or 1660, writes, "in respect of its scarceness and dearness, it hath been only used as a regalia in high treatments and entertainments, and presents made thereof to princes and grandees." In that year he purchased a quantity of the rare and much-prized commodity, and offered it to the public, in the leaf, at fixed prices varying from 15s. to 50s. the lb., according to quality, and also in the infusion, "made according to the directions of the most knowing merchants and travellers into those eastern countries." Pepys's often-quoted mention of the fact that on September 25, 1666, "I did send for a cup of tee, a China drink of which I never had drunk before," proves the novelty of tea in England at that date.

Until the Revolution no duty was laid on tea other than that levied on the infusion as sold in the coffee-houses. By 1 William and Mary, c. 6, a duty of 5s. per lb. and 5 per cent. on the value was imposed. For several years the quantities imported were very small, and consisted exclusively of the finer sorts. The first direct purchase in China was made at Amoy, the teas previously obtained by the Company's factors having been purchased in Madras and Surat, whither it was brought by Chinese junks after the expulsion of the British from Java. During the closing years of the century the amount brought over seems to have been, on the average, about 20,000 lb. a year. The average price of tea at this period was 16s. per pound.

As the 18th century progressed the use of tea in England rapidly increased, and by the close of the century the rate of consumption exceeded an average of 2 lb. per person per annum, a rate in excess of that of to-day of all people except those of Mongol and Anglo-Saxon origin. The business being a monopoly of the East India Company, and a very profitable one, the company at an early stage of its development endeavoured to ascertain whether tea could not be grown within its own dominions. Difficulties with China doubtless showed the advisability of having an independent source of supply. In 1788 Sir Joseph Banks, at the request of the directors, drew up a memoir on the cultivation of economic plants in Bengal, in which he gave special prominence to tea, pointing out the regions most favourable for its cultivation. About the year 1820 David Scott, the first commissioner of Assam, sent to Calcutta from Kuch Behar and Rangpur—the very districts indicated by Sir Joseph Banks as favourable for tea-growing—certain leaves, with a statement that they were said to belong to the wild tea-plant. But it was not till 1834 that Captain Francis Jenkins proved the fact of the genuine tea-plant being a native of British territories in Upper Assam. In the meantime a committee had been formed by Lord William Bentinck, the governor-general, for the introduction of tea culture into India. Evidence of the abundant existence of the indigenous tea-tree was obtained; and the directors of the East India Company resolved to institute an experimental establishment in Assam for cultivating and manufacturing tea.



Flowering shoot of the tea plant (Camellia Thea, Linn.), and (A) seed pod

In 1834 the monopoly of the East India Company was abolished and an era of rapid progress in the new industry began. In 1836 there was sent to London 1 lb. of tea made from indigenous leaves; in 1840 there were grown, and offered at public auction in Calcutta early the following year, 95 packages, "the produce of the Government tea plantation in Assam." This auction is most interesting as being the first of British-grown tea, and it included about 6,000 lb. In Jan. 1840 the Assam Company was formed to take over the early tea garden of the East India Company.

The Dutch were rather earlier than the English in attempting to establish tea growing in their eastern possessions. A beginning was made in Java in 1826, but probably because of the even more marked influence of Chinese methods and Chinese plant, the progress was slow and the results indifferent. Later, however, by the introduction of fine Assam seed and the adoption of methods similar to those in use in India, great success was achieved.

Somewhere about 1860 the practical commercial growing of tea was introduced into the island of Formosa. The methods of cultivation and manufacture followed there differ in many ways from those of the other large producing countries, but the industry has been fairly successful throughout its history.

Attempts were repeatedly made to introduce tea culture in Ceylon, under both Dutch and British authority. No permanent success was attained till about 1876, when the disastrous effects of the coffee-leaf disease forced planters to give serious attention to tea. Since that period the tea industry has developed with marvellous rapidity, and now takes first rank in the commerce of the island.

Since the beginning of the 20th century tea-growing has been established in certain districts in Africa and also in Sumatra, where in 1926 the production exceeded 138,000,000 pounds.

(X.)

Botany of Tea.—The tea bush or tree is a member of the family Theaceae (formerly included under Ternstroemiaceae) and closely related to the well-known ornamental shrub the Camellia. As cultivated in China it is an evergreen shrub growing to a height of from 3 to 5 ft. The stem has numerous and very leafy branches; the leaves are alternate, leathery, elliptical, obtusely serrated, strongly veined and placed on short, channelled footstalks. The under side of the young leaf is densely covered with fine hairs, which disappear with increasing age. A characteristic feature of the cellular structure of the tea-leaf is the presence of large, branching, thick-walled, smooth cells (idioblasts), which, although they occur in other leaves, are not found in such as are likely to be confounded with or substituted for tea. The flowers are white, axillary and slightly fragrant, often two or three together on separate pedicels. The fruit is a woody capsule containing one to three or more nearly spherical seeds about the size of a hazel nut. The plant was originally described by Linnaeus as one species, *Thea sinensis.* Later, Linnaeus recognised two species, as previously described by Hill, viz., *Thea viridis* and *Thea Bohea,* and it was erroneously assumed that the latter was the source of black tea, while *Thea viridis* was held to yield green tea. In 1843, however, Robert Fortune found that black and green tea were produced from the leaves of the same kind of plant by varying the manufacturing process.

For botanical reasons the tea plant is now referred to the genus *Camellia* and is usually described as *Camellia Thea Linn.,* though some authorities, on grounds of priority, would prefer the name *Camellia theifera* (Griffith) Dyer.

Sir George Watt (*Jour. Roy. Hort. Soc.,* vol. xxxii., 1907) described the recognised varieties and races of *Camellia Thea* (with special reference to those of India) and placed them in the following classification:

A. Variety *viridis*:—races
  1. Assam Indigenous.
  2. Lushai.
  3. Naga Hills.
  4. Manipur.
  5. Burma and Shan.
  6. Yunan and Chinese.
B. „ *Bohea.* (China, Japan, Formosa, India.)
C. „ *stricta.* (India, China.)
D. „ *lasiocalyx.* (Malacca, Penang.)

Teas of Commerce.—Of the foregoing, the teas of commerce are derived almost entirely from the varieties *viridis* and *Bohea.* The Assam Indigenous, in its two sub-races of Singlo and Bazelona, and the Manipur have, with various intermixtures and crossings, been used to cover the greatest areas of all the more modern planting in India, Ceylon and the Dutch East Indies (Java and Sumatra). The large size of leaf when fully developed (4 to 9 in. long and 2 to 3½ in. broad) has made them in demand because of the heavy yields. From the variety *Bohea,* or from hybrids of descent from it, came the China teas and the earlier plantings in India grown from imported China stock. The leaves of this variety are generally about half the size of those of the Assam Indigenous and Manipur sorts. The bush is in every way smaller than the Assam types. The latter is a tree attaining in its natural conditions, or where allowed to grow unpruned as in a seed garden, a height of from 30 to 40 feet. Full information regarding the botanical classification of the plants yielding China teas is not yet available, but it would seem that in the main they fall under the varieties *viridis* and *Bohea.*

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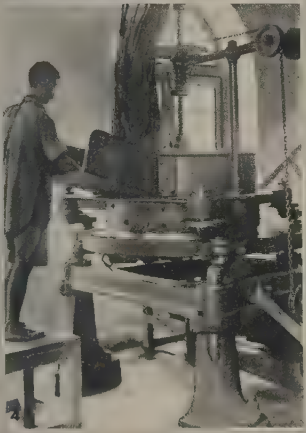
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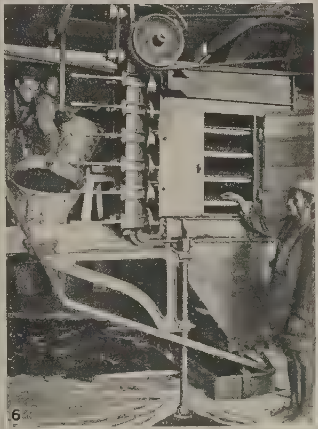
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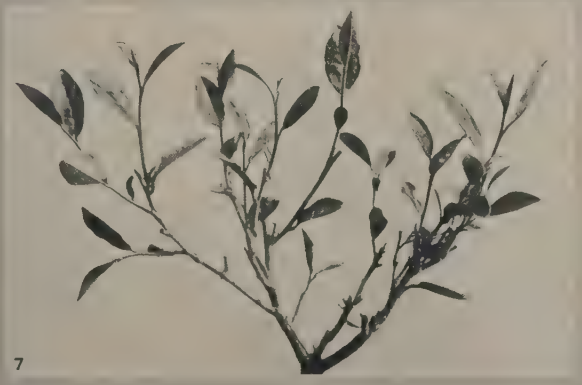
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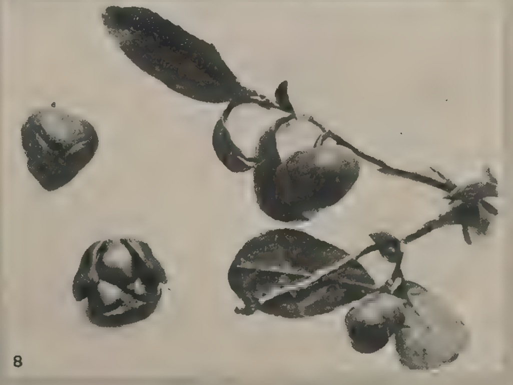
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BY COURTESY OF THE INDIAN TEA ASSOCIATION, LONDON

CULTIVATION OF TEA

1. Chinese coolies transporting tea from the fields in baskets. 2. Young coolies waiting in line to have their baskets of tea weighed. 3. Plucking tea leaves in the field. Both hands are used. 4. Rolling the tea. A twist is imparted to the leaves by the top and bottom tables which revolve in opposite directions. 5. Withering the tea leaves. This is one of the most important of all the operations in tea manufacture. About 18 hours are needed to complete the process. 6. Firing the tea in a "Venetian" drier. A temperature of 220° F. is maintained. 7. A tea shoot. Only the bud spike and the first two leaves are plucked. 8. Tea seed-vessels showing seeds

Much controversy has taken place as to the original home of the tea-plant. The modern view is that the plant is probably indigenous to the whole monsoon region of Eastern Asia, notably the Assam-Yunan area.

Tea Planting.—The following account of the planting, harvesting and manufacture of tea may be taken as generally representative of the practice adopted in India, Ceylon, Java and Sumatra which, apart from China and Japan, are the chief tea-producing countries.

Climate and Soil.—For its successful cultivation as a crop plant tea requires a warm, sub-tropical climate and a moist, steaming atmosphere resulting from frequent, copious rains. It thrives best in rich, light, friable soils, containing stores of humus, well drained and of good depth. Undulating, well-watered tracts where the rain escapes freely, yet without washing away the soil, are the most valuable for tea gardens. Propagation is from seed obtained from special plants set apart for seed purposes. The young plants are raised in carefully prepared nurseries and, when about 6 or 8 inches high, are set out in the plantation at a distance of from 4 to 6 ft. each way. Much attention is paid to the cultivation of the soil and the weeding of the plantation.

The value of manures is now widely recognised by planters, and animal, chemical and "green" manures are used.

Pruning.—Pruning is a most important operation and is designed to produce a bush of convenient size for plucking and to increase leaf-production. Commonly, the plant when one or two years old is cut down to within less than a foot of the ground. The main stem thus removed is replaced by three or four lateral branches which, after growing for two years, are cut back at the second pruning and later themselves bear laterals. Subsequent prunings in India are usually carried out annually, or at longer intervals in Southern India and in Ceylon. Old bushes yielding poor crops are often "heavy pruned" by cutting down to within 12 or 15 inches from the ground.

Plucking.—A very small crop of leaf may be obtained in the second year after planting out; in the third year about 150 lb. of finished tea per acre per annum is obtained in the Indian plains; and by the sixth or eighth year the bushes should be in full bearing yielding from 400 lb. to 1,000 lb. of finished tea per acre annually. In India plucking is carried out every seven to ten days, there being 20 to 30 pluckings during the season. The first plucking or "tipping" is done when the new shoots are about 9 inches long and with not less than five or six leaves, excluding the apical bud and the scale-leaf at the base of the shoot.

This plucking removes the apical bud and the two youngest leaves and is carried out more for the purpose of inducing further "flushes" (young shoots) from the axils of the remaining leaves than of obtaining leaf. The flushes are taken every seven or ten days. In the best practice the tip of the shoot, including two leaves and the terminal bud, is the standard pluck; one leaf and the bud yields a finer tea, while a pluck of three or four (older) leaves gives a coarser tea. Late in the season a heavy "close pluck" of nearly all leaf growth is commonly taken to secure a heavy crop. The finest teas are produced at high elevations in Darjeeling (India) and Ceylon and in the plains of Assam.

Pests and Diseases.—Among insect enemies of the tea plant the so-called "mosquito" (*Helopeltis theivora*), a plant-bug, is the most serious, other important pests being "red spider" (a mite, *Tetranychus bioculatus*), pink mite (*Eriophyes* [*Phytopus*] *theae*), the misnamed "green fly" (a plant-bug, *Chlorita flavescens*) and "thrips" (*Physothrips setiventris*, the common thrips; and *Haplothrips tenuipennis*, the black thrips); a number of caterpillars and scale insects also cause damage. All these pests attack the leaves or young shoots. Among blights of vegetable origin the so-called "red-rust" of the leaves and shoots, caused by an alga (*Cephaleuros parasiticus*), is probably the most serious. The chief fungus diseases are "grey blight" (*Pestalozzia Theae*) and "blister blight" (*Exobasidium vexans*) which attack the leaves and shoots; while "pink disease" (*Corticium salmonicolor*), branch canker (*Nectria* sp.) and "die-back" are stem diseases; root diseases caused by fungi also occur.

Tea Manufacture.—In the making of a good quality tea much depends upon the character of the plant and the circumstances of its growth and cultivation, but satisfactory methods of manufacture in dealing with the plucked leaf are also essential. Formerly, the processes were carried out by hand methods, but in the most modern practice machinery is employed in practically every operation. In the manufacture of tea the most important feature is the regulation of the fermentation (oxidation) process. This fermentation is the cardinal feature in the making of black teas (which form by far the greater part of the teas entering commerce), but in preparing green teas the fermentation is prevented.

BLACK TEA.—The following are the stages in the manufacture of black tea:

(1) *Withering.* The plucked leaf is brought at once into the shady withering house and spread thinly in sterilised shallow trays made of hessian, bamboo or wire netting and arranged on racks; or, the leaf is commonly spread on clean withering floors. Withering is complete when the leaf has become soft and flaccid. The process usually occupies from 18 to 20 hours but must obviously depend upon varying conditions of temperature and moisture of the air. On this account special machines for withering the leaf under conditions which may be readily controlled are now being widely used. The immediate object of withering is to obtain the leaf in a physical condition suitable for the subsequent rolling, but during the process the oxidising enzyme (ferment) present in the leaf, which brings about the important changes in the later fermentation process, greatly increases in quantity, while other chemical changes also take place.

(2) *Rolling.* The withered leaf is fed into the "jackets" of rolling machines which operate by rubbing the leaf, under adjustable pressure, between two metal surfaces. The time occupied in the rolling varies from 15 to 60 minutes after which the rolled leaf is sifted and the older leaves treated again; irregular balls of leaf are broken up by revolving beaters fitted to the sieves. Rolling imparts to the tea its characteristic "twist," but the operation is essentially subservient to the fermentation process which is an oxidation of the cell-contents of the leaf. The rolling ruptures the leaf-cells and the juice (sap) is pressed out on to the surface of the tissue where, under the influence of the oxidising enzyme (oxidase) present, its constituents combine with the oxygen of the air. This is the commencement of the fermentation.

(3) *Fermentation.* This process is designed to encourage the chemical action initiated during the rolling. The leaf removed from the rolling machines is transferred to the darkened fermenting rooms where it is spread out in layers 1 or 2 inches thick to give full access to the air which is freely admitted. In large factories special fermenting floors made of cement, tiles or plate glass squares, which can be readily sterilised when necessary, are used. The atmosphere of the room is kept moist usually by suspending wet cloths or by mechanical water sprays. During fermentation the leaf colour changes to a bright copper shade. The colourless "tannin" present becomes partly oxidised into reddish-brown products, giving "body" and colour to the tea liquor; while the characteristic odour and flavour of tea are also developed. The oxidation, however, must not be allowed to proceed too far or the quality of the tea is affected as a result of an excess production of insoluble brown substances. Investigations have shown that a number of micro-organisms (chiefly yeasts and bacteria) are always present in fermenting tea leaf. The organisms are present on the fresh leaf and increase during the withering and fermentation. Improvement in the flavour and aroma of the tea appears to be associated with increased numbers of yeast cells. It is possible to improve the qualities of the tea by the use of cultures of "pure" selected yeasts.

(4) *Firing or Drying.* The action of the oxidising enzyme is arrested at the desired moment by means of heat. The fermenting leaf is transformed to machines ("tea driers") where it passes automatically over a series of moving "tables" in the drying chamber through which hot air is passed. The firing is completed in about half an hour, though a second firing may be necessary. The firing arrests fermentation by the destruction of the enzyme and also dries the tea.

(5) *Grading*: The fired tea is subsequently sifted into grades which in the main correspond to the size of the leaf. The four chief grades of black tea, arranged in descending order of quality are Orange Pekoe, Pekoe, Pekoe Souchong and Souchong, the first-named being the youngest leaf.

The graded tea is stored in air-tight receptacles until it is required for packing. Previous to the latter it is again dried by machinery (the final firing) and is then ready for packing in the familiar lead-lined chests which are now usually made of three-ply wood.

GREEN TEA.—In making green tea the primary object is to prevent the occurrence of the chemical changes which take place in the withering and fermenting processes of black tea manufacture. The plucked leaf is therefore subjected to heat as the first process in the manufacture, with a view to the destruction of the oxidising enzyme in the leaf tissue. In China the method is by heating in cast-iron pans, but in India and Ceylon, where green tea is also made on a small scale, the plucked leaf is placed in a cylindrical steam heater for one or two minutes. Subsequently the moisture is removed in a centrifugal machine and the leaf subjected to a short and light rolling. The green tea is then fired (dried), graded and packed as in the case of black tea. The total tannin in green tea is higher than that in black tea made from similar leaf. This results from the fact that, during the fermentation of black tea, a proportion of tannin is converted (oxidised) into red and brown substances which are not extracted by hot water. (S. E. C.)

TEA: CONSUMPTION AND TRADE. The world's annual consumption of tea is in the region of 900 million pounds. This is exclusive of the tea consumed by the population of China which, in the nature of things cannot even be estimated.

The sources of supply, with their fluctuations during the last thirty years, may be gauged from the following table:

Exports of Tea

Year	*India	†Ceylon
	Pounds	Pounds
1896–7	150,421,245 (100)	110,095,194 (100)
1905–6	214,224,000 (142)	170,184,000 (154)
1915–6	338,470,000 (225)	215,633,000 (195)
1925–6	325,733,000 (216)	209,700,000 (190)
1926–7	349,264,000 (233)	217,082,000 (197)
	China	Java
1896–7	240,106,266 (100)	..
1905	132,367,000 black and green 61,494,000 brick, tablets and dust (80)	25,650,156 (100)
1915	143,662,000 black and green 93,777,000 brick, tablets and dust (98)	101,603,000 (400)
1925	88,020,000 black and green 23,048,000 brick, tablets and dust (46)	94,774,000 (376)
1926	82,897,000 black and green 29,012,000 brick, tablets and dust (46)	118,713,000 (472)

*India, fiscal year.
†Ceylon, calendar year as in left hand column.

(The percentage figures have been added in brackets for the sake of comparison.) India and Ceylon, as sources of the world's tea supplies, show a steady increase. Java, thanks to the energy and enterprise of the Dutch, exhibits a remarkable advance.

The acreage under tea in India during the same period with the production therefrom is shown by the following table:

Year	Acreage	Production
		lbs.
1895–9 (average)	467,291	158,375,000
1906	532,208	241,077,000
1915	634,940	372,203,000
1926	739,700	392,918,000

In 1927, Ceylon produced 226 million pounds of tea from 403,000 acres. Java and Sumatra together produced 136 million pounds from 250,000 acres.

Japan's production was in the same year 176,153 piculs, equal to 23½ million pounds, very little of which found its way into the United Kingdom. The Island of Formosa (Japanese) produced 22 million pounds in 1925, mostly Oolong.

Of the varieties of tea, the great proportion produced in British India and in Ceylon is good, sound black tea. Thus, while India exported 360 million pounds of black during the season 1927–8, only 945,000 pounds of green left the country. During 1927, the proportions exported from Ceylon were 225 million pounds of black to about 2 million pounds of green. The latter figures compare with over 5 million pounds of green in 1913, a symptom of the general decline in the taste for green tea. The export of tea from China is divided into several kinds. Thus in 1926, the proportions were: black, 39 million pounds; green, various sorts, 43 million pounds; brick and tablet (mostly exported to Russia through North Pacific ports) 18 million pounds; other sorts, including unfired, scented, siftings, dust and stalk, 10 million pounds.

Of the smaller producing states, it is noteworthy that Nyasaland sends small quantities to the British market, nearly a thousand packages having been sold during the first half of the year 1928. Kenya Colony had in 1927, 3,156 acres under tea, producing 8,700 lb.—a pioneer industry which is likely to expand. Other centres of production for local consumption are Natal, Persia, the Caucasus, Annam, Burma, Palestine, and even the southern part of the United States. The quantity is very small in each case.

Importation and Consumption.—Great Britain and Northern Ireland consume more tea than all other countries combined. On the authority of the Tea Brokers' Association of London the following figures of imports are given:

Imports of Tea for Home Consumption

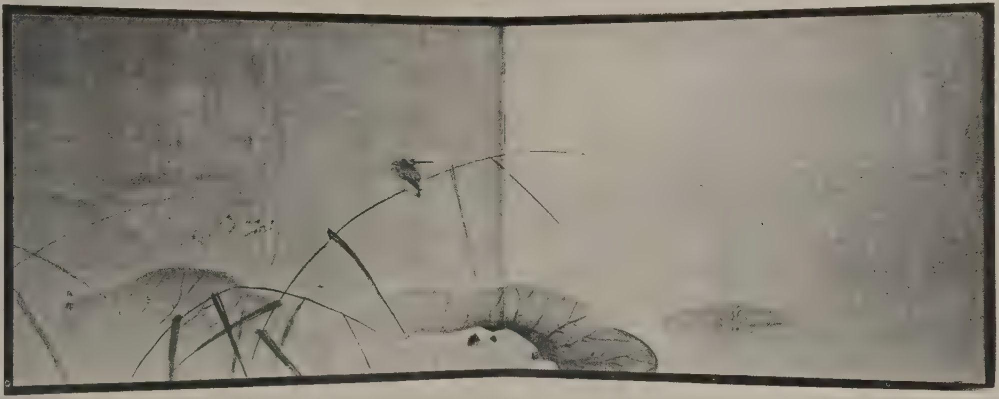
Countries	1927	1926
	lbs.	lbs.
Great Britain and Northern Ireland	416,152,552	408,836,871
United States of America	88,518,696	95,926,377
Australia	49,672,000	46,950,000
Canada	38,116,897	37,629,652
Russia (European)	35,794,450	31,768,607
Irish Free State	23,767,045	23,596,281
Holland	22,453,000	21,153,000
Persia	12,000,000	12,341,617
Union of South Africa	11,812,072	10,303,132
Germany	11,409,361	10,115,689
Morocco	11,000,000	11,183,672
New Zealand	10,827,381	10,863,556
Countries consuming less than ten million pounds	60,825,046	57,872,385
TOTAL	792,348,500	778,540,839

(The figures for 1926 are revised: those for 1927 provisional.)

Of the total imports of tea into Great Britain and Northern Ireland in 1927,—539,348,620 pounds valued at £41,751,333—416,152,552 pounds were retained for home consumption. The sources of this tea were as follows:

Importation of Tea for Home Consumption into Great Britain and Ireland, 1927

From	Quantity
	lbs.
British East Indies (except Ceylon)	232,534,080
Ceylon	109,754,985
China, including Hongkong and Macao: black	10,567,308
China, including Hongkong and Macao: green	82,289
Java, Sumatra and other Dutch Possessions and Netherlands	61,240,148
Other countries	1,973,742
	416,152,552



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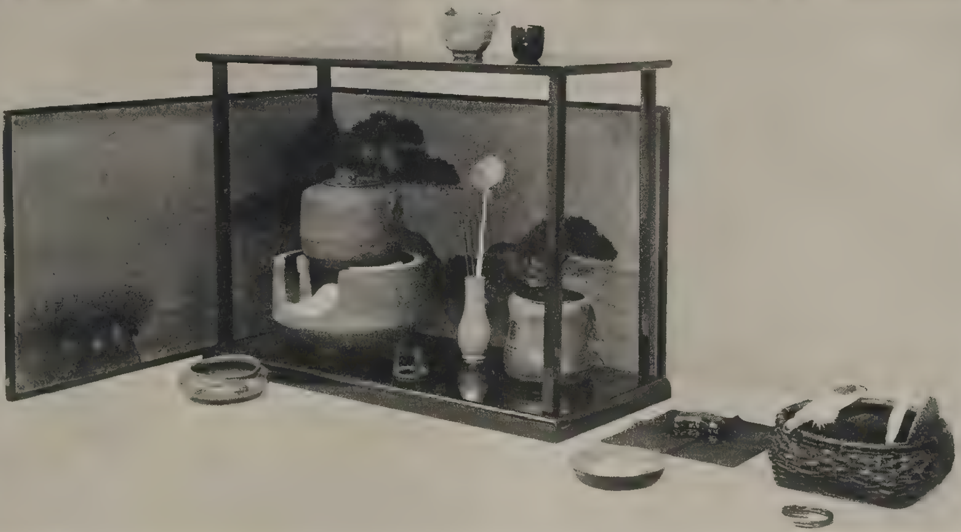

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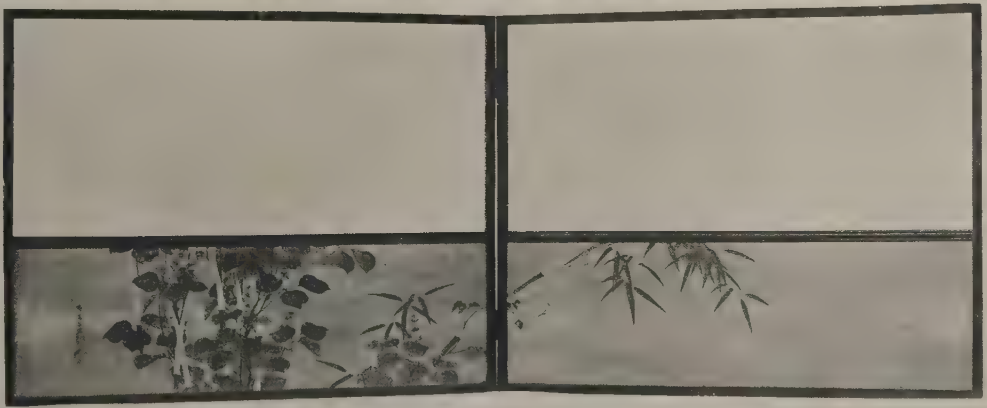

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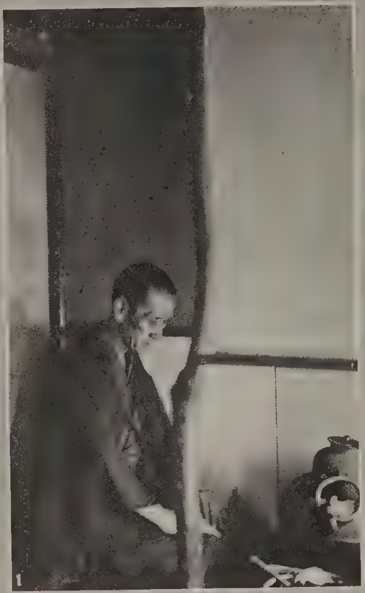
BY COURTESY OF (1, 3) THE TOKYO IMPERIAL HOUSEHOLD MUSEUM, (2) THE METROPOLITAN MUSEUM OF ART, NEW YORK

TEA SET AND SCREENS USED IN THE TEA CEREMONY

1. Furosaki-byobu tea screen painted by Hashimoto Gahō, 20th century. Height, about 2½ ft.; length of each panel, 3 feet
2. Daisu (shelf) with tea ceremony utensils
3. Tea screen by Kō Sūkoku

PLATE II

TEA CEREMONY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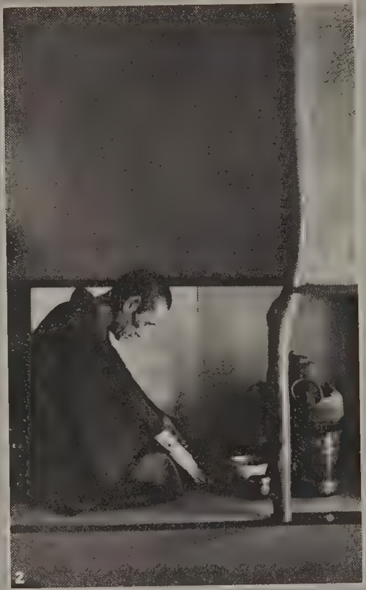
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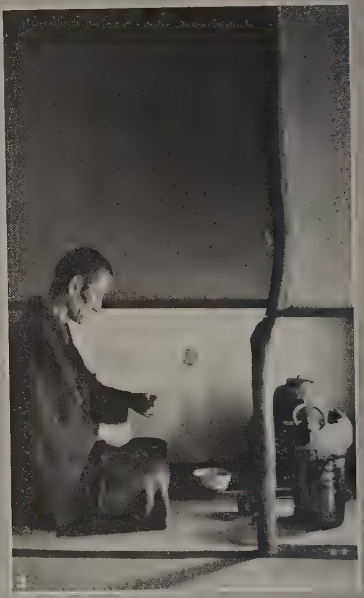
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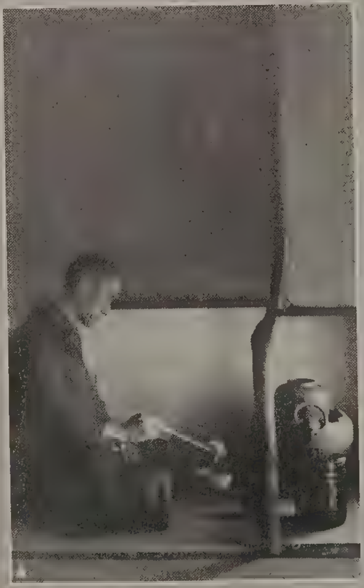
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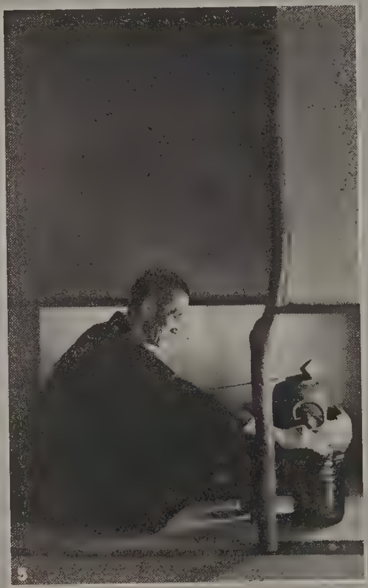
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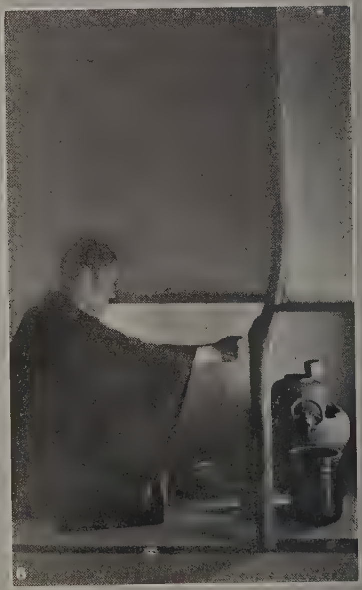
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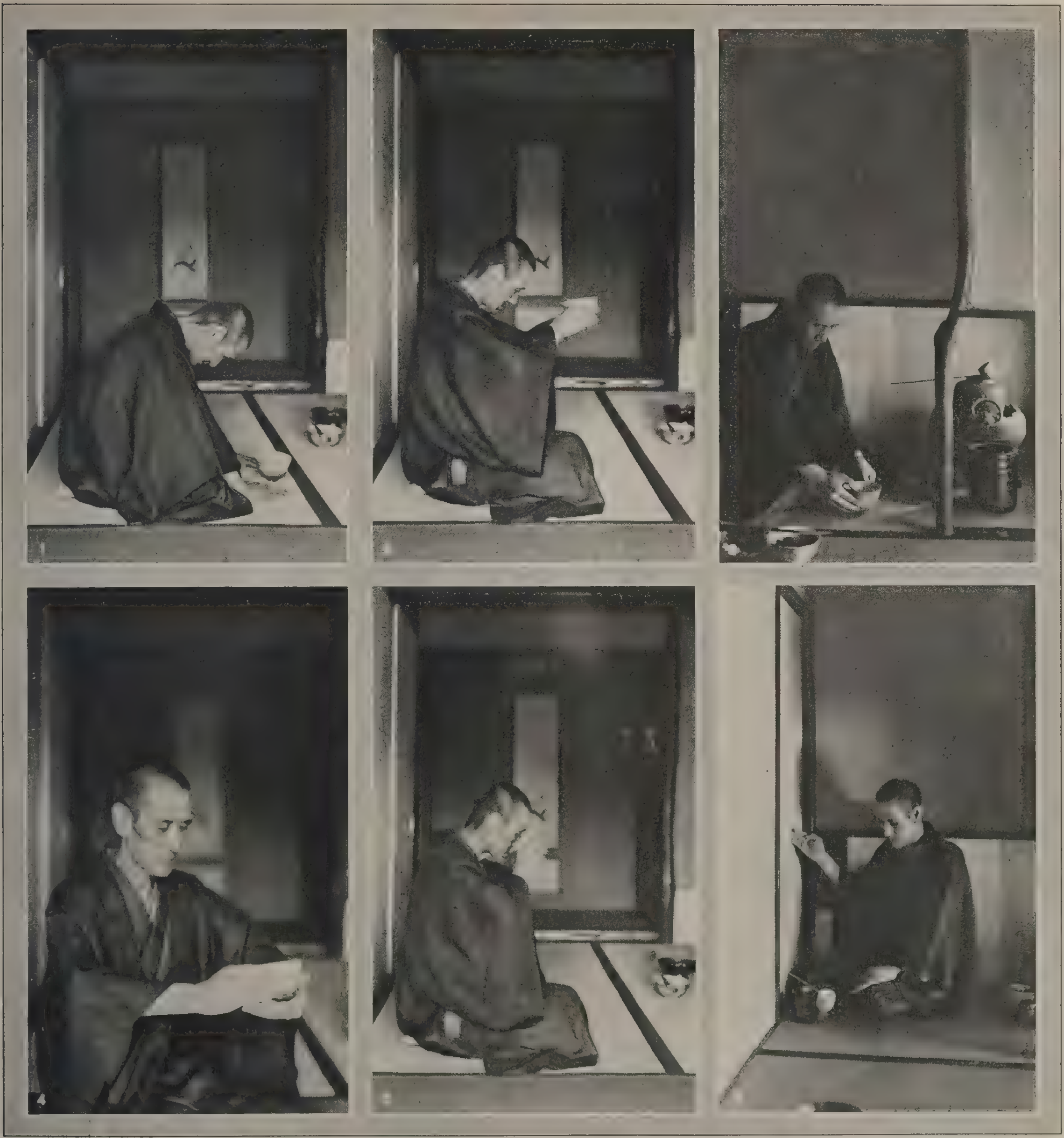
BY COURTESY OF JIRO HARADA

METHOD OF PREPARING TEA FOR THE TEA CEREMONY

1. The host has just brought in a basket of charcoal to replenish the fire in the brasier and a case of incense to perfume the room. There is an art and science in making the fire; a rhythmic motion in manipulating the charcoal with a pair of iron sticks, and the placing of the charcoal is well thought out to enable it to ignite and blaze up quickly
2. Having brought in everything to the cha-seki (tea-room) and sitting in front of the iron kettle, which murmurs tranquilly like the lone pine tree by the sea, the host is making obeisance before proceeding to prepare the tea
3. Picking up the dipper made of bamboo, which he holds before him as if he were holding a mirror, the host is shown in a pose just before proceeding to remove the lid of the kettle
4. Having removed the lid of the kettle the host is pouring hot water into the tea bowl to rinse it and also the bamboo whisk to be used for stirring the pulverized tea in hot water
5. The host is about to take the lid off the water jar. Of the infinite number of ways in which the lid may be removed, only one, the most beautiful, way is insisted on. Each movement must be beautiful, not only in itself, but in its relation to that which precedes and that which follows it
6. Having placed a quantity of pulverized tea in the bowl, the host is taking up the dipper to get hot water from the kettle and to pour it over the tea to be whipped with a bamboo whisk already rinsed. The pulverized tea is kept in a keramic or lacquered caddy, and a bamboo or ivory scoop is used for taking out the tea



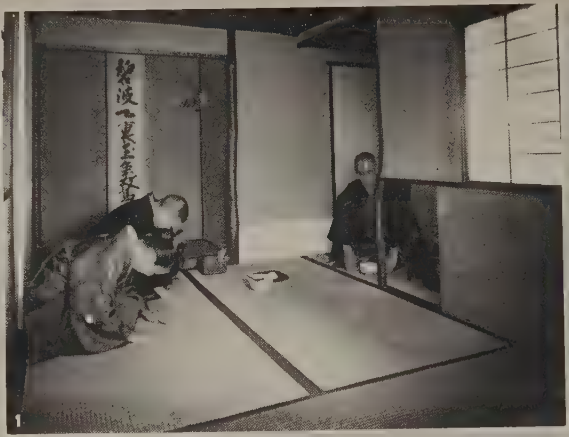
BY COURTESY OF JIRO HARADA

ETIQUETTE OBSERVED BY HOST AND GUEST IN THE TEA CEREMONY

1. After having eaten the sweet, the guest receives the bowl of tea, places it on the mat upon which he sits, and makes obeisance to the host before taking it up to drink
2. The guest holding up the bowl of tea to his forehead in token of respect before proceeding to drink. His mind should be so perfectly calm and attuned to higher things of life that it may be susceptible to any aesthetic suggestion the bowl of tea may bring
3. The host about to offer a bowl of tea to the guests who, having finished their tea, persuade him to partake of it, having placed the sweets near him. This pose shows the host in the act of picking up the bowl to place it towards the guests before accepting it for himself
4. The bowl should be held secure in both hands, its perfect balance in the hands being essential to the maintenance of the mental equilibrium. The bowl thus held, the beauty of the green beverage, whose bubbles may suggest the evanescence of life, must not escape notice
5. Drinking the tea in three sips and a half, the last being accompanied by an appreciative sound of drawing the last drop. After wiping the edge where his lips touched, he looks into the bowl for the tea design may perchance give him a clue for an aesthetic contemplation and the beauty of the bowl should not escape his appreciation
6. The host after everybody has finished drinking the tea is about to open the sliding door to take away the utensils from the cha-seki (tearoom). Etiquette requires that he be on his knees when opening or shutting the sliding screens

Plate IV

TEA CEREMONY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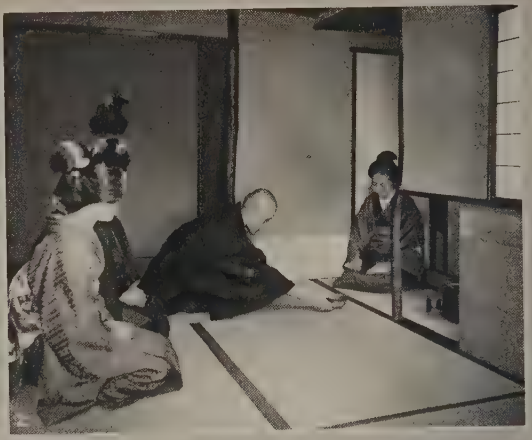

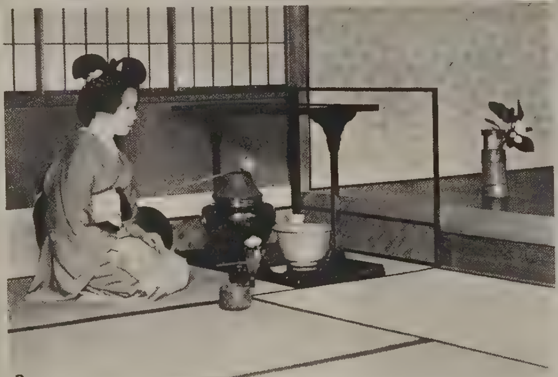
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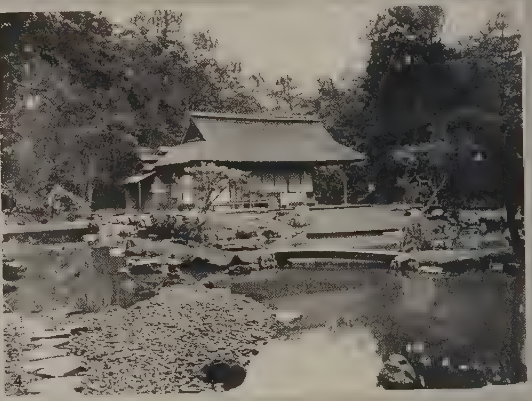
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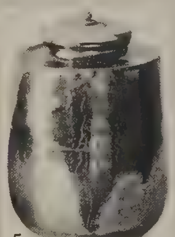
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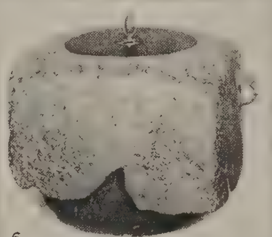
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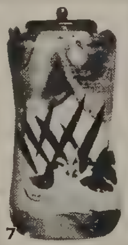
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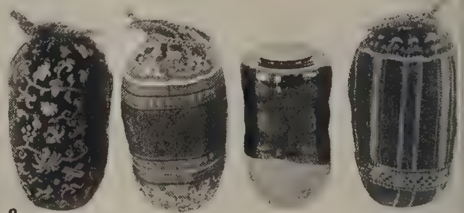
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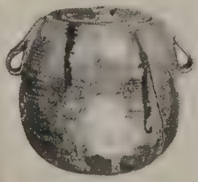
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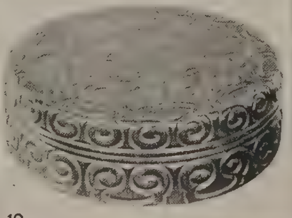
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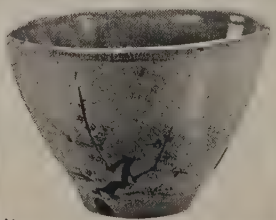
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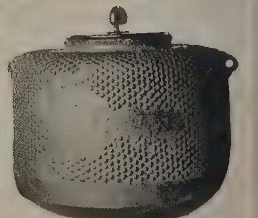
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BY COURTESY OF JIRO HARADA

ETIQUETTE OBSERVED BY HOST AND GUEST IN THE TEA CEREMONY

1. *Usu-cha* (thin tea). The host is about to drink tea at the persuasion of the guests after they have finished drinking theirs. In the cha-seki belonging to Mr. Miyazaki, a tea-master in Nagoya. 2. *Koi-cha* (thick tea). The head guest is receiving the bowl of tea from the hostess. In the *cha-seki* (tea-room) belonging to Mr. Miyazaki, a tea-master in Nagoya. 3. The hostess is ready to prepare tea in the *hiro-ma* (large room). 4. *Cha-seki* in the garden of the Katsura detached palace in the suburb of Kyoto. 5, 7. Ceramic tea caddies with ivory lids. 6, 12. Iron kettles used in tea ceremony. They have extra pieces of iron stuck to the inside bottom so that the kettles, when the water becomes heated, may murmur even as the lone pine tree by the sea. 8. A ceramic tea caddy, with three brocade bags belonging to it. Bags contain dummies so as to keep them in shape. 9. Ceramic water jar used in the tea ceremony. 10. Carved lacquer incense case, used in tea ceremony. 11. Ceramic tea bowl for drinking the pulverized green tea whipped in hot water in the tea ceremony

Tea Consumption per Head.—The present per capita consumption, in the principal consuming countries of tea in pounds per head, arrived at by dividing the figures as given above for home consumption by the latest ascertainable number of the population, is as follows: Great Britain and Northern Ireland, 9·4; New Zealand, 9; Australia, 8·3; Irish Free State, 7·6; Canada, 4; Holland, 3·2; South Africa, 1·7; United States of America, ·84; European Russia, ·27; Germany, ·18; France ·07.

Value of Imports and Duty.—The average landing values of tea in the United Kingdom for the following years may be compared:

Country	1899	1913	1916	1927
	d. per lb.	d. per lb.	d. per lb.	d. per lb.
India . . .	9·25	9·24	11·25	19·06
Ceylon . . .	8·80	9·04	11·49	20·20
China . . .	7·24	9·00	11·22	16·31
Java and Netherlands . . .	. .	8·03	10·68	14·22

The duty since 1900, when it was raised from 4d. to 6d. per lb., has been as follows: 1904, 8d.; 1905, 6d.; 1906, 5d.; 1914, 8d.; 1915, 1s.; 1919, 10d. British grown, 1s. foreign grown; 1922, 6⅔d. British grown, 8d. foreign grown; 1924 and since, 3½d. and 4d.

How Consumed.—In Great Britain, Ireland and the British Dominions, tea is drunk simply as an infusion and usually with milk and sugar. In Russia, the samovar is traditional and a pot of strong China tea is made. A little of the liquor is put in a glass and filled up with boiling water from the samovar, and a spoonful of jam or a slice of lemon, and a lump of sugar added. In America, iced tea is a hot-weather drink. (C. L. T. B.)

TEA-CADDY, a box, jar, canister or other receptacle for tea. The word is believed to be derived from *catty,* the Chinese pound, equal to about a pound and a third avoirdupois. The earliest examples that came to Europe were of Chinese porcelain, and in shape resembled the ginger-jar. They had lids or stoppers likewise of china, and were most frequently blue and white. The English kilns at first imitated them, but speedily devised forms and ornament of their own, and there was hardly a ceramic factory in the country which did not compete for the supply of the new fashion. But tea-caddies were not for long confined to porcelain or faience. They were presently made in a variety of materials, and in an equal variety of shapes. On the whole the mahogany or rosewood caddy of the latter part of the 18th and the early years of the 19th century was, from the artistic point of view, the most elegant and satisfying.

TEA CEREMONY is a time-honoured institution in Japan—an institution rooted in the principles of Zen (a sect of Buddhism) and founded upon the adoration of the beautiful in the daily routine of life, such as preparing a meal and tea, cleaning the house and garden, etc. The Japanese word for tea ceremony, *Cha-no-yu,* literally hot water of tea, means an aesthetic way of entertaining guests, usually five at a time, with thick and weak tea of pulverized tea-leaf whipped in hot water, preceded by a meal, according to the established rules of etiquette. The entertainment takes place in the tea-room (*chaseki*), usually a small building constructed to suggest a refined poverty, though with great forethought and after endless trouble in the choice of the material and in the construction. The room in which the guests are entertained is generally about 9 ft. square, or smaller, containing an alcove for ornaments and a small fire-place for boiling the kettle, sunk into the floor. Into that room each guest in humility crawls through a small opening less than 3 ft. square. It is connected with the waiting room by stepping stones through a garden path (*roji*), which should contain a water basin (*tsukubai*) for the guests to rinse mouth and wash hands before entering the tea-room.

In this ancient institution—for it was founded under the Shogun Yoshimasa (1449–73) and perfected by Sen-no Rikyu in the 16th century—which still continues to influence the life of the Japanese people and all their art, the spirit of old Japan still lives.

BIBLIOGRAPHY.—E. S. Morse, *Japanese Homes and Their Surroundings* (1885); F. Brinkley, *Japan—Its History, Arts and Literature* (1901); Kukuzo Okakura, *The Book of Tea* (1906). (J. HAR.)

TEACH [THATCH or THACH], **EDWARD** (d. 1718), English pirate, popularly known as Blackbeard, is believed to have been born at Bristol. He is said to have gone out to the West Indies during the war of the Spanish Succession, to have engaged in privateering, and after the declaration of peace (1713) to have turned pirate, but he is not actually heard of in this capacity till the end of 1716. The following year he captured a large French merchantman, rechristened her "Queen Anne's Revenge," and converted her into a warship of forty guns. His outrages in the Spanish main, the West Indies, and on the coasts of Carolina and Virginia, quickly earned him an infamous notoriety. He made his winter quarters in an inlet in North Carolina, the governor of which colony was not above sharing in the proceeds of his crimes, but the governor of Virginia at last despatched two sloops, manned from the British warships on the station, to cut him out. On Nov. 22, 1718 Lieutenant Maynard boarded Teach's sloop, after a sharp fight, and himself shot the pirate dead.

TEACHERS, TRAINING OF. The training of teachers dates, in England, from the beginning of the 19th century, when the National Society for Promoting the Education of the Poor in the Principles of the Church of England and its Nonconformist rival, the British and Foreign School Society, first attacked the problem of elementary education on a national scale. Both these societies adopted the "monitorial system," the principle of which was that picked older scholars should learn their lessons from the adult teacher in charge of the school and hand them on to the younger children. Some training of the instruments of this system was found to be necessary and training schools were accordingly set up to give it. One of these developed into the Borough Road training college which is still in existence. About 1840 James Kay (afterwards Sir James Kay-Shuttleworth), a far-seeing official to whom, more than to any other single man, the English educational system is due, began the movement which replaced the monitors by "pupil-teachers," *i.e.,* boys and girls who were regularly apprenticed for a period of five years from the age of 13, and both learnt the art of teaching and continued their education under the head teacher of an elementary school. Kay's scheme also involved training colleges where the professional and academic education of at least the best pupil-teachers could be carried to a higher stage after their apprenticeship was completed. He himself founded the college which, as St. John's College, Battersea, London, was taken over by the National Society and furnished a model widely imitated. Within a few years the Church had training colleges in a large proportion of its dioceses and there was a smaller number of others founded by Nonconformist bodies. As the result of Kay-Shuttleworth's efforts these colleges came into a definite relation with the Government; they received financial assistance towards the cost both of building and of maintenance, a competitive examination was instituted upon the results of which "Queen's Scholarships" were awarded to ex-pupil-teachers who came to them for a period of training, and contributions were made to the salaries of the teachers they turned out. As a condition of this financial aid to the colleges and their students, the Government laid down the courses to be followed, conducted the examinations on the results of which it awarded to successful candidates its Elementary School Teacher's certificate and required the colleges to submit to inspection.

The "voluntary" colleges which developed upon this basis became and are still a very important factor in the elementary school system. They now number nearly 50 and supply about one-half of the trained teachers who enter the elementary school service. At the beginning of the present century the length of their course became standardized at two years; they are, accordingly, known officially as two year colleges.

The monopoly of training enjoyed by the colleges was broken in 1893, when new regulations made it possible for the universities to open grant-aided departments for the training of teachers for elementary schools. All the universities and university colleges, to the number of 22, have taken advantage of these regulations. The Education Act of 1902 made it possible also for local educational authorities to found and maintain training colleges. There are now about 20 of these "council" training colleges and their annual output of teachers is more than half that of the "voluntary" colleges. They differ from the latter type of colleges in the absence of any religious affiliation and in the circumstance that they are often "day" as distinguished from "residential" colleges.

The act of 1902 produced a much more important modification of the existing system in that it led to drastic changes in the education of pupil-teachers. Under the act the local authorities were given powers in connection with secondary as well as elementary education and could establish secondary schools. It thus became possible for the Board of Education to insist that entrants to training colleges should normally have taken a four year course in a secondary school. The effect of this reform upon the culture and outlook of the elementary school teacher—who had hitherto spent his life, as a rule, within the confines of the elementary system—has without doubt been beneficial in a very high degree. It has also led to the gradual disappearance of the pupil-teacher system, now only in vogue in some country areas; for as the customary standards of secondary education have risen it has proved impossible for the young intending teacher to comply with them, and at the same time to receive the old thorough training in teaching. In recent years pupil-teachers have, accordingly, tended to give place to "student-teachers," who have had an uninterrupted general education until the age of 17, and at that age enter upon a year of preliminary training in an elementary school chequered by continued attendance at their secondary school. But the departmental committee on the training of teachers for elementary schools reported in 1925 against the perpetuation even of this remnant of the old system; and although many of the provincial authorities still cling to a belief in its efficacy there is a growing tendency to follow the recommendations of the report and to allow intending teachers to complete the full secondary course terminating at the age of 18, and to enter college without passing through any considerable period of professional probation or initiation. The advantages looked for are a still wider and deeper culture in the teachers and the preservation of a power of growth which the older system, it is alleged, often destroyed; it is, on the other hand, only fair to note that the strain upon the disciplinary powers of the young teacher —which only the drastic training of the old system could enable him to meet—has largely disappeared under modern conditions.

The curriculum in the two year colleges has always included academic and professional elements side by side, though with the improvement in the educational standard of the entrants and the attenuation of their preliminary training there is a growing tendency to emphasize the professional side of the work. The academic studies are practically confined to subjects which enter into the curriculum of elementary (including central) schools; the professional work comprises instruction in the theory of education, methods of teaching, hygiene, practical subjects such as music, drawing and needlework, and teaching practice under supervision in schools. Hitherto the curricula have been laid down by the Board of Education and the board has, as a rule, conducted the final examination with a view to the award of the Elementary School Teacher's certificate. A change which must have far-reaching consequences is, however, now in progress. The board's examination is to be discontinued, the training colleges have been classified into groups around the several regional universities, and the universities will, with varying degrees of fullness of responsibility, step into the place which the board has vacated. Boards or delegacies, either appointed by the universities or largely filled by their representatives will conduct the final examination and, as an inevitable corollary, will prescribe the syllabuses of instruction. The Board of Education will, however, retain the right of judgment of the efficiency of the practical training given by the colleges. It is hoped in some quarters that intimate and fruitful relations between the colleges and the universities may develop from their association in the work of examination.

During the present century there have been important developments in the training departments of the universities. These were established to enable a select number of intending elementary school teachers to come under the broadening influences of university life and teaching; they have developed into institutions by whose aid future teachers in secondary and elementary schools may obtain a university degree and professional training. For some years the maximum length of the course was three years and professional training was given concurrently with the student's academic studies. It was, however, found that the full value of the scheme could not thus be obtained; the course was, accordingly, extended to four years, of which the first three are devoted practically entirely to preparation for a degree while the last is given wholly to a course of professional training comprising much the same elements as the professional course in the two year colleges. Students admitted to the four year course receive free academic teaching and professional training and, like the two year students, also receive an annual grant for maintenance from the Board of Education.

The original theory of the four year course was that it was to supply the elementary school system with teachers of superior ability, education and training; but a very large proportion of the graduates it turned out actually found their way into secondary schools. Eventually the board recognized the situation officially. It extended its grant system to include graduates in honours in the secondary training departments of the universities, and permitted four year students who had taken a degree in honours at the end of the third year to be transferred to those departments. So slight a change in official regulations has not often produced greater consequences. Formerly training expressly intended to fit teachers for secondary school work was an almost negligible factor in the English system; now some hundreds of young men and women, graduates in honours who have received such training, are entering the secondary schools annually from the universities. *See* also EDUCATION: *England.* (T. P. N.)

France.—Elementary teachers are generally recruited from the higher elementary school. They enter the training college at the age of 15 after passing the *brevet simple* or its equivalent and after a three year course take the *brevet supérieur,* and a test in teaching. All State teachers have to be trained. In the non-State schools the head alone of the teachers has to possess the *brevet simple.* Secondary teachers in the other classes of the *lycées* generally recruited from the *école normale supérieure,* have to pass the *agrégation,* a stiff competitive examination in knowledge and the art of setting forth a subject; teachers in the other classes are not obliged to be trained, their academic qualifications are deemed sufficient; teachers in the preparatory classes must possess the elementary certificate.

Germany.—Elementary teachers attend the ordinary training college. Those who teach in the secondary schools undergo a severe apprenticeship in the school to which they are attached, and pass an examination conducted by the Government inspector.

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NORMAL SCHOOLS AND TEACHERS' COLLEGES IN THE UNITED STATES

Teacher training schools in the United States, exclusive of departments of education in colleges and universities, fall into five general classes: State normal schools, State teachers' colleges, city normal schools and teachers' colleges, county normal schools and high schools and private normal schools. The first school for the preparation of teachers was opened at Lexington, Vt., in 1823 by Rev. Samuel Reed Hall, who had been a teacher as well as preacher, and who accepted the pastorate of the Congregational Church at Lexington on condition that he might conduct a seminary for teachers. The school continued for seven years.

State Normal Schools.—Massachusetts was the first State to establish normal schools. James G. Carter, who is called the "father of normal schools," being primarily responsible. Through his influence the State Board of Education of Massachusetts was established and the normal school bill was passed in 1838. Three normal schools were established, the first being opened at Lexington in 1839. New York established a normal school at Albany in

1844; Connecticut and Michigan authorized normal schools in 1849 and the Connecticut school opened the same year, the Michigan in 1852. In 1928 all but five of the 48 States have State teachers' colleges or normal schools.

Normal schools were established for the purpose of training teachers for the common schools, which generally meant the ungraded schools. The curriculum of the normal school at Lexington provided for a study of "all the common branches, particularly and fully; together with composition, geometry, algebra, physiology; natural, intellectual and moral philosophy; botany, political economy, bookkeeping, vocal music and the art of teaching."

State Teachers' Colleges.—The rise of many normal schools to the rank of teachers' colleges was a natural result of the development of education and especially of the remarkable growth of the high school. From the very first some of the normal school graduates, especially in the middle West, found their way into high schools; entrance requirements were gradually advanced, and in some the curriculum was extended to four years. In 1893 the Normal school at Albany became the Albany State Teachers' college and began to confer degrees. In 1897 the Michigan State Normal school became the Michigan State Normal college and was given the power to grant degrees. Other States in the middle West soon followed. The World War stimulated greatly the development of the teachers' colleges, for the lack of teachers called attention to the institutions which were largely responsible for training them. In 1920 the (U.S.) bureau of education listed 46 teachers' colleges, four of which were private institutions; in 1922 the number had increased to 80, in 1924 to 88, and in 1926 to 101. Since the 1926 bulletin was published several States have advanced their normal schools to full collegiate rank.

Other Normal Schools and Teachers' Colleges.—County normal schools were organized to supplement the State normal schools in the preparation of teachers for the rural schools. The curriculum in some States is one year beyond high school and in some two years. Among the States which have such institutions are Michigan, Wisconsin and Nebraska. In 1926 every State with the exception of New Hampshire reported teacher training in high schools. In a majority of instances the training is a part of the high school course. In other instances it is preceded by high school graduation. In some States the county normal organization is separate and apart from the public school system.

City normal schools or teachers' colleges have been established in connection with many of the larger city school systems. The length of the curriculum varies from two to four years. Institutions giving a four year course are generally called teachers' colleges and some grant the collegiate degree.

The private normal schools, of which the Bureau of Education lists 64, are largely schools for the training of teachers of physical education and for the kindergarten and primary grades. Most of these schools are associated with religious organizations. The curriculum of study is generally two years in length. (C. McK.)

TEACHERS' PENSIONS: *see* PENSIONS IN THE UNITED STATES; PENSIONS: *Civil Service, Municipal.*

TEACHERS REGISTRATION COUNCIL. Originally authorized by the English Education (Administrative Provisions) Act of 1907, the Teachers Registration Council was established by an Order in Council of Feb. 29, 1912. It consisted of 44 members, all of whom were teachers or persons recently engaged in teaching. These members were elected by the appointing bodies named in the first schedule of the Order in such a manner that eleven universities and 42 associations of teachers were represented on the council, 11 members being drawn from each of the four main groups of teachers.

Under a new Order, officially known as the "Teachers Registration Council Order, 1926," the number of the council may be increased to 50. There are four groups representing, respectively, university teachers, teachers in public elementary schools, teachers in secondary schools, specialist teachers with teachers in technical institutes, and each group is represented by 12 registered teachers engaged in the type of teaching work to which the group belongs. These 48 elected members may, if they choose, co-opt two additional members to represent any type of teaching work which, in their opinion, is inadequately represented among their own number. The period of office for each Council has been extended from three to five years. The 12 university members are appointed by the 12 universities now existing in England and Wales.

Representatives of teachers other than university teachers are elected directly by the registered teachers of the country, who vote according to the types of teaching work to which they belong, and have a number of votes equal to the number of representatives assigned to that particular type in the Order.

For admission to the register, the council has framed conditions which must be fulfilled by all applicants. The great variety of examinations in special subjects renders the task of standardization very difficult, but already the council has established standards of attainment and of professional training in connection with the teaching of such subjects as music, art, handwork and domestic science. The main principle that is being kept in view is that no one should be permitted to become a fully recognized teacher, or to claim professional status who has not undertaken a suitable course of study and a course of training in the art of teaching.

The council has recently taken steps to bring within its purview not only those who are eligible to become registered, but also those who are likely to become eligible, by the institution of a list of associate teachers, open to all who have passed an approved entrance examination. The council has decided to remove from the list of associate teachers all who do not become fully registered within seven years of their admission to the list. (G.)

In the United States there is no teachers' organization that corresponds to the Teachers Registration Council. There the governmental agencies certificate teachers directly, and there is no register kept except the list of persons who have been granted governmental certificates.

TEACHING, METHODS OF, for countries other than the United States *see* EDUCATION. The following section deals with a special phase of educational methods in the United States.

American students of education define teaching as the learning process. To promote the learner's growth is the teacher's objective, but growth, it is contended, results only from the activity of the learner himself. American educational theory looks upon the direct imparting of knowledge as a subordinate rather than a major function of the teacher. Especially does it condemn the "lecture method," and in the elementary and high schools anything resembling this method has long been taboo. The use of textbooks has been subjected to serious criticism, although the prevailing "pattern" of teaching still comprises (1) assignment of a textbook lesson, (2) independent study of the lesson by the pupils and (3) a class meeting or recitation for testing the pupils' efforts to learn the assigned materials.

Late in the '90s, the Herbartian "developmental" method was brought to the attention of American teachers through the writings especially of Charles DeGarmo and Charles A. and Frank M. McMurry. As crystallized in the "five normal steps of the recitation," developmental teaching aimed to lead the learner to make his own inferences and formulate his own conclusions, after a careful study of the facts in each case. This method also emphasized the importance of having the learner conscious of the aim or purpose of each lesson.

The "problem" method, in part an outgrowth of the Herbartian movement, gained its chief support from other sources. The theories of Froebel, at first limited in their application to the kindergarten (*q.v.*), tended to emphasize throughout the field of elementary education the importance of "doing" as contrasted with "knowing." Manual training, introduced as a complement to and corrective of mental training, was gradually integrated with the latter; problems of construction in the workshop provided a field of application for the lessons of the classroom, and the needs of construction furnished motives for learning new lessons. John Dewey's insistence that school is life rather than merely preparation for life also encouraged the educational use of problems that arise in the everyday experience of children. The development of a dynamic psychology added strength to the growing conviction that knowledge may be most effectively brought to the learner, not in a logically organized form, but rather in the context of real problems and as a means of meeting real needs and conquering real obstacles.

The "project" method has been the natural outcome of this increasing recognition of the problem as the basic unit in teaching and learning. Long used in schools of architecture, the term "project" was taken over by secondary vocational education about 1912 and applied particularly to "home projects" in agriculture and the household arts. The conception of the project as a relatively large problem "carried to completion in its natural setting" was amplified by Werrett W. Charters and John A. Stevenson and applied to educational fields other than strictly vocational. Under this conception, a large problem arising under conditions closely approximating those of real life may become the centre around which can be organized some of the skills, facts and principles the learner is expected to master.

A less restricted conception of the project method has been developed by William H. Kilpatrick. In Kilpatrick's theory, the essential characteristic of a true project is not to be sought in any set of objective conditions, but rather in the attitude of the learner toward his learning activities. Some advocates of project teaching hold that the teacher's primary duty is to watch for these learning activities, to seize upon such of them as are worthy, and then to guide the learner toward their realization. According to this view all learning activities should originate in the learner's own spontaneous purposes and any imposition of learning tasks by the teacher would be an injustice. This limitation obviously excludes assigned lessons or prearranged courses of study. In fact a radical wing of the project group would have the school curriculum grow from day to day—even from hour to hour—in response to the interests and purposes of the learner.

While the theory of project teaching has had a pronounced vogue and is, indeed, the central and dominant doctrine of the "Progressive Education" (*q.v.*) movement, certain other proposals, not in harmony at all points with the project theory, have attracted attention. The plans for intensive individual instruction proposed by Mrs. Helen Parkhurst (the Dalton plan) and Carleton W. Washburn (the Winnetka plan) give a central place to carefully organized and closely articulated subject-matter assignments which the learner masters *seriatim,* progressing at his own rate but having advice and guidance from the teacher.

Closely related to these plans are the numerous devices for promoting individual learning developed as a result of the testing movement: practice exercises which provide drill on the essentials of arithmetic and language; remedial exercises to correct the weaknesses revealed by diagnostic tests; and "self-administered" measures of various types which enable the learner to note the progress that he makes. These devices provide "problems" for learning, as do the assignments of the Dalton and Winnetka plans, but not the type of problem that the project theory emphasizes.

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TEAK, one of the most valuable of known timbers. The Sanskrit name of teak is *saka,* and it is certain that in India teak has been known and used largely for more than 2,000 years. Teak is a large deciduous tree, of the family Verbenaceae, with a tall, straight but often buttressed stem, a spreading crown, and the branchlets four-sided with large quadrangular pith. It is a native of the Indian peninsula, Burma and Siam, and is also found in the Philippine islands, in Java and elsewhere in the Malay archipelago, although there is no record of its being native in these places. In India proper its northern limit is 24° 40′ on the west side of the Aravalli hills, and in the centre, near Jhansi, 25° 30′ N. lat. In Burma it extends to near Myitkyina, in lat 25° 30′. In Bengal or Assam it is not indigenous, but plantations have been formed in Assam as far as the 27th parallel. In the Punjab it is grown in gardens to the 32nd. Teak thrives best in districts with a mean annual rainfall of more than 50 in. The mean annual temperature which suits it best lies between 75° F and 81° F. Near the coast the tree is absent, and inland the most valuable forests are on low hills up to 3,000 ft. It grows on a great variety of soils, but there is one indispensable condition—perfect drainage or a dry subsoil. On level ground, with deep alluvial soil, teak does not always form regularly shaped stems, probably because the subsoil drainage is imperfect.

During the dry season the tree is leafless; in hot localities the leaves fall in January, but in moist places the tree remains green till March. At the end of the dry season, when the first monsoon rains fall, the fresh foliage comes out. The leaves, which stand opposite, or only whorled in very young specimens, are from 1 to 2 ft. in length and from 6 to 12 in. in breadth. On coppice shoots the leaves are much larger, and not rarely from 2 to 3 ft. long. In shape they somewhat resemble those of the tobacco plant, but their substance is hard and the surface rough. The small white flowers are very numerous, on large erect cross-branched panicles, which terminate the branches.

The tree seeds freely every year, but its spread by self-sown seed is impeded by the forest fires of the dry season, which in India generally occur in March and April, after the seeds have ripened and have partly fallen. Germination is slow.

The bark of the stem is about half an inch thick, grey or brownish grey, the sapwood white; the heartwood of the green tree has a pleasant and strong aromatic fragrance and a beautiful golden-yellow colour, which on seasoning soon darkens into brown, mottled with darker streaks. The timber retains its aromatic fragrance to a great age.

Durability of Teak.—The principal value of teak timber for use in warm countries is its extraordinary durability. In India and in Burma beams of the wood in good preservation are often found in buildings several centuries old, and instances are known of teak beams having lasted more than 1,000 years. In one of the oldest buildings among the ruins of the old city of Vijayanagar, on the banks of the Tungabhadra in southern India, the superstructure is supported by planks of teakwood 1½ in. thick. These planks were examined in 1881; they were in a good state of preservation and showed the peculiar structure of teak timber in a very marked manner. They had been in the building for 500 years (*Indian Forester,* vii. 260). In the wall of a palace of the Persian kings near Baghdad, which was pillaged in the 7th century, two Americans found in 1811 pieces of Indian teak which were perfectly sound (Ouseley, *Travels in Various Countries of the East,* ii. 280, n. 67). In the old cave temples of Salsette and elsewhere in western India pieces of teak have been found in good preservation which must have been more than 2,000 years old.

Teak is used for shipbuilding, for furniture, for door and window frames, for the construction of railway carriages, and for many other purposes. White ants eat the sapwood, but rarely attack the heartwood of teak. It is not, however, proof against the borings of the teredo, from whose attacks the teak piles of the wharves in the Rangoon river are protected by metal.

Growth.—In its youth the tree grows with extreme rapidity. Two-year-old seedlings on good soil are 5 to 10 ft. high, and instances of more rapid growth are not uncommon. In the plantations which have been made since 1856 in Burma, the teak has on good soil attained an average height of 60 ft. in 15 years, with a girth, breast high, of 19 inches. This is between 16° and 18° N. lat., with a mean annual temperature of 78° F and a rainfall of 100 inches. In the Burma plantations it is estimated that the tree will, under favourable circumstances, attain a diameter of 24 in. (girth 72 in.) at the age of 80. Timber of that size is marketable, but the timber of the natural forests which is at present brought to market in Burma has grown much more slowly, the chief reason being the annual forest fires, which harden and impoverish the soil. In the natural forests of Burma and India teak timber with a diameter of 24 in. is never less than 100 and often more than 200 years old. The trees are not generally more than 100 to 150 ft. high, even under favourable circumstances.

THE TEAK TRADE

While it is true that by far the largest volume of the teak wood produced is used in India and Burma, Ceylon, and the East, nearly all of the best quality is exported to other parts of the world, the demand from all countries having been on a continually increasing scale. Nearly all the produce of the forests of Travancore, Cochin, Madras Presidency, Coorg, Mysore, Bombay, Berar, and the Central Provinces is so consumed, although small supplies from Travancore and the Madras and Bombay Presidencies have continued almost annually to find their way to Europe. The actual output from Burma, shipped from Rangoon and Moulmein, far exceeds anything which is produced from any other source, the volume for 1926 being 550,000 loads. Next in volume is that produced in Siam and shipped from Bangkok: certain quantities have been regularly shipped from Java and Saigon, but of late the export from Java has been much restricted on account of the Dutch Government regulations.

The timber brought to the Burma ports is derived:—(1) from the forests in the British coast provinces, Pegu and Tenasserim; (2) from the forests in the former kingdom of Burma, floated to Rangoon down the Sittang and Irrawaddy rivers; (3) from the forests in the Shan States formerly tributary to Burma, from the Karenni country, and from western Siam, whence it is floated to Moulmein by the Salwin river.

In British India, including Burma, a large portion of the teak-producing tracts have since 1856 been placed under conservancy management with the object of preventing overcutting and maintaining a permanent and gradually increasing supply. Similar measures have been taken in Siam and in the teak-producing native States in the peninsula. The teak plantations in Java had come into bearing by 1908, and while it was expected at that time that teak might be produced from the Philippine islands, this expectation has not been fulfilled. (X.; A. L. H.)

TEAL, a small and beautiful duck, highly esteemed for the table. It inhabits the whole of Europe and Asia, visiting northern Africa in winter. In habits and nesting sites this species (*Anas crecca*) resembles the wild duck (*q.v.*) though it more often nests at a distance from water. It is replaced in North America by the green-winged teal, *A. carolinense* or *Nettion carolinense,* and in China by the Mandarin-duck, *Aix galericulata.* Hardly less showy than these are the two species of the subgenus *Eunetta,*—the Falcated duck, *E. falcata,* and the Baikal teal, *E. formosa.*

TEANO (anc. *Teanum Sidicinum*), a town of Campania, Italy, in the province of Frosinone, 21 m. N.W. of Caserta on the old main line to Rome from Naples, forming conjointly with Calvi an episcopal see. Pop. (1921) 9,154 (town); 11,683 (commune). It stands at the south-east foot of Rocca Monfina, 643 ft. above sea-level. There is a feudal castle built by the dukes of Sessa in the 15th century.

The ancient Teanum Sidicinum (there is a Teanum Apulum in Apulia) was the capital of the Oscan tribe of the Sidicini which drove the Aurunci from Rocca Monfina. Remains of the city walls, of a theatre and an amphitheatre still exist, and some extensive baths and some Roman dwellings, both some way below the modern town. A tomb with a mosaic representing the visit of the three kings to Bethlehem was found in 1907.

TEA-POY (Hindustani *tēpāi*), a small table, supported upon a tripod, for holding a tea-service.

TEAR GAS: *see* CHEMICAL WARFARE.

TEASEL. Wild teasel is a common plant of the English copses and hedges, with a tall, stout, rigid, prickly stem, bearing large spreading opposite leaves, the midrib of which is prickly, and conspicuous oblong heads, the purplish flowers in which are subtended by very long, narrow, stiff, upright bracts. The plant is known botanically as *Dipsacus sylvestris.* Fuller's teasel, *D. fullonum,* in which the bracts are hooked, is probably a cultivated form of the wild species; the dry heads are used to comb up the nap on cloth. The wild teasel is extensively and the fuller's teasel sparingly naturalized in the eastern parts of the United States.

TEA SHOP: *see* CAFÉ and CAFETERIA.

TEATE MARRUCINORUM: *see* CHIETI.

TEBESSA (the Roman Theveste), a town of Algeria in the department of Constantine, 146 m. S.E. of Bona by rail and 12 m. W. of the Tunisian frontier, on a plateau 2,950 ft. above the sea. Pop. 7,018, of which 1,614 are Europeans. The modern town, which is within the walls of the Byzantine citadel, boasts nothing of interest save a church built out of the ancient ruins. The Byzantine walls, pierced by three gates, are in tolerable preservation. They are strengthened by numerous square towers. One of the gates is formed by the quadrifrontal arch of Caracalla, a rare form of construction. The arch, erected A.D. 214, is in good preservation. A pair of monolithic columns, disengaged, flank each façade. The most important ruins are those of the great basilica. This building, one of the finest Roman monuments in Algeria, bears evidence of having been built at various epochs; the earlier portions probably date from not later than the beginning of the 2nd century A.D. The basilica was partially destroyed by the Berbers in the 5th century, and was rebuilt in A.D. 535 by the Byzantine general Solomon, who surrounded it with a wall about 25 feet high, still standing. The tessellated pavement which covers the basilica proper is in almost perfect condition. Next the basilica are the ruins of the forum.

Theveste was founded towards the close of the 1st century A.D. In the succeeding century it was connected with Carthage by a great highway. In the 5th century, under Vandal dominion, it declined in importance. Refounded by the Byzantines in the 6th century, the city disappeared from history at the time of the Arab conquest of the country in the 7th century. In the 16th century the Turks placed a small garrison of janissaries in the place, but Tebessa continued to be but a small village until the establishment of French rule. Near by are the phosphate quarries of Jebel Kouif, with annual output of 450,000 tons.

See Sir R. Lambert Playfair, *Handbook for Travellers in Algeria and Tunis* (1895), pp. 233–240, *Guides-Joanne, Algérie et Tunisie* (1928); Abbé Kopp, *Tébessa, guide historique* (Tebéssa, 1923); Pierre Castel, Tébessa, 2 vol.

TEBU ("Men of Tu," *i.e.*, "of the rocks"), a nomad negro-Berber race of the eastern Sahara. Their westernmost settlements are the oases of Agram, Kawar and Jebādo, their northernmost the district of Gatron (Qatrūn) within the Fezzan frontier, while south and south-east they merge in the negroid populations of Kanem, Bornu (Chad basin), Wadai and north-west Darfur. But the bulk of the nation is concentrated in Tibesti or Tu, hence their name. There are two main divisions—the northern Teda, or less negroid Tebu, and the southern Daza, or more negroid Tebu. Less closely connected are the Baele of the eastern and south-eastern oases and the Zoghāwa (Zaghwa) of Darfur.

The Tebu are usually identified with the Garamantes of Herodotus (iv. 183), whose capital was Garama (Idrisi's Germa) in Phazania (Fezzan), and of whom Ptolemy spoke doubtfully as Ethiopians (Negroes ?). But Leo Africanus transfers them to the Berber connection, whose fifth great division he deals with under the names of Gumeri (Garamantes ?) and Bardaei or Bardoa, that is, the Teda of the Bardai oasis, Tibesti.

TECHNICAL EDUCATION. Technical education (Greek *τέχνη*, art or craft) may be defined as the special training of persons in the arts and sciences that underlie the practice of some trade or profession. The description "vocational training" (*q.v.*) is often used, particularly in the United States, as an alternative; and when so used includes commercial education.

THE UNITED STATES

The first technical instruction in the United States appears to have been given in connection with the U.S. Military Academy, organized in 1802 at West Point. Naturally the instruction was concerned with military problems. In 1824 Rensselaer Polytechnic Institute was founded at Troy, N.Y., and started the work of training "civil" so called in distinction to "military" engineers. Rensselaer conferred its first engineering degrees in 1835. Harvard opened the Lawrence Scientific School and Yale established the Sheffield Scientific School in 1847. The University of Michigan began instruction in engineering in 1853.

In 1862 Congress passed the Morrill Land Grant Act and thus laid the foundation of the Land Grant colleges from which have grown the State universities. The Act in setting aside public lands for the support of these colleges specifically prescribed that they shall teach "such branches of learning as are related to agriculture and the mechanic arts." Under the impetus of this Act and the economic pressure due to the needs of a new country engineering grew apace. The School of Mines at Columbia was founded in 1864, the Massachusetts Institute of Technology in 1865, Cornell University and Worcester Polytechnic Institute in 1868.

Technical education of university grade has grown therefore under two auspices, namely private ownership and State ownership. In the first group are to be found technical schools of high grade independent of general educational functions as illustrated by the Massachusetts Institute of Technology, and Rensselaer Polytechnic Institute. Again many large privately endowed universities such as Harvard, Yale, Cornell, etc., have engineering colleges which are integral parts of a group of colleges that comprise the university. In some of the State universities the colleges of engineering and agriculture are separated from the general courses not only educationally but geographically as well. Thus the University of Michigan proper is at Ann Arbor, while the Michigan College of Agriculture and Mechanic Arts is at Lansing some distance away. The increase in the number of technical schools of collegiate rank is noteworthy. In 1866 there were but six engineering colleges of established reputation and only 300 men had been graduated in the previous thirty-one years. In 1929 the U.S. Bureau of Education listed 148 technical colleges with a total enrollment in 1928 of 65,520.

While there is considerable variation in the entrance requirements of this large group in general a high school education is required. The colleges of highest grade require plane and solid geometry, advanced algebra and trigonometry, a certain amount of language training and sometimes elementary chemistry or physics in addition to such standard requirements as English, history, etc. In general, the entrance requirements of the privately endowed colleges are somewhat higher than those of the State institutions, the latter from the nature of State educational systems being closely articulated with the high schools of the state.

There is also a singular degree of uniformity in the curricula of the better type of technical college. This is necessarily so in a measure since engineering is an application of the basic sciences of mathematics, physics and chemistry and their derivatives. Analytic mechanics, which is a key course, is usually completed by the middle of the third year leaving at least one year and a half of the four year course for engineering fundamentals and applications. There is considerable variance however in the matter of instruction for specific technical callings. Practically all colleges recognize the three principal fields of engineering, namely, civil, mechanical and electrical. For the most part also the higher technical schools recognize the necessity of offering a limited amount of instruction in specialized fields such as heat-power, radio, industrial, hydraulic engineering, etc., in the senior year, usually as optional studies. There is always, however, a strong pressure from the industrial field in the direction of highly specialized courses with their beginnings much earlier and not a few colleges have yielded to this pressure. For the most part, however, educators have become convinced that the student's time is best spent during the first three years, at least, in acquiring fundamentals. Specialization should be deferred as long as possible and any extended special study should be carried to a fifth year study. All technical colleges of repute offer graduate study.

Until comparatively recent years the technical colleges were the principal centres of research work in engineering and the chief sources of engineering data. The growth of commercial research laboratories has changed this situation but there is still an immense amount of research conducted in college laboratories. There is a growing tendency for industrial enterprises to cooperate with college laboratories in the prosecution of special problems. If properly conducted such joint efforts are most fruitful since the commercial concern can supply the practical data for the problem and the funds for its prosecution while the college can supply the necessary apparatus and knowledge.

The growing tendency of the engineer to take a leading place in industrial administration has given rise to a need for a broadening of the curriculum by the introduction of economics, accounting and subjects of a more liberalizing character such as history, etc. While a certain amount of such topics have been introduced into the standard four-year courses any great addition necessitates a lengthening of the curriculum and five-year courses are coming into use. Whether this tendency will result in extending the curriculum to five or six years in length or in eventually making the engineering colleges graduate institutions as some even now advocate remains to be seen.

No outline of American technical education would be complete without mention of the co-operative methods now in operation in many colleges whereby the student spends part of his time in practical work and part in study thus obtaining his practical training and theoretical work at the same time. Students in such courses may "earn as they learn" and contact with industry stimulates interest in theory. There is also an important group of polytechnical institutes offering instruction in technology somewhat below the level of the higher schools but of great importance. Pratt Institute in Brooklyn may be cited as an excellent illustration. It is possible that this type of school may be increased by certain tendencies in the state educational plans. The high schools tend more and more to prepare boys and girls specifically for life and to lay less accent on college preparation. Many state educational departments are even now offering technical training in the high school grades. If the tendency to create junior colleges, by adding two or more years to the high school curriculum, continues we may look for the introduction of technical training in such colleges equivalent in value at least to the first two years of the present college courses.

Technical education in the United States, it will be noted, is still growing and is still somewhat in a state of flux though its principal characteristics seem to be fairly well evaluated. In any case it is an entity that has grown up as an independent educational function and which in all probability must be developed along its present lines rather than through any radical readjustments. (D. S. K.)

ENGLAND

In Great Britain, technical education (including commercial education [*q.v.*]) and adult education are the two main divisions of the system of continued education. Adult education (*q.v.*) differs from technical education in that it has no specific relation to vocational demands. Both technical and adult education had their origins in the industrial revolution of the nineteenth century, although it was not until the twentieth century that technical education began rapidly to take the place of the system of apprenticeship which dated back to the mediaeval craft guilds. The first "mechanics' institute" in England and Wales was set up in London at the Birkbeck College in 1824. Similar institutes were rapidly established in other parts of the country; by 1841 there were over 200, and by 1860 there were 750, of which the majority were in the industrial towns of the Midlands and of Lancashire and Yorkshire. The mechanics' institutes were mainly designed to give, at evening classes, scientific and technological instruction to workmen. (*See* COMMERCIAL EDUCATION.)

Legislation.—The Great Exhibition of 1851 led to the formation of the Science and Art Department, and until 1879 the main income of the mechanics' institutes and "science and art" schools, some of which had been built under the Public Libraries Act, was derived from grants made by that department in respect of students successful at its annual examinations. The arrangements were criticised before the Royal Commission on Technical Education which heard evidence in 1882 and 1883. In 1879 the City and Guilds of London Institute began its support of technological instruction from funds placed at its disposal by the City Livery Companies. During the last forty years the Companies have given about £2,000,000 for secondary and technical educational purposes.

The City of London Parochial Charities Act, 1883, fostered the development of polytechnic institutions in London (*q.v.*). In 1889, the Technical Instruction Act empowered county councils and county borough councils to aid technical education and in 1891 the Local Taxation (Customs and Excise) Act provided these bodies with funds (colloquially known as "whiskey money") for that purpose, although some of this was afterwards diverted for secondary education (*q.v.*). In 1899 the Science and Art Department and the Education Department of the Privy Council were merged into one national department called the Board of Education. The Education Act of 1902, which was applied to London in 1903, made the county councils and the county borough councils responsible for supplying or aiding the supply of technical education, and these powers enlarged by the Education Act of 1918 were subsequently incorporated in the Education (Consolidation) Act of 1921.

Municipal Technical Schools.—From 1889 to 1899 there was great activity in the provision of sites and buildings for science, art and technology. In London two more polytechnic institutions were established, and the London County Council inaugurated its policy of "maintained" technical schools, that is, schools supported entirely by the local education authority. Among such schools were the technical institutes at Shoreditch, Westminster, Wandsworth and Norwood, the Central School of Arts and Crafts, the Camberwell School of Arts and Crafts, the School of Photo-Engraving and Lithography, the School of Building at Brixton, and the School of Engineering and Navigation at Poplar. Many of the great towns, such as Birmingham, Blackburn, Brighton, Halifax, Huddersfield, Hull, Leicester, Loughborough, Manchester, Oldham, Rochdale, Salford and West Ham, provided new or enlarged technical schools. In 1898–9, £866,063 was spent by public authorities on technical education in England and Wales, apart from the amounts raised by loan, and nine out of ten of the county councils and the county borough councils had voted grants in aid.

The Education Act of 1902, by adding the provision of secondary and university education to the responsibilities of the local education authorities, slowed down the rapid developments in technical education which had previously occurred. London enlarged five of the polytechnics and five technical schools, and built new schools at Hammersmith and Lambeth, while building work was also done at twenty-one other large towns.

The most characteristic development was the establishment in 1907 of the Bloomsbury Trade School for Girls, the first trade school to be provided in the English educational machinery on self-contained premises and organised on independent lines. Other trade schools were founded in London, Middlesex and elsewhere. Fostered by a system of trade scholarships awarded to girls at the age of thirteen, they have achieved a notable success with employers and have created opportunities for skilled employment for girls. In 1913 full time day technical classes for boys and girls, which were definitely pre-apprenticeship or trade schools, became eligible for state aid under regulations for "junior technical schools."

Under municipal auspices all the large towns of Great Britain have established technical schools of the first rank, and these are effectively organised to meet the requirements of local industries. Throughout the country, however, both industry and commerce had attained a high development before the support of technical education became a duty of the education authorities.

Statistics.—Since 1919 technological instruction in universities and constituent colleges has ceased to be aidable by the Board of Education, University Grants Committee now undertaking this function. The number of students in England and Wales under technical instruction, as defined by the regulations of the Board of Education, was 781,034 in 1926–27. The public expenditure on technical education is about £3,000,000 annually. The technical and continuation schools included 145 junior schools, 54 senior full-time courses, 134 technical day classes, 237 senior art schools, 67 day continuation schools and 4,911 evening institutes and evening courses in colleges. About 19 persons for each 1,000 of population were under technical instruction and other forms of continued education as compared with 10 per 1,000 under instruction at secondary schools. In London nearly 250,000 students attend day and evening continuation schools of all kinds, equivalent to about 40 persons per 1,000 of population; 37 evening institutes and 21 technical schools each have over one thousand students; the number of female students is slightly in excess of the number of male students, while the number of adults, that is persons over eighteen years old, is the same as the number of young persons between 14 and 18 years of age.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

An important development of technical education was the founding in 1907 of the Imperial College of Science and Technology. A Royal Charter merged the Royal College of Science, the Royal School of Mines, and the City and Guilds (Engineering) College, institutions at South Kensington, which had been established at different times during the nineteenth century, into a federation under the name of the Imperial College of Science and Technology, for the specific purpose of the highest education and research in science, especially in its application to industry. (*See* EDUCATION AND INDUSTRY, ENGINEERING EDUCATION.) Buildings of the Imperial College in 1928 numbered seven. The governing body is constituted from representatives appointed by the Crown, the Board of Education, the University of London, the London County Council, the City and Guilds of London Institute, of professional bodies and of the Dominions Overseas.

The College is mainly supported by grants from public authorities and industrial organisations. For the period 1925–29 the London County Council granted £27,000 yearly, and this was voted on the assumption that the Treasury, through the University Grants Committee, would vote at least three times that amount. The Rubber Growers' Association raised a fund of £30,000 for development purposes in 1921, and the Air Ministry, and the Ministry of Agriculture and Fisheries pay contributions for research carried out on their behalf. Other contributors to its financial resources include the Empire Cotton Growing Association and the Goldsmiths' and Clothmakers' guilds. About thirty per cent of the students are now engaged in post-graduate work and research. In the north of England the Manchester College of Technology, an institution of university rank, provides facilities on somewhat similar lines, while the Shirley Institute conducts very important research for the textile industry. (*See* also UNIVERSITIES.)

SCOTLAND

Modern technical education in Scotland had its origin in the founding of Anderson's University in Glasgow at the close of the eighteenth century. Dr. George Birkbeck founded the Mechanics' Institution in 1823, and these two foundations have since become the Royal Technical College, Glasgow.

A Technical Schools Act was passed in 1887. In 1893, the first "Scotch Code of Regulations for Evening Schools" appeared, and this led to a consolidation of effort and the development of a homogeneous system of continuation class instruction. In 1897, the Education Department of Scotland was separated from that of England, and the administration of science and art grants was transferred to a Scottish education department.

Section 87 of the Code of 1901 constituted the technical colleges and schools of art in Edinburgh, Glasgow, Dundee and Aberdeen, and certain other colleges as special institutions ("Central Institutions"). These institutions were relieved of their more elementary teaching and received subsidies which enabled them to develop higher studies.

Some of the central institutions such as the Heriot-Watt College, Edinburgh, the Royal Technical College, Aberdeen, and Robert Gordon's Technical College, Aberdeen, are of University rank, co-operating closely with the corresponding universities in the provision of degree courses. In most of the districts the general continuation class system is linked up with the central institutions, subjects and courses are correlated, and bursaries are available to provide financial aid to the poor student.

The Education (Scotland) Act, 1908, provided that "it shall be the duty of a School Board to make suitable provision of continuation classes for the further instruction of young persons above the age of 14 years with reference to the craft and industries practised in the district. . . ." In 1923 and 1926, regulations were introduced which strengthened the tie between day school and continuation class education, and adapted the latter to changes of industrial conditions and educational requirements.

NORTHERN IRELAND

Technical education in Northern Ireland is mainly derived from the Department of Agriculture and Technical Instruction which was set up in Dublin by an Act of 1899. Under this Act county boroughs, urban districts and counties which struck a special rate for the purpose were enabled to receive grants for approved schemes of technical instruction. The Northern Ireland Education Act of 1923 made the City Councils of Belfast and Londonderry and the six county councils the education authorities for their own areas. Twenty-five technical schools have been transferred to the County Education Authorities. The special rate for technical education disappeared as a rule and the general rate for education took its place. In 1926–27, 23,704 students were in attendance at technical schools and a system of junior technical and day commercial schools had been inaugurated. A trade scholarship scheme is in operation and apprentice scholarship courses are held.

IRISH FREE STATE

The Department of Education set up in 1924 took over the functions of the Technical Instruction Branch of the Department of Agriculture and Technical Instruction established by the Agricultural Technical Instruction (Ireland) Act, 1899. Technical instruction schemes are now all under the management of local Statutory Committees, State grants being contingent on the raising of a local contribution from the rates. The chief technical schools are at Dublin, Cork, Galway, Limerick, Rathmines, Tralee, Waterford. In 1927, the total number of students enrolled in classes in technical schools was 22,718, while 35,437 students (mainly evening students) enrolled in classes conducted under county schemes of technical instruction elsewhere than in established technical schools. Instruction in the Irish language forms the largest portion of the work done in the county schemes. The Local Government (Temporary Provisions) Act empowered councils to strike a rate not exceeding 1d. in the £ of rateable valuation for instruction in Irish, the administration being placed in the hands of the committees of technical instruction. In preparation for employment in trades, there are ten trades preparatory schools, the largest of which is at Cork. The Report of the Commission on Technical Education, which was issued in 1927, referred to the meagreness of technical instruction, particularly in rural areas.

BRITISH DOMINIONS OVERSEAS

Australia.—The expenditure on technical education for Australia is comparatively small. In 1925, the total expenditure on maintenance was £599,077 and on buildings £138,161. The expenditure on maintenance amounted to 2s. per head of the population, as compared with 27s. 10d. per head for primary and secondary education. New South Wales adopted a co-ordinated scheme of technical education in 1913.

In Victoria a Royal Commission was appointed in 1899, and in 1910 the control of the schools passed from local councils to the Education Department. In Queensland, under the Technical Instruction Act of 1908 and an amending act of 1918, the State was empowered to assume the control of technical institutions, and this power has been steadily exercised. The policy of combining technical colleges with high schools in the country centres has proved successful in some States, and peripatetic schools of Domestic Science and Manual Training, housed in specially fitted railway cars, visit the smaller towns. In four States, systems of apprenticeship operated by commissions are linked up with industry.

A Director of Technical Education for South Australia was appointed in 1916, and in 1921 further steps were taken, by proclamation, to develop the technical education of apprentices. All technical schools in Western Australia are under the control of the Education Department, which also employs a director of technical education. In Tasmania, a trained technologist was appointed as organiser in 1917, and a Technical Education Branch established in 1918.

New Zealand.—Technical schools are well distributed throughout New Zealand. Any young person between 14 and 17 years of age who is not otherwise receiving a suitable education may be compelled to attend a technical or continuation class. Although not yet in full operation, these compulsory powers have been applied to a number of school districts.

Canada.—Technical education in Canada is now organised in accordance with the Dominion Technical Education Act of 1919. In 1926, the number of municipalities providing day and evening schools was 238, the teachers employed numbered 3,478 and the number of students enrolled was 88,961. The Federal grants amounted to nearly one million dollars, the grants to local boards to nearly two million dollars.

South Africa.—As the outcome of a conference at Durban in 1924, vocational education in South Africa was transferred from Provincial to Union control. Under the Union Education Department there were in 1926–27 seven technical colleges, seventeen part-time technical schools and thirteen departmental trades, housecraft and agricultural schools. These schools were attended by 16,364 students. The largest technical schools are the Witwatersrand Technical Institute, the Cape Technical College, Cape Town, and the Natal and Pretoria Technical Colleges. Technical and commercial examinations are regularly held under the supervision of the Union Department of Education with the object of stimulating vocational education in combination with or in continuation of the ordinary school curriculum.

India.—In recent years there has been a demand in India for more facilities for technical education. In 1925 there were 556 technical institutes, amongst the most notable being the Sydenham College of Commerce at Bombay, the Technological Institute at Cawnpore, and the Technical Institute at Jamshedpur, the centre of the iron industry. (For the Dominions *see* also UNIVERSITIES.)

FRANCE

In France the arrangements for technical and commercial education were re-organised by the *Loi Astier* of 1919, and by a decree of 1922 the organisations, public and private, interested in vocational guidance were placed under an Under-Secretary of State for Technical Education. Each department into which France is divided has a committee for technical instruction and the majority of them have offices for vocational guidance. Apprentices and young employees under eighteen years of age can, in districts specified by Ministerial Order, be compelled to attend *cours professionels*. There has been in recent years a considerable increase in the number of full-time schools of industrial and commercial education (*écoles pratiques de commerce et d'industrie et écoles de métiers*). In 1926, technical and vocational schools were attended by 311,753 students; the number of vocational schools in 1924 was 1,085 as compared with 143 in 1892. Among the most famous schools of the first rank are the École Centrale (Marine Engineering), the École Nationale des Arts et Métiers at Châlons, the École des Mines and École des Ponts et Chaussées. In all there are 6 national schools of arts and crafts, 5 national vocational schools, 114 practical schools of commerce and industry, 30 courses in household arts for girls, and about 650 compulsory vocational courses in 82 departments and 332 communes. In Paris have been organised schools of industrial heating, for foundry work, milling, dietetics, an institute for sanitation and hygiene in industries, an optical institute, and, at Sèvres, an institute of ceramics. A law of 1918 authorised the development of agricultural education, and by 1924, 32 practical schools of agriculture had been formed while meetings for the dissemination of agricultural knowledge were being conducted under expert guidance.

GERMANY

The characteristic aim of technical education in Germany has been to build up a great industrial nation by systematic training of all grades, from leaders to workmen. The Technische Hochschule is an institution of university type, providing facilities for scientific research and degrees in engineering. In 1926 the commercial college at Berlin began to confer the doctorate in economics. The Charlottenburg Institution in Berlin, which was completed in 1884 at a cost of about £450,000, includes departments for the highest specialised instruction in nearly all technological subjects. The success of this institution was one of the factors which led to the establishment in London of the Imperial College of Science and Technology. Although the Federal Continuation School Law is, for financial reasons, largely inoperative, Saxony, Thuringia, Anhalt, Brunswick and Hamburg have introduced compulsory attendance for both sexes; other states require it of boys for skilled trades. Since the war, evening classes have become more numerous, particularly in connection with the continuation and engineering schools. "The contrast between the fragmentary beginnings of the system of continuation schools which this country (*i.e.*, Great Britain) can show," reported in 1927 Sir Arthur Balfour's Committee on Industry and Trade—*Factors in Industrial and Commercial Efficiency*—"and the wide and rapidly extending provision in Germany is a fact of very great importance."

The city of Berlin maintains two schools of arts and crafts. In Leipzig there is an arts and crafts section of the City High School and of the Technical Academy, to the latter of which has been added a school of mechanics. Bavaria has two state schools of applied art, one at Munich and the other at Nuremberg. In 1921–22, the German Republic had 11,747 vocational full-time and continuation schools with 1,013,019 male and 329,475 female students.

OTHER COUNTRIES

Austria.—In Austria, the first arts and crafts schools were founded in the nineteenth century; to-day the Republic possesses a variety of such schools. At Vienna are the Polytechnic School and the Graphic School and Experimental Institute. Included in the federal trade schools are higher sections for training students to qualify as owners or directors of industrial establishments in such occupations as the building trades, engineering, and the chemical and textile industries. Successful attendance reduces the period of apprenticeship, while students who pass out with honours are entitled to attend the Austrian Technical University or the College for World Commerce. There are also two-year and one-year educational establishments for women's trades, and special schools for weaving and textiles, locksmiths, watchmaking, electrotechnics, woodwork, metalwork and stonework, ceramics and decorative painting. In 1923–24 there were 148 special vocational schools.

Italy.—Technical education in Italy is regulated by the Ministry of National Economy and by decree of 1923. Vocational training is given in people's schools for workers or preparatory schools, in industrial or apprenticeship schools, at courses for journeymen for developing the working capacity of apprentices or workers, in industrial institutes for training future managing and technical staff in factories, industrial workshops and technical laboratories, and at experimental establishments for furthering technical progress in industry by means of study, research, analysis and inquiries.

In 1921–22, the number of industrial schools (apprenticeship schools, vocational schools for girls, and special schools) was 174, of which 93 were royal (*i.e.*, set up by royal decree) and 81 free (*i.e.*, set up by local authorities or private organizations), and the number of pupils was 28,091. There were also 282 (18 royal and 264 free) part-time schools with 26,292 pupils.

The most important of the industrial institutes is the Institute for Vocational Education at Rome. It has two sections, one for the training of expert mechanics and electricians, and the other for training experts in the building industry.

Scandinavia.—In Sweden, technical schools are of comparatively recent origin; it was not until 1918 that they were brought together into a systematic organization. In 1920, a Central Institute for Training Vocational Teachers was established in Stockholm. Technical instruction is now provided at full-time workshop schools, apprenticeship schools, trade schools, and schools of commerce and domestic economy. Technical trade schools and technical gymnasiums are, for the most part, maintained by the State, although there are private commercial gymnasiums. In Norway, continuation schools have been established both in cities and country districts.

Holland.—There are many trade and vocational schools in Holland, where most of the chief industries have higher and lower technical schools. There were in 1925, 12 technical high schools and numerous other technical, trade and agricultural schools.

Switzerland.—In Switzerland, continuation schools are, as a rule, organized by the communes, although the state has made them compulsory in many of the cantons. Vocational schools, whether municipal or cantonal, are subsidised by the Confederation. The country also possesses a federal "Polytechnicum" at Zürich, which is of university rank. The national industries, also, have stimulated the establishment of schools for the industrial arts, while vocational guidance is being developed by the *Association Suisse des Conseils d'Apprentissage.* Zurich has a bureau of vocational guidance, and a beginning has been made with psychological tests at the Institut J. J. Rousseau in Geneva and at the Psychotechnisches Institut in Zürich. Efforts are also being made to develop continuation courses in agriculture, in 1926, there were 22 agricultural schools.

Czechoslovakia.—The organization of continuation schools in Czechoslovakia is fixed by orders of the State, based upon a law of 1919. Every trade apprentice is required to attend a continuation school and to remain in attendance for eight to fourteen hours weekly. Specialised technical instruction is provided for groups of at least seven students in a general trade continuation school. Professional continuation schools are, however, steadily replacing general trade schools. In 1925–26 there were 2,615 continuation schools attended by 203,227 pupils, of whom 49,631 were girls.

Estonia.—In Estonia, trade schools were constituted by a law of 1925. Vocational training in Finland is provided in commercial, agricultural, technical and trade schools. Lower and higher technical schools are organized in Poland, as well as artisans' schools, evening continuation, commercial and agricultural schools. In Latvia, the number of students at the technical and commercial middle schools increased from 285 in 1919–20 to 2,610 in 1924–25. A Royal Decree of 1923 determined the organization of technical institutes in Italy; other vocational schools are organized by the Ministry of National Economy.

Japan.—Technical education in Japan is for the most part provided at government and public institutions. In the category of technical schools are included also agricultural schools, commercial schools, nautical schools, fishery schools. Generally speaking, students admitted must be above twelve years of age. Industrial schools are provided for children of superior attainments, and technical continuation schools for children from elementary schools who are engaged in industry. In 1924, there were 15,528 public and 193 private technical schools, staffed by 17,620 teachers and attended by 1,206,098 pupils. Most of the schools were junior continuation schools. The higher technical schools, of which there were 35 under the direct control of the Department of Education, provide advanced studies in the same subjects as are found in the curricula of European institutions. (*See* also, for the above countries, UNIVERSITIES.)

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TECHNIQUE IN ART. Technique is the manner of artistic execution, the performance or method of manipulation in any art, but as to just how inclusive this definition should be regarded is a question. Certain authorities claim that technique is distinct from any consideration of general effect or expression, while others assign to it the meaning of the doctrine of the arts in general. The first conception might be called "Mechanical technique" and the latter "Technique principle."

In this work the mechanical technique in each art is treated under each individual heading as the mechanical techniques vary considerably in detail—that of the sculptor being different from that of the wood-engraver, and that of the painter differing from that of the etcher. This article will therefore deal only with the broader conception of the definition—the technique principle, or those underlying rules which are found to be true in the practice of all of the arts.

It may be said that such a discussion falls within the field of aesthetics, but the difference lies in the fact that while aesthetics is a metaphysical discussion of man's conception of beauty, the technique principle is a discussion of how to obtain beauty or human appeal in a work of art. The one is philosophy and the other is a practical science based upon observation and reason. The one has to do with a discussion of the result, while the other shows how this result, indescribable as it sometimes may seem, can be obtained. The means whereby man can appeal to man in the creation of beauty, modern science has analyzed to a remarkable degree, and just as Henri Bergson in *L'Evolution Créatrice* destroyed the old philosophical conception of negation by the application of modern psychology, so have many of the old principles of philosophic aesthetics been destroyed by like methods. The modern artist must not only have mastered rules of anatomy and perspective through study such as that of many of the old masters over the dissection tables, and of mathematics, but must inquire into the psychological reactions caused by light or by various colours, the chemical action of his paints, the analyses of movement as revealed by the motion picture camera and many other phases of modern scientific development, and therefore the old conception of the artist as an intuitive being dreaming his way through life and seizing now and then with the aid of a divine fire a dream which he in some inexplicable way makes tangible and durable for his fellowmen, must be cast aside. The artist may dream, as the man of science or the inventor dreams of the creation of some remarkable work, but the work itself is a painstaking process of reason and the result may often be quite different from the cloudy original blur which was the first conception. The study of the subconscious has done much to explain intuition, and the modern man has learned to place less faith in the vision of glory which used to move his forefathers, for he realizes that these immediate apprehensions of "truth" are topsy-turvy mirages of what may or may not be proved true by the searchlight of modern scientific reason. The modern artist is first of all a modern man in every sense abreast of the times, and, as an indispensable prerequisite, every artist must first learn to appeal to his fellowmen. (*See* AESTHETICS.)

Although the modern artist is perhaps more awake to the necessity of adopting this viewpoint, because of the recent marvelous developments of science, nevertheless many of the great masters of the past have also expressed themselves clearly along the same lines. Leonardo da Vinci has said "Thou, O God dost sell unto us all good things at the price of labour" and throughout all of his writings Da Vinci has laid stress upon reasonable labour rather than trust to inspiration. Rodin said, "Nothing will take the place of persevering study—to it alone the secret of life delivers itself." Turner stated that he had no secret but hard work, and Pliny relates that the secret of Apelles was due to constant practice. Hundreds of other examples might be quoted, but it is sufficient to say that throughout the ages both in the Far East, where a great painter has been quoted as saying, "Man cannot call himself an artist until he has painted 10,000 pictures," to the western schools represented by such quotations as above, artists in writing of their own work have laid great stress upon the labours of pure reason involved, while critics in writing of art (that field in which they have as a rule never practised) explain it on the grounds of a mysteriously intuitive and God-sent passion. Due to the critics, art has too long been considered a gift of the gods and artists who are usually contented to let the results of their labours speak for themselves have too long been misunderstood. Let us therefore examine a few of the processes of thought of which they make use. (*See* PAINTING.)

Conception.—The original conception of a work of art or of an invention of any sort is usually largely intuitive, in that it may be said to reach out beyond the regular step by step procedure of pure reason. The possibility of such and such a thing often occurs suddenly after a long and arduous searching of the facts which may be more or less involved. The mind grasping the trend in which the assembled facts seem to be leading will reason ahead of the yet unproved result and the inventor or artist may say to himself that if such and such could only be done the result would be desirable, and he then sets himself to obtain this result as he conceives it. Thomas Edison must have said something of the sort to himself when he first made an electric wire glow in a vacuum and suddenly perhaps imagined the possibility of stringing these glowing bulbs along a street so that it might be illuminated by a current of electricity. The artist's conception is similar. He suddenly realizes that a certain grouping of figures under an illumination of a certain sort producing certain highlights and shades would give a magnificent effect for some cathedral mural decoration. For years this general idea may be kept in the back of his mind until the opportunity offers itself and certain other relative conditions fall into line and make it possible for him to attempt its development.

His first step is often a preliminary sketch which is rough and undetailed and which is only a sort of notation aiding him to keep his general scheme in mind. He may then proceed to work out the details just as does an inventor. "Will such an arm if lifted procure a more rhythmical line in the composition?" "Would such a raising of the arm be natural to the figure?" "Is this shadow to be darker than that or would it be too much of a spot and should it glow with a diffused light reflected from some nearby surface?" "What surface could be brought to use in the reflecting of this light?" and similar questions occur in his mind and must be solved logically and reasonably.

During the solution of these questions he may make innumerable sketches or notes just as the scientist takes notes during the various steps of experimentation in his laboratory, and it is through the assembling of the more important of these various considerations that finally the work of art is actually conceived and constructed.

Expression of Material.—Among the fundamental considerations of every great artist is that of the appropriate expression of the material in which his work is to be executed. Watercolours should not be handled in such a way as to resemble oil; brass should not be finished to imitate bronze; and the reason for this is that people who may never have consciously thought about art have learned to associate certain characteristics with each substance they find about them. There is a feeling of disconcerting surprise when these characteristics are not evidenced, like the sensation when one touches one of the metal desks made to appear so perfectly like wood. One may never have considered consciously the warmth of wood though subconsciously one's mind has taken note of it. This surprise whether to the sense of touch or sight is always misleading and is usually ruinous to the effect of what might otherwise be an excellent work of art. We know for instance that iron is so strong that man cannot bend a slender rod of it and if we are confronted therefore with an iron garden gate made of thick and uselessly heavy pieces of metal we mistrust that it is iron and suspect that it may be lead or some other substance. Tapestry lends itself to a certain sort of design which can be better expressed in its weave than it can in a mosaic or fresco. (*See* WATER COLOUR PAINTING, OIL PAINTING, TAPESTRY, etc.)

The faculty for properly expressing the medium, avoiding its limitations and taking advantage of its possibilities, is one not arrived at by intuition but by careful research and practice, so that the artist sometimes learns almost *to think* in the medium which he has studied. Thus a painter may actually learn to see a landscape in brush strokes, or a composer of music associate at once a certain section of the score with the tone quality of a certain instrument or group of instruments.

The Expression of the Tool.—Fully as important as the consideration of material is that of the characteristics of the tjantjing tools with which it is to be worked. The brush of sable, the tjantjing, the etching point, the chisel, the wheel of the gem cutter or even the fingers of the sculptor modelling in clay, will each make a certain cut, mark or impression which must be studied in relationship to the material. (*See* ART, FAR EASTERN METHODS.) It is unpleasant to see clay carved with a sharp instrument as though it were wood, or stone, or to behold what appears to be a woodblock print and find that it has been painted with the brush.

Not only must the mark of the tool be considered in relationship to the material but it is capable if properly handled of a beauty in itself comparable to the single note drawn by a master hand from a fine violin. Look at the line drawn upon a piece of paper by a master draftsman. Is it not similar to the violin note with its gradations of shade and its sweeping curve? The expression of beauty in a masterful handling of the tool so that each note is pleasing was a joy to the ancient artist and he would often spend years acquiring this deftness which many modern artists have been fooled into thinking is unnecessary because of the stressing of originality and spontaneity in art training.

But even this carelessness, deplorable as it is, is more forgivable than the custom of the last century of deliberately faking tool marks. Wood cut by machines to give the appearance of being hand-hewn and iron artistically dented to appear hand-forged had come to be almost universally accepted though nothing could show greater evidence of dishonesty of technique and bad taste.

Style.—No two artists can paint the same face or the same landscape in the same way any more than two business men can sign their names in the same way. Neither the style nor the personality of the artist need be thought about and certainly should not be artificially cultivated. However, if one is to permit his style to grow he must not hamper it by the slavish copy of some other artist's personal style. He may to advantage copy works of art again and again, but should do so simply to broaden his outlook, as a writer may read the books of many other writers.

The present day stressing of originality in art teaching is responsible for much of the worst of our modern art. Technique is all that can be taught. Style and originality of real value can only come after the artist's experiences both in life and in art have broadened and enriched his personality, for the artist cannot express a personality until he has one and, if he has one, he cannot help but express it. (*See* THEATRE; DIRECTION AND ACTING.)

Suitability.—Suitability to surroundings is an element often lacking in the art of to-day due to a strange occurrence which took place during the decadence of the Renaissance. It is interesting to know that during the best periods of art the distinction between fine arts and applied art was not clear. In Egypt it was unknown. In Greece sculptors did as masterful work for the pediment of a building as for a pedestal. In the Orient the distinction has not existed for thousands of years and a porcelain vase or a piece of lacquer may be regarded just as highly as a painting or a piece of sculpture.

Michelangelo and Cellini did not recognize the distinction and were as proud of what might be called their craftsmanship or works of applied art as they were of those which could be labelled "fine art." Both were craftsmen at heart and unspoiled by what occurred immediately following their times.

"Fine Arts" as a term came into use meaning painting, sculpture, music and poetry, with sometimes the inclusion of architecture or those arts which exist for the pleasurable qualities alone and apart from any utilitarian consideration, but "fine arts" came to be thought of as of greater importance than applied arts for, if some of the arts are termed fine, the implication is that the other arts are less fine, and the result of this usage was that people came to consider art which had no application superior to art which was applied. They argued "Yes, that is beautiful for its purpose, but this is finer for the very reason that it has no purpose other than that of being beautiful." (*See* FINE ARTS.).

The result was a tendency toward less and less consideration of the principles of application of art. Sculptors preferred to work in their studios than to co-operate with architects. Great painters ceased to do murals and worked upon easel pictures. Recently, however, there has occurred a happy revolt against this attitude, more especially in America because it was found there that applied art paid better than fine art. In other words the public had judged and with the disappearance of the marble pedestal and whatnot from the Victorian interior, there was also a disappearance of bibelots and the old time easel paintings so that the artist is now confronted with the necessity of studying the antique as did the great masters and the principles of proper spacing, and must adopt the more modest attitude that his work, in order to be successful, must be considered as only part of an ensemble. (*See* SCULPTURE; GARDEN; LAMPS.)

Time Consideration.—Works of art differ from works of nature in that they cannot reproduce themselves and should therefore express in some way their vulnerability before the onslaughts of time. Part of the appeal of the antique is due to the fact that it is bowing with such grace and such pathetic dignity and beautiful spirit before the inevitable. The patina of an old bronze or the iridescence of an ancient glass vase is the touch of great Nature bidding it return to its original state. (*See* BRONZE AND GLASS.)

Structure.—Structure itself may be considered but an admission of the necessity for fortification against time and when proper structure is not observed one can foresee at a glance the indignity of the final defeat. Some works of art like some people grow more beautiful with age, for the scars of years serve only the more clearly to prove the sturdiness within. It is wise therefore for the artist to think of the final conditions of ruin of his work and build it in such a manner that it will be beautiful as long as it is recognizable. (*See* IRON.)

Fragility.—If structure appeals to us because of its intelligent defence against time, fragility undoubtedly appeals because of its pitiful bravery, for just as we have regard for some men for their reasonable sanity we like others for their careless daring. It is this appeal which has undoubtedly been responsible for the preservance of some of the delicate glass which has been passed from hand to hand down through the ages. Each hand though perhaps calloused by the sword or plough, though made careless by wine and laughter has touched it with a certain amount of care because of the realization of its brave stand against time. (*See* GLASS.)

A most strange and interesting study is this element, time, and our accounting for it, for though we realize that in it lies ultimate destruction we anxiously look for its touch on many works of art, feeling a mistrust for those things which have not proven themselves against it. Sculptors finish their bronzes with artificially applied patina not for the purpose of faking antiquity but simply to satisfy the eye as the boy with a new pair of shoes will scuff them in the dirt to take off the newness. A round corner is more beautiful than a sharp new one. Old polished wood is more beautiful than new and a painting, a statue or a piece of furniture finds a pleasing richness as the years impose a modification of the exact statements of the artist's brush or chisel.

Such considerations as those few outlined above will give the reader an idea of what the artist is thinking about as his work proceeds, and an understanding as to why and how it is made to appeal to the mind of his public. Abstract beauty may exist, though the philosophers seem to have some difficulty in defining it, but some of the elements of beauty which appeal to man in a work of art can thus be analyzed, weighed and combined by the artist into a worthy result. (W. E. Cx.)

TECK, a ducal castle in the kingdom of Württemberg, immediately to the N. of the Swabian Jura and S. of the town of Kirchheim, crowning a ridge (2,544 ft.) of the same name. It was destroyed in the Peasants' War (1525).

The duchy of Teck was acquired early in the 11th century by Berthold, count of Zähringen, whose great-grandson Albert, or Adalbert, styled himself duke of Teck. In 1381 it passed both by conquest and purchase to Württemberg. The title, which had lapsed with the extinction of the Zähringen line in 1439, was revived in 1495 by the German King Maximilian I., who bestowed it upon the dukes of Württemberg. The dignity was renounced by Duke Frederick William Charles upon his elevation to the rank of king in 1806. In 1863 the title "prince of Teck" was conferred by King William I. of Württemberg upon the children of Duke Alexander of Württemberg (1804–1885) by his morganatic marriage with Claudine, countess Rhédey, ennobled as countess of Hohenstein; in 1871 Prince Francis, the eldest son of Duke Alexander, was created duke of Teck. His eldest son Adolphus (b. 1868) was in 1910 the holder of the title.

TECUCI, the capital of the Tecuci department of Rumania, picturesquely situated among wooded hills on the right bank of the river Bêrlad, and at the junction of railways from Bacau, Bêrlad, and Galatz. Pop. 21,000. Tecuci has a large transit trade in grain, timber, cattle and horses, between northern and eastern Moldavia and the Danubian ports.

TECUMSEH, TECUMTHE or **TECUMTHA** (*c.* 1768–1813), American Shawnee chief, was born probably in the old Shawnee village of Piqua, near the site of Springfield (O.), between 1768 and 1780. While still a youth he took part in attacks on settlers passing down the Ohio river and in widely extended hunting expeditions or predatory forays to the west and south; and he served in the Indian wars preceding the Treaty of Greenville in 1795. His eloquence and his self-control made him a leader in conferences between the Indians and whites as early as 1800, and when in 1804 and 1805 the Indians of the North-west became aroused by a series of treaties calling for new cessions of their territory and by the prospect of war between Great Britain and the United States, the opportunity was presented to Tecumseh and to his brother Tenskwatawa (*i.e.*, the Open Door), popularly called "the Prophet," to put into operation a scheme which followed the ambitious dream of Pontiac. With some scattered Shawnee clans as a nucleus, the brothers proceeded to organize, first near Greenville, Ohio, and later on the White and Tippecanoe rivers in Indiana, "the Prophet's town," which was based on a sort of Communism and was apparently devoted to industry and sobriety, but their actual plan was to combine all of the Indians from Canada to Florida in a great democratic confederacy to resist the encroachment of the whites. Tribal organizations were to be disregarded, but all warriors were to be represented at periodical assemblages where matters of interest to all Indians were to be definitely decided. The twofold influence that was to dominate this league was the eloquence and political ingenuity of Tecumseh and the superstitious reverence aroused by "the Prophet." This programme alarmed the whites along the north-western border. In the course of the next three years Governor William Henry Harrison of Indiana held interviews with each of the brothers, and during one of these, at Vincennes in 1810, the respective leaders narrowly avoided a hostile encounter. Nevertheless "the Prophet" and Tecumseh reiterated their determination to remain at peace with the United States if the recent cessions, including that of 1809 which deprived the Indians of their best hunting-ground, were given up and if no purchases were made thereafter without the consent of the tribes. Harrison refused to consider this arrangement, and during Tecumseh's absence in the South, made a hostile move against "the Prophet's town." The latter ventured to meet him, but was defeated Nov. 7, 1811, in the famous battle of Tippecanoe, which broke the personal influence of "the Prophet" and largely destroyed the confederacy built up by Tecumseh.

Tecumseh still professed to be friendly toward the United States, probably because his British advisers were not ready to open hostilities, but a series of border outrages indicated that the fatal moment could not long be postponed. With the breaking out of the War of 1812 he was commissioned a brigadier-general in the British army and participated in the skirmishes which preceded General William Hull's surrender at Detroit. He took an active part in the sieges of Fort Meigs, where he displayed his usual clemency towards his prisoners. After the battle of Put-in-Bay, when Col. Henry Proctor began to retreat from Malden, Tecumseh bitterly reproached him for his cowardice and finally forced him to join battle with Harrison on the Thames river Oct. 5, 1813. In this battle Tecumseh was killed. "The Prophet" remained with a small band of Shawnees and died west of the Mississippi in 1834. Like Pontiac, whom he doubtless imitated consciously, he had a wonderful eloquence and a power of organization rare among the Indians. He is depicted in many historical plays and novels.

See Benjamin Drake, *The Life of Tecumseh and of his Brother the Prophet* (1841); Ethel T. Raymond, *Tecumseh* ("Chronicles of Canada" series, vol. xvii.); H. J. Webster, *Harrison's Administration of Indiana Territory* (1907); also sketches in Don Seitz, *Uncommon Americans* (1925); and Frances M. Perry, *Four American Indians* (1904), designed for juvenile readers.

TEDDER, HENRY RICHARD (1850–1924), English writer and bibliographer, was born in South Kensington in 1850. He studied in England and in France and dedicated himself chiefly to bibliography and library administration. In 1873 he became librarian to Lord Acton and several years later librarian of the Athenaeum Club. In 1889 he was also appointed secretary of the club and held both offices until his resignation in 1922. He was one of the active promoters of the first international conference of librarians held in London in 1877, out of which grew the Library Association of the United Kingdom of which Tedder was first honorary secretary and, from 1889 until his death, treasurer. He was active in all the society's meetings and undertakings and contributed about 20 papers to its different publications. He was treasurer of the Royal Historical Society from 1904 until his death, secretary to the Herbert Spencer Trustees and editor of a continuation of Spencer's *Descriptive Sociology*, and a member of the Royal Commission on Public Records from 1910 to 1919. He wrote a number of articles for the *Encyclopædia Britannica*, 11th edition, and also for the *Dictionary of National Biography* and the *Dictionary of Political Economy*. He died on Aug. 1, 1924.

TEDDER: *see* CULTIVATING MACHINERY.

TEDDINGTON, an urban district in the Spelthorne parliamentary division of Middlesex, England, close to the Thames, 13 m. W.S.W. of St. Paul's cathedral, London, on the N. London and S. railways. Pop. (1921) 21,213. The district is residential and the town is a resort of visitors both to the river and to Bushey park, which lies immediately south. (*See* HAMPTON.)

TE DEUM, opening words of the ancient Latin hymn *Te Deum laudamus* (We praise Thee O God), at one time believed to have been written by St. Ambrose of Milan and now generally ascribed to Nicetas, Bishop of Remesiana in Dacia. Its noble character speedily procured its incorporation in the liturgy of the Latin church while it has been set separately by countless composers as a hymn of thanksgiving for special occasions.

TEE, in golf a small conical mound made of damp earth on which the ball is placed before making the first drive for a hole. Sometimes an artificial tee, usually made of rubber or wood is used. In some games, such as quoits, horseshoes, and hobs, the tee is the mark toward which the player throws.

TEELE, RAY PALMER (1868–1927), American economist, was born in Fillmore county, Minnesota, on Oct. 22, 1868. He was educated at the University of Nebraska (M.A., 1899), and from 1899 until his death was economist of the U.S. Department of Agriculture. In 1910–12 and 1919–21 he served as special agent of the Census Bureau in charge of irrigation. He made investigations and wrote a number of government reports on water rights and irrigation and also contributed numerous articles to periodicals on these subjects. He was the author of a large number of government bulletins including "Land Reclamation Policies in the United States" (Dept. of Agri., Bull. No. 1257, 1924) and "The western farmer's water right" (Dept. of Agri., Bull. No. 913, 1920). He also wrote *Irrigation in the United States* (1915), and *The Economics of Land Reclamation in the United States* (1927). He died at Myton, Utah, on Sept. 1, 1927.

TEEMANT, JAAN (1872–), Estonian statesman, was educated in law at Petrograd University. He practised in Reval, but in 1905 associated himself with the revolutionary movement for which he was condemned to death by the Russian government. He escaped to Switzerland where he lived a number of years, but in time returned to Russia and served a sentence of one and one-half years' imprisonment. He then resumed his practice in Reval. After the 1917 revolution he took an active part in the establishment of the new Estonian government, was a member of the Constituent Assembly, 1919–20, and after 1920 of the Estonian Diet. He rose to power as a leader of the Agrarian party and in December, 1925, became prime minister.

TEES, a river of England, rising on the east side of Cross Fell, and traversing a valley about 85 m. in length to the North sea. In the earliest part of its course it forms the boundary between the counties of Westmorland and Durham. The head of the valley (upper portion known as Teesdale) is not without desolate grandeur, the hills, exceeding 2,500 ft. in height at some points, consisting of bleak moorland. A succession of falls or rapids, where the river traverses a series of hard, black basaltic rocks, is known as Caldron Snout; and from a point immediately below this to its mouth the Tees forms the boundary between Durham and Yorkshire almost without a break. The dale becomes bolder below Caldron Snout, and trees appear, contrasting with the broken rocks where the water dashes over High Force, one of the finest falls in England. The scenery becomes gentler but more picturesque as the river descends past Middleton-in-Teesdale (Durham), the terminus of a branch of the North-Eastern railway from Darlington. In this locality lead and iron-stone are worked. The town of Barnard Castle, Eggleston abbey, and Rokeby hall, well known through Sir Walter Scott's poem, are passed; and then the valley begins to open out, and the river meanders across the rich plain east and south of Darlington. The river now becomes an important commercial waterway, having on its banks the ports of Stocton-on-Tees, Thornaby-on-Tees and Middlesbrough, and forming an outlet for the rich iron-working district of Cleveland in the North Riding of Yorkshire. The drainage area is 708 square miles.

TEETH, the modified papillae or elevations of the mucous membrane of the mouth, impregnated with lime salts. Each tooth has a biting part or crown covered by enamel, a neck where the gum surrounds it, and one or more roots or fangs fitting into sockets (alveoli) in the jaw bone. For surgery of the teeth *see* DENTISTRY.

There are 32 permanent teeth in man, 16 in the upper and 16 in the lower jaw; they are also arranged in symmetrical sets of 8 teeth on each side. The upper and lower symmetrical sets of 8 will be described. The two teeth from the mid-line in front are "incisors" and have chisel-shaped crowns. The central incisor of the upper jaw is broader than any of the others, and bites against the central and lateral incisors of the lower jaw; the same want of exact adaptation continues throughout the series, so that every tooth in the upper jaw except the last molar bites against its corresponding tooth of the lower jaw and also against the tooth behind that.

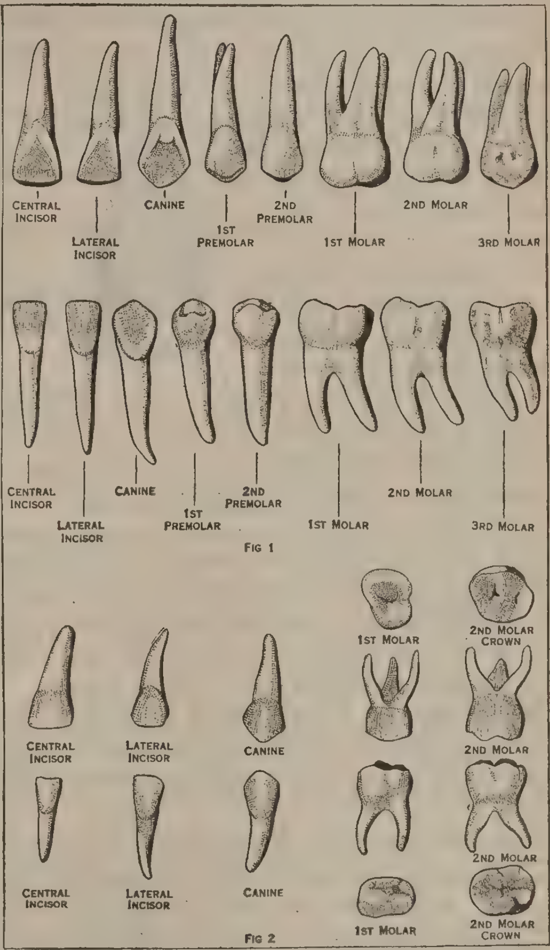
Next to the incisors comes the "canine (or eye) tooth," the crown of which is somewhat peg-shaped, while behind this are the two "premolars" or "bicuspids," whose crowns are flattened from before backward and bear two cusps, the larger of which is external. As a rule there is a single root, though sometimes in the first upper premolar it is double.

The three "molars" are placed behind the premolars, and the upper and lower sets can be easily distinguished because the upper have three roots while the lower have only two. The grinding surface of the crowns of the upper molars shows three or four cusps, while on the grinding surface of the lower molars four or five cusps are found.

Of the three molars the first is the largest, and the third, or wisdom tooth, the smallest, while the upper wisdom tooth is smaller than the lower.

In the "milk teeth" or temporary dentition of the child there are only 20 teeth, 10 in each jaw and 5 in each segment. They are two incisors, one canine and two so-called molars. These molars occupy the position which the permanent premolars later on take. The temporary teeth differ from the permanent in their smaller size, their whiter colour, the greater constriction of their necks, and in the fact that the roots of the molars are widely splayed.

The dates at which the milk teeth are cut are very variable. The lower central incisors come first between the sixth and ninth month, or even later; then come the central and lateral upper incisors; then the lower lateral incisors, followed closely by the first molars. After a rest of four or five months come the canines, while by about the end of the second year the second molars have appeared, and the milk dentition is complete. The milk teeth are cut in batches with resting intervals between.



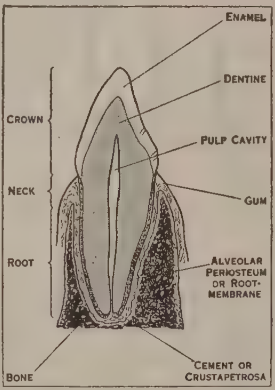
FROM BIRMINGHAM IN CUNNINGHAM'S, "TEXTBOOK OF ANATOMY" (OXFORD MEDICAL PUBLICATIONS)

FIG. 1.—PERMANENT TEETH OF THE RIGHT SIDE, SHOWING INNER OR LINGUAL ASPECT. FIG. 2.—MILK TEETH OF THE LEFT SIDE

The first permanent tooth to be cut is the first molar, and this happens during or soon after the sixth year. It does not displace any of the milk teeth, but comes down behind the second milk molar. During the seventh year the central milk incisors fall out and their place is taken by the permanent ones; the shed teeth are mere shells of the crown, all the root having been absorbed.

The lateral incisors succeed their milk predecessors at about eight years old, the first premolar takes the place of the first temporary molar about nine, the second premolar that of the second temporary molar about ten, the canine about eleven, while the second molar comes down behind the first about twelve. The third molar, or wisdom tooth, usually appears between eighteen and twenty, but may be much later, indeed it is sometimes never cut at all, and when it is, it often does not come down to a level with the other teeth. It is believed that man is gradually undergoing a suppression of his last molar teeth.

Histology.—In a vertical section the exposed part or crown is seen to be covered with enamel, which, microscopically, is composed of fine hexagonal prisms arranged at right angles to the surface of the tooth, and formed chiefly of calcium phosphate with small amounts of calcium carbonate, magnesium phosphate and calcium fluoride, but containing practically no organic matter. The enamel rests on the "dentine," of which hard yet elastic substance by far the greater part of the tooth is composed. It is made of the same salts as the enamel, but contains in addition a good deal of organic matter and forms a structureless mass through which the fine "dentinal tubes" run from the pulp cavity to the periphery.



FROM BIRMINGHAM IN CUNNINGHAM'S, "TEXT BOOK OF ANATOMY" (OXFORD MEDICAL PUBLICATIONS)

FIG. 3.—VERTICAL SECTION OF CANINE TOOTH ILLUSTRATING ITS PARTS AND STRUCTURE

Surrounded by the dentine is the "pulp cavity," which is filled by the tooth pulp, a highly vascular and nervous mass of branched connective tissue cells, which, in a young tooth, has a layer of epithelial cells, the "odontoblasts," lying close against the wall of the cavity and forming new dentine. Slender processes ("Tomes's fibrils") project from these cells into the dentinal tubes and are probably sensory. A nerve and artery enter the apex of the root of the tooth, but it is not understood how the nerve ends.

Surrounding the dentine where it is not covered by enamel is the "cement" or "crusta petrosa," a thin layer of bone which is only separated from the bony socket by the alveolar periosteum.

Embryology.—The lip is marked off in the mouth by a "lip groove," which, in the case of the lower jaw, grows obliquely downward and backward, and the mass of ectodermal cells bounding it penetrates for some distance into the surrounding mesoderm below the bottom of the groove. This is known as the "tooth band."

On the under surface of this oblique tooth band (still taking the lower jaw), and close to its edge, appear ten thickenings, below each of which the mesoderm rises up into a "dental papilla," and so moulds the thickening into a cap for itself—the "enamel organ." The superficial cells of the dental papilla become the "odontoblasts" and manufacture the dentine, while those cells of the cap (enamel organ) which are on its concave surface and therefore nearest the dental papilla are called "ameloblasts," and form the enamel. The cutting or grinding part of the tooth is first formed, and the crown gradually closes round the dental papilla, so that at last, when the root is formed, the central part of the papilla remains as the pulp cavity surrounded by dentine except at the apex of the root. The roots, however, are formed slowly, and as a rule are not complete until some time after the tooth is cut. The mesoblastic connective tissue surrounding the developing tooth becomes condensed into a fibrous bag called the tooth-sac, and round this the lower jaw grows to form the alveolus. The crusta petrosa covering the root is developed from the tooth-sac. Hence of the various structures which make up a tooth, the enamel is derived from the ectoderm, while the dentine, pulp and crusta petrosa or cement are mesodermal.

Comparative Anatomy.—The details of the teeth vary so greatly in different animals, and, on account of their being the most durable tissues of the body, are so important for classificatory purposes, that they are dealt with freely in the various zoological articles. All that can be done here is to give a broad general survey, taking the details of man's dentition as a point of departure.

In some fishes the teeth are continuous over the edges of the jaws with the scales on the surface of the body, and there is no doubt that teeth should be regarded as modified scales which have migrated into the mouth.

In the Cyclostomata (lampreys and hags) the teeth are horny cones, but beneath them there are papillae of the mesoderm covered with ectoderm which resemble the dental papillae and enamel organs although no calcification occurs except in Bdellostoma. In the Elasmobranchii (cartilaginous fishes) the teeth are arranged in several rows, and as those of the front row fall out the hinder row take their place; sometimes they are triangular and very sharp as in the sharks, sometimes flattened and arranged like a pavement for crushing as in rays. These teeth only represent the crowns of man's teeth, and they are not embedded in sockets except the teeth in the saw of the saw-fish (Pristis), moreover the dentine of which they are largely composed resembles bone and fills up the whole pulp cavity. From its structure it is known as *osteodentine.*

In the Teleostomi (teleostean and ganoid fishes) there is great variability; sometimes, as in the sturgeon, there are no teeth at all, while in others every bone bounding the mouth, including the branchial arches, bears teeth. As an example of a very full tooth armature the pike's mouth and pharynx may be instanced. Both in the pike and the hake hinged teeth occur; these bend backward during the passage of prey down the throat, but are re-erected by elastic ligaments. As a rule, the dentine of the Teleostomi is osteodentine, but sometimes, as in the hake, it is vascular and is known as vasodentine.

In the Amphibia teeth are not so numerous as in the fishes, though like them they are not confined to the jaws, since vomerine teeth are very constant. The toad is edentulous, while the frog has no teeth in the lower jaw. An extinct order of tailed amphibians, the Stegocephali, are often called labyrinthodonts on account of the complex way in which the enamel is involuted into the interior of the teeth.

In the Reptilia various arrangements of the teeth are found. In the Chelonia (turtles) there are no teeth, although the ectodermal ingrowth (dental band) from which they are developed in other animals is present in the embryo. The place of the teeth in these reptiles is taken by horny jaw-cases.

In the Ophidia the non-poisonous snakes have two rows of teeth in the upper jaw, one on the maxillae and another on the palatine and pterygoid bones, while in the lower jaw there is only one row. These teeth are sharp pegs anchylosed to the bones and so strongly recurved that one of these snakes would be unable, even if it wished to do so, to let any prey which had once entered its mouth escape. The poisonous snakes have a special poison fang in the maxilla of each side; these have a deep groove or canal running down them which transmits the poison from the poison gland. In the colubrine snakes, such as the cobra, the poison fang is always erect, but in the viperine, such as the adder and rattlesnake, there is a mechanism by which the tooth is only erected when the jaws are opened for striking. At other times the teeth lie flat in the roof of the mouth.

In the lizards or Lacertilia the teeth usually consist of a series of pegs in the upper and lower jaw, each resembling the one in front of it; sometimes, as in the chameleon, they are anchylosed by their bases to the bone, but at others, as in the iguana, they are fused by their sides to a ridge of bone which forms a low wall on their lateral surface. In the former case the dentition is spoken of as "acrodont," in the latter as "pleurodont."

In the Crocodilia the teeth are fitted into definite sockets as in mammals and are not anchylosed with the jaws. This arrangement is spoken of as "thecodont."

Existing birds are toothless, but palaeontology shows that they originally had teeth of a reptilian character.

In all these lower vertebrates, then, the teeth are similar or nearly similar in character; at least they are not divided into definite incisor, canine, premolar and molar regions. Their dentition is therefore known as "homodont." Another characteristic is that in almost all of them there is an arrangement for a continuous succession of teeth, so that when one is lost another from behind takes its place, and to this arrangement the term "polyphyodont" is applied.

Mammalia.—In the Mammalia the different groups of teeth (incisor, canine, etc.) already noticed in man are found, and these animals are characterized, with some exceptions, by having a "heterodont" as opposed to a homodont dentition. In the mammals too the polyphyodont or continuous succession of teeth is reduced to a "diphyodont" dentition, which means that there is only one relay of teeth to replace the first set. In the marsupials the reduction of the succession is carried still further, for only one premolar in each segment of the jaw is replaced, while in the toothed whales there is no succession at all. When one set has to do duty throughout life the dentition is called "monophyodont."

It is uncertain how the complex back teeth of mammals with their numerous cusps were derived from the simple conical teeth which are generally assumed to have been the primitive arrangement. The "tritubercular" theory, which is most favoured, is largely based on the researches of E. D. Cope and H. F. Osborn, two American palaeontologists. According to this theory a simple peg-like ("haplodont") tooth develops two additional smaller pegs or cones, one in front and one behind the original main cone. This is known as the triconodont stage, and it is found in some of the oldest extinct mammals. As a later adaptation the two small cones become external to the original cone in the upper jaw and internal in the lower. The surface of the tooth has now a triangular shape with a cone at each angle, and this is the "tritubercular tooth" which is very common among the ancestral mammals. Other cusps may be developed later, and so the quadricuspid and quinquecuspid molar teeth of man and other mammals are accounted for.

Incisor teeth are those which in the upper jaw have their sockets in the premaxillary bone; they are generally chisel-shaped, and with their opponents of the lower jaw act like scissors. The *canine tooth* is the first tooth behind the premaxillo-maxillary suture, provided it be not far behind it; it is almost always the first of the premaxillary series, speaking accurately, which is elongated and sharply pointed. The *premolar teeth* are those in the maxillary bone which are preceded by milk teeth. The *molar teeth* are those, behind the premolars, which are not preceded by temporary teeth.

In front of the premolar teeth, and between them and the canine, if it be present, or the incisors, if it be absent, there is often a space called the "diastema." It is best marked in the Rodentia and Ungulata, and in the horse is familiar as the place where the bit lies. The elephant's tusks are modified incisors, those of the walrus and wild boar are modified canines.

Dental Formulae.—In recording the teeth of any particular mammal it saves time and space if a dental formula be used. This simply means setting down the number of each kind of tooth in one side of the upper and lower jaw in their order from before backward. Thus man's formula would be, incisors $\frac{2}{2}$, canines $\frac{1}{1}$, premolars $\frac{2}{2}$, molars $\frac{3}{3}$. This is condensed into $\frac{2.1.2.3}{2.1.2.3}$.

Some other types of dental formulae are—

Catarrhine (old world) monkeys	$\frac{2.1.2.3}{2.1.2.3}$
Platyrhine (new world) monkeys	$\frac{2.1.3.3}{2.1.3.3}$
Marmosets	$\frac{2.1.3.2}{2.1.3.2}$
Most lemurs	$\frac{2.1.2.3}{2.1.2.3}$
or	$\frac{2.1.3.3}{2.1.3.3}$
Insectivorous bats (full series)	$\frac{2.1.3.3}{3.1.3.3}$
Frugivorous bats	$\frac{2.1.2.3}{2.1.3.3}$
Insectivora (teeth variable)	
Hedgehog	$\frac{3.1.3.3}{2.1.2.3}$
Mole	$\frac{3.1.4.3}{3.1.4.3}$
Carnivora—	
Cat family (Felidae)	$\frac{3.1.3.1}{3.1.2.1}$
Dog family (Canidae) Bear family (Ursidae)	$\frac{3.1.4.2}{3.1.4.3}$
Civet family (Viverridae) Racoon family (Procyonidae)	$\frac{3.1.4.2}{3.1.4.2}$
Hyaena family (Hyaenidae)	$\frac{3.1.4.1}{3.1.3.1}$
Weasel family (Mustelidae)	$\frac{3.1.4.1}{3.1.4.2}$
Eared seal family (Otariidae)	$\frac{3.1.4.1}{2.1.4.1}$
Seal family (Phocidae)	$\frac{3.1.4.1}{3.1.4.1}$
Walrus family (Trichechidae), adult	$\frac{1.1.3.0}{0.1.3.0}$
In a young animal (probably)	$\frac{3.1.3.2}{3.1.3.1}$
Ungulata—	
Hippopotamus	$\frac{2.1.4.3}{2.1.4.3}$
Pig family (Suidae)	$\frac{3.1.4.3}{3.1.4.3}$
Camel	$\frac{1.1.3.3}{3.1.2.3}$
Chevrotain (Tragulidae)	$\frac{0.1.3.3}{3.1.3.3}$
Deer family (Cervidae)	$\frac{0.(0 \text{ or } 1).3.3}{3.1.3.3}$
Hollow-horned ruminants (Bovidae)	$\frac{0.0.3.3}{3.1.3.3}$
Tapir	$\frac{3.1.4.3}{3.1.3.3}$
Horse (Equidae)	$\frac{3.1.3.3}{3.1.3.3}$
Rhinoceros	$\frac{(0-2).0.4.3}{(0-1).(0-1).4.3}$
Procavia (Hyrax)	$\frac{(1-2).0.4.3}{2.0.4.3}$
Elephant	$\frac{\text{d.i.1.i.1.c.0.d.m.}(3-4)\text{m.}3}{0\quad 0\quad 0\quad (3-4)\quad 3}$

In this animal there are no premolars, but the milk molars (d.m.) and true molars gradually replace one another from before backward throughout life, so that there are never more than two back teeth in each segment of the jaw at any one time.

Rodentia—	
Typical rodents (Simplicidentata)	$\frac{1.0.(0-1).3}{1.0.(0-1).3}$
Hares and rabbits (Duplicidentata)	$\frac{2.0.3.3}{1.0.2.3}$

Cetacea.—In the living toothed whales (Odontoceti) the dentition is homodont and may be as great as $\frac{60}{60}$. There is every reason to believe, however, that they are derived from heterodont ancestors.

The homodont dentition of the whales is a retrograde process, and is therefore not comparable to the homodont dentition of the vertebrates below mammals.

Sirenia.—The dentition is monophyodont. The manatee has i. $\frac{2}{2}$, c. $\frac{0}{0}$, back teeth $\frac{11}{11}$.

In the Edentata the ant-eaters (Myrmecophagidae) and pangolins (Manidae) are toothless, though the latter have foetal tooth germs. The aard varks (Orycteropodidae) are somewhat heterodont, while the armadillos (Dasypodidae) and sloths (Bradypodidae) have a homodont dentition, which, like that of the whales, is retrogressive. In the giant armadillo (*Priodon gigas*) the formula is $\frac{25}{25}$. This animal therefore has a hundred teeth. In none of the Edentata are the teeth covered with enamel.

In the Marsupialia the typical formula is $\frac{3\cdot 1\cdot 3\cdot 4\cdot}{3\cdot 1\cdot 3\cdot 4\cdot}$. They are divided into *diprotodont*, in which there are not more than $\frac{3}{3}$ incisors, often $\frac{3}{1}$ as in kangaroos, and *polyprotodont*, in which the incisors are more than $\frac{3}{3}$, as in the Tasmanian wolf (Thylacinus) and Tasmanian devil (Sarcophilus). The marsupial teeth are often regarded as all milk teeth.

In the Monotremata the Echidna or spiny ant-eater is quite edentulous, while the duck-mole (Ornithorhynchus) has functional molar teeth in youth, though in the adult these are lost, and their place is taken by horny plates.

Reviewing the various tooth formulae of mammals the following is usually regarded as typical:

$$\frac{3\cdot 1\cdot 4\cdot 3}{3\cdot 1\cdot 4\cdot 3}.$$

This, it will be noticed, is the formula of the pig, and it is also that of almost all the Eocene Ungulata.

Brief Dental Glossary.—As the teeth are of such importance in the classification of animals, some of the chief terms by which they are described are recapitulated and briefly defined here.

1. *Acrodont*, a tooth which is anchylosed by its base to the summit of a parapet on the jaw.
2. *Bilophodont*, a molar tooth having two transverse ridges on its grinding surface, as in the tapir.
3. *Brachyodont*, a low-crowned molar tooth—the opposite of hypsodont.
4. *Bunodont*, a tooth bearing conical cusps.
5. *Diphyodont*, having two series of teeth (milk and permanent).
6. *Diprotodont*, a marsupial with not more than $\frac{3}{3}$ incisors, often only one on each side of the mandible.
7. *Haplodont*, a tooth having a simple conical crown with a single root.
8. *Heterodont*, a dentition in which the teeth are not all alike, chiefly characteristic of the Mammalia.
9. *Homodont*, a dentition in which the teeth are all alike, as in many of the lower vertebrates and some mammals.
10. *Hypsodont*, a high-crowned molar tooth, such as that of the horse,—the opposite to brachydont.
11. *Lophodont*, a transversely ridged molar tooth.
12. *Monophyodont*, having only one dentition (*cf.* diphy- and polyphy-odont).
13. *Multituberculate*, a tooth, the crown of which bears numerous conical cusps; held by some to be the primitive condition of the mammalian teeth.
14. *Pleurodont*, a tooth anchylosed to the inner side of a parapet on the jaw.
15. *Polybunodont*, a synonym for multituberculate.
16. *Polyphyodont*, having an endless succession of teeth, as in most vertebrates below the mammals.
17. *Polyprotodont*, a marsupial having an incisor formula of more than $\frac{3}{3}$.
18. *Protodont*, a stage met with in fossil mammals which is an advance on the haplodont tooth in that two small cusps are added to the main cone.
19. *Secodont*, a back tooth adapted to cutting, as in many of the Carnivora.
20. *Selenodont*, a molar tooth with crescentic ridges on its grinding surface, as in most ruminants.
21. *Thecodont*, a tooth embedded in a socket or alveolus, as in mammals.
22. *Triconodont*, a fossil stage in advance of the protodont. There are three well-marked cones in an antero-posterior line.
23. *Tritubercular*, a fossil stage succeeding the triconodont. The main cone is external in the lower teeth and internal in the upper. A very common form of back tooth in fossil forms and one which gives its name to the "tritubercular theory."

(F. G. P.)

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TEETH, ARTIFICIAL. In the beginning of the restorative art in dentistry, artificial substitutes were human teeth, teeth of cattle and sheep, teeth carved from the tusks of the elephant, and from the tooth of the hippopotamus. The first recorded substitute other than animal substances was a paste made of white wax, gum elemi and the powder of white mastic, of coral, and of pearl. It was originated by the Frenchman, Guillemeau, in 1710. In 1728 Fauchard, also a Frenchman, is credited with the development of a porcelain and a technique for making artificial teeth. The porcelain teeth thus made in France were introduced into America in 1874 by Plantou. Silica, kaolin and feldspar are the three basic materials used in the manufacture of porcelain teeth. Silica is used as a vehicle for holding the form of the tooth; it is of selected high quality and has an exceptionally high fusing point. Kaolin adds density and strength and forms the body material of the tooth. Felspar is the flux, which combines the silica and kaolin, thereby forming a porcelain that is the finest in texture, translucency and quality, with a high degree of strength, yet developed in the ceramic arts. Colour is supplied through the use of the oxides of titanium, platinum, cobalt, iron, gold and tin. These materials, known as colouring frits, are incorporated with the basic ingredients to produce the tints desired.

Artificial teeth are first carved in plaster or other suitable material to a size approximately one-fifth larger than the desired finished product. This allows for the shrinkage in the porcelain during the fusion process. Moulds of hard metallic substance are made from the enlarged plaster teeth and the porcelain is packed in them in the form of a paste. After hardening to a bisque form, the teeth are removed from the moulds, placed in a furnace, and fused at a temperature varying from 1,700 to 2,500° F. Crowns, facings and vulcanite teeth are the types required to meet individual needs. Porcelain crowns are used to replace the crowns of natural teeth when their roots are in place. The porcelain crown is attached to the natural root by means of a post that is fitted and cemented to place. Facings are of the veneer type and are used to restore the loss of one or more teeth by bridge work. Vulcanite teeth are generally used when partial or full sets of dentures are required. These teeth are attached to a base and made to fit over the various individual forms of the gums. Materials used for bases are hard rubber, gold, platinum or bakelite. The typal classification of selecting artificial teeth is the one now in current use. There are three basic typal forms of faces, square, tapering and ovoid, and the teeth harmonize with these types.

(M. M. H.)

TEGEA, an ancient Greek city of Arcadia, on a plateau enclosed by Mts. Parthenium and Maenalus on east and west, and by transverse ranges which separate it from the plateau of Orchomenus and from the Eurotas valley. Tegean territory occupied the southern part of this plain; the northern half belonged to Mantineia (*q.v.*). Its geographical position accounts for the conflicts which arose with Mantineia and with Sparta.

Tegea was one of the most ancient cities of Peloponnesus; tradition ascribed its concentration (*synoecism*) out of eight or nine primitive cantons to a mythical king Aleus. As several Cretan townships passed for colonies of Tegea, oversea connections may be inferred in prehistoric days. The prominence which legend assigns to its king Echemus in opposing the Heraclid invasion shows that it was one of the chief Peloponnesian communities in pre-Dorian days. For several centuries Tegea screened Arcadia against expanding Sparta; ultimately subdued about 550 B.C. it was allowed to retain independence and Arcadian nationality. During the Persian invasion the Tegeans displayed a readiness unusual among Peloponnesian cities; in the battle of Plataea they were the first to enter the enemy's camp. A few years later they headed an Arcadian and Argive league against Sparta, but after losing two pitched battles at Tegea and Dipaea they resumed their former loyalty about 468–467. In 423 there was open war with the Mantineians, and when the latter rebelled against Sparta and allied themselves with Argos and Athens, the Tegeans stood firmly by Sparta's side: in the decisive battle of Mantineia (418) their troops had large share in the overthrow of the coalition; and during the early 4th century Tegea continued to support Sparta against the Mantineians and other malcontents. But after the battle of Leuctra the philo-Laconian party was expelled with Mantineian help.

Tegea henceforth took an active part in the revival of the Arcadian League and in alliance with Thebes against Sparta (371–362), and the defection of Mantineia confirmed its federalist tendencies. The foundation of the new federal capital Megalopolis threw Tegea somewhat into the shade. Hostile to the Macedonians, in 266 it joined the Chremonidean League against Antigonus Gonatas. To the incorporation of Mantineia into the Achaean League (233) Tegea replied by allying itself with the Aetolians, who in turn made it over to Cleomenes III. of Sparta (228). From the latter it was transferred by Antigonus Doson to the Achaean League (222); in 218 it was again occupied by the Spartans but reconquered in 207 by the Achaean general Philopoemen. In Augustus' time Tegea was the only important town of Arcadia, but its history throughout the Roman and Byzantine periods is obscure; it ceased to exist as a Greek city after the Gothic invasion of 395. The site is now occupied by the small village of Piali.

Archaeology.—The temple of Athena Alea at Tegea is described by Pausanias as excelling all others in Peloponnese. The original temple built by Aleus, the founder of the city, was superseded by a larger one which was destroyed by fire in 395 B.C. Rebuilding was entrusted to Scopas, the great sculptor; and probably he also provided the pediment sculptures, representing at the front, the hunt of the Calydonian boar, and, at the back, the battle of Achilles and Telephus. Both subjects were intimately associated with the temple, for Atalanta had dedicated in it the face and tusks of the boar, and Telephus was the son of Heracles and the priestess Auge. Two heads of heroes and that of the boar were found before 1880; later excavation, in 1883, showed the plan of the temple, which had six columns at front and back, and thirteen at the sides. Like the temple at Phigalia (*q.v.*) it combined all three orders—Doric, Ionic and Corinthian. In 1900 the French School at Athens recovered more fragments, including a head of Heracles and the torso and possibly the head of Atalanta, these last two of Parian marble. *See* GREEK ART.

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TEGERNSEE, a lake in Upper Bavaria, situated in a beautiful mountain country, 2,382 ft. above the sea, 34 m. south from Munich by rail to Gmund, a village on the north shore. The lake is 4 m. long, 1¼ broad, and about 235 ft. deep. Its waters discharge through the Mangfall into the Inn. It is one of the most frequented summer resorts in the vicinity of Munich.

The village of Tegernsee, on the east bank, has a 15th century parish church and a ducal castle (formerly a Benedictine monastery).

TEGETTHOFF, WILHELM VON, BARON (1827–1871), Austrian admiral, son of Lieutenant-Colonel Karl von Tegetthoff, was born at Maribor (Marburg) on Dec. 23, 1827. After passing through the naval college at Venice, he became ensign in 1848 and lieutenant in 1852. He served in the Crimean war, on the Mediterranean station, and in the North Sea against the Danes (1863). In 1866 he was placed in command of the effective force of the Austrian navy. The decisive victory of the Austrian fleet at Lissa over superior Italian numbers (July 20) was entirely due to the personal superiority of Tegetthoff and the officers whom he in great measure had trained. Tegetthoff was immediately promoted vice-admiral. In March 1868 he became head of the naval section of the War Office and commander-in-chief of the navy. He died at Vienna on April 7, 1871.

TEGNER, ESAIAS (1782–1846), Swedish writer, was born on Nov. 13, 1782, at Kyrkerud in Wermland. His father, a pastor, whose name had been Esaias Lucasson, took the surname of Tegnerus—altered by his fifth son, the poet, to Tegnér—from the hamlet of Tegnaby in Småland. In 1792 Tegnerus died. In 1799 Esaias Tegnér, educated in the country, entered the University of Lund, where he graduated in philosophy in 1802, and continued as tutor until 1810, when he was elected Greek lecturer. In 1806 he married Anna Maria Gustava Myhrman. In 1812 he was named professor, and continued as a lecturer in Lund until 1824, when he was made bishop of Vexiö. At Vexiö he remained until his death, twenty-two years later. Tegnér's early poems have little merit. He was comparatively slow in development. His first great success was a dithyrambic war-song for the army of 1808, which stirred every Swedish heart. In 1811 his patriotic poem *Svea* won the great prize of the Swedish Academy, and made him famous.

In the same year was founded in Stockholm the Gothic League (*Götiska förbundet*), of young and patriotic men of letters, of whom Tegnér quickly became the chief. The club published an excellent magazine, *Iduna,* in which it urged the study of old Icelandic literature and history. Tegnér, Geijer, Afzelius, and Nicander became the most famous members of the Gothic League. Tegnér's fame rests principally on three longer poems *Nattvardsbarnen* ("The First Communion," 1820), well known in Longfellow's version; *Frithjofs saga* (1820–25), a romantic paraphrase of an old saga, which was translated into nearly every European language; and the romance, *Axel* (1822). In later years Tegnér began, but left unfinished, two important epic poems, *Gerda* and *Kronbruden.*

The period of the publication of *Frithjofs saga* (1825) was the critical epoch of his career. It made him one of the most famous poets in Europe; it transferred him from his study in Lund to the bishop's palace in Vexiö; it marked the first breakdown of his health, which had hitherto been excellent; and it witnessed his unhappy passion for Euphrosyne Palm. On Nov. 2, 1846, he died in Vexiö. From 1819 he had been a member of the Swedish Academy, where he was succeeded by his biographer and best imitator Böttiger.

See Böttiger, *Teckning af Tegnérs Lefnad;* Georg Brandes, *Esaias Tegnér;* Thommander, *Tankar och Löjen;* E. Böök, *Esaias Tegnér* (vol. i., 1917).

TEGUCIGALPA (tā-go͞o-thē-gahl′pạ), the capital of Honduras and of the department of Tegucigalpa; 3,200 ft. above sea-level, on the Choluteca, at the head of a highway to the port of San Lorenzo on Fonseca bay. Tegucigalpa is the only capital in the Americas excepting Asunción, Paraguay, which is without a railway. Pop. (1925) 38,950. Tegucigalpa became capital of Honduras, a status it had previously shared with Comayagua, in 1880. During the 18th century the neighbourhood was famous for its gold, silver and marble, but in modern times the mines and quarries have greatly declined in value, and farming is the chief local industry.

TEHRAN (tē-rahn′), capital of Persia and of a province of that name, is situated in 35° 41′ N., 51° 25′ E., at an elevation of 3,810 ft., on an extensive gravel deposit which slopes down from the foot of the Elburz mountains (some 10 m. distant) and extends for 5½ miles beyond the city, on the south. It occupies a radical position in Persia commanding routes in all directions, Isfahan being 224 m. distant on the south, Bushire 677 m., Baghdad 500 m. west; Tabriz 374 m. north-west, Meshed 471 m. north-east, Herat 672 m., and the Caspian sea 70 m. distant.

Streets and Buildings.—Formerly Tehran consisted of a fortified polygon of 4–5 m. circuit surrounded by a battlemented mud wall 20 ft. high flanked with circular towers and having a dry ditch and six gates. In 1869 Nasr-ud-Din Shah decided upon enlarging the city; the old walls and towers were demolished and replaced by a moat and earthen ramparts 12 m. in circumference, constructed on the plan of the fortifications of Pavis as they were before the Franco-German War, and completed in 1874. The city now encloses an area 7½ miles square, with 12 gates consisting of lofty archways adorned by turrets. The principal public place is the Maidan Tupkhaneh or Artillery Square, 270 yd. by 120, surrounded by barracks; another square is the great Maidan-i-Mashq, the military parade ground, 550 yd. by 350. From the Tupkhaneh two broad streets planted with poplars run in a northerly direction towards the outer walls, the westerly called the Khaiban-i-Dawlat, where are many foreign residences.

Occupying a space nearly a quarter of a mile square south of the Maidan Tupkhaneh, the site formerly of the ark or citadel, is a collection of gardens, courts and buildings attached to the royal palace, within the precincts of which are the *Talar*, or throne room, in which is the white marble throne or *Takht-i-marmar* of Kerim Khan Zand brought from Shiraz; and in the council chamber is the *Takht-i-taus*, or Peacock throne, not however that of the Mogul emperors brought by Nadir Shah from India, but a throne made for Fath Ali Shah.

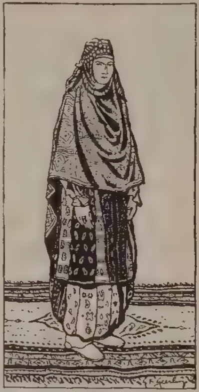
A census taken in 1919 gave a population of 250,000, which is supposed to be a decrease of 100,000 from the population of 1917–18, due to visitations of famine, influenza and typhus in that year. The great proportion are Farsi-speaking Persians and Shiah Mohammedans. Baha'is are numerous and there are a number of Armenians (some 5,000) mostly shop-keepers; also some Jews and Chaldeans. Tehran has a municipality under the guidance in 1928 of an energetic army officer and municipal conditions show some progress.

In Tehran there are medical, art, industrial, political science, law, military, agricultural and normal schools, some of which are under foreign direction and all staffed, in part, by foreign instructors. The American Presbyterian Mission has also an institution enrolling 670 students, 500 of college grade.

The water supply is almost wholly from *kanats* bringing water from the Shimran slopes of the Elburz. There are some 40 of them, 5–8 m. in length, the majority fed from underground sources, and entirely dependent upon the snow and rainfall.

The climate of Tehran used to be considered somewhat unhealthy, particularly in summer and early autumn, when typhoid, ague and other fevers were frequently prevalent; but something in the way of sanitation has been effected of late years and there has been a distinct improvement in the health of the city. For the years 1902–12, the average maximum shade temperature was 104·6° F, the average minimum 14·7°; the highest shade temperature registered was 109° and the lowest 6°. The average rainfall over a period of 15 years was 9·3 in.

A state-owned electric light plant provides lighting from sunset to 11 P.M. There is otherwise no general lighting of the streets at night, except that the municipality provides a few wick lamps in some of the main thoroughfares. A single track of tramway of about 6 m. traverses the city from east to west from the Abdul Azim gate to the Kazvin gate, and from the bazaars to the north. A single line of railway was laid in 1888 to Shah Abdul Azim about 5 m. south of the city. The telephone service within Tehran, and outside it to the principal summer resorts, is effectively maintained by the *Société Anonyme des Téléphones Persans;* in 1925–6 the subscribers numbered 1,372. Metalled roads passable for all kinds of motor transport at practically all seasons lead via Kazvin to Kermaushah and Resht, to Qum and Sultanabad (195 m.), and to Isfahan; and partly metalled roads to Meshed (566 m.), to Demavend (39 m.) and to Saveh and Hamadan (213 m.).



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THE DAUGHTER OF A RUG-MAKER OF TEHRAN

TEHRAN PROVINCE is bounded north by Mazanderan, west by Kazvin and Hamadan, south by Qum, and east by Semnan-Damghan provinces, and it embraces a large part of the southern slopes of the Elburz range, while again to the south is found the Daria-i-Namak, a salt lake, or morass, which extends for 150 m. E. and W. and has a breadth of 35 m. in some places.

History.—Though a modern capital Tehran is old historically, but was for long small and insignificant. It is thought that the name means "the plains" in contradiction to *shamran, i.e.*, "mountains." Almost the earliest mention of the place is by Yaqut (12th century) who speaks of its houses, constructed underground. It is described by Hamdullah Mustawfi, in the 14th century, as a town of some size and importance.

Under the later Safavis (end of the 17th and beginning of the 18th centuries) Tehran was sometimes the residence of the court. Sir Thomas Herbert who visited the city in 1627 states that it then contained 3,000 houses built of sun-dried bricks and supplied with water from a little river. The town was taken and pillaged by the Afghans in 1723; and receives mention by Jonas Hanway, 1744. With the rise of the Qajar dynasty at the close of the 18th century, the first epoch of the city's ascendancy began, Agha Mohammed Khan selecting it, about 1788, to supersede Isfahan or Shiraz as his capital, because of its proximity to Mazanderan, the starting point from which he had conquered the country and to which he could retire if hard pressed. Agha Khan, however, did little for the city after making it the capital.

Under the rule of Fath Ali Shah the city so increased in size and population that when visited by Ouseley and Morier about 1810, it had 12,000 houses and 40,000–60,000 people. It remained at about this size for the first seventy years of the 19th century until it underwent an entire renovation at the hands of Nasr-ud-Din Shah.

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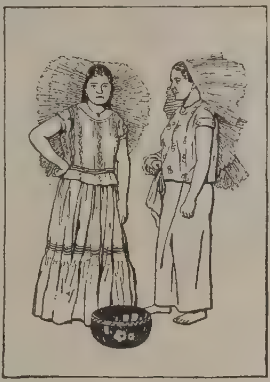
TEHRI, a mountain state in Northern India, politically connected with the United Provinces: area 4,180 sq.m.; population (1921) 318,414. It lies entirely amid the Himalayas, containing ranges from 20,000 to 23,000 ft. above sea-level, and also the sources of both the Ganges and the Jumna, with the places of pilgrimage associated with them. The forests, which have been leased to the British government, are very valuable, yielding several kinds of pine, oak and cedar. The chief, whose title is raja, is descended from a Rajput family which formerly ruled over all Garhwal, and enjoys a salute of 11 guns. The existing state was created by the British after the war with Nepal in 1815.

TEHUANTEPEC (tā-wahn-tā-pĕk), the town which gives its name (from *tecuani-tepec*—"jaguar-hill") to the isthmus, gulf and railway, stands on the Tehuantepec river about 15 m. from its mouth and 13 m. by rail from Salina Cruz. Pop. (1921) 9,252. It is a typical, straggling Indian town, occupying the slope of a hill on the Pacific side of the divide, with a beautiful view of the river valley and the distant sierras to the north. The streets are little more than crooked paths up the hillside, and the habitations are for the most part thatched, mud-walled huts. The population of the town and of the surrounding district is composed almost wholly of Indians of the great Zapoteca family.



INDIAN WOMEN OF TEHUANTEPEC IN NATIVE COSTUME

TEHUANTEPEC, an isthmus of Mexico lying between the gulfs of Campeche (Campeachy) and Tehuantepec, with the Mexican States of Tabasco and Chiapas on the east and Vera Cruz and Oaxaca on the west. It includes that part of Mexico lying between the 94th and 96th meridians of longitude W., or the south-eastern parts of Vera Cruz and Oaxaca, with perhaps small districts of Chiapas and Tabasco. It is 125m. across at its narrowest part from gulf to gulf, or 120m. to the head of Laguna Superior on the Pacific coast. The Sierra Madre breaks down at this point into a broad, plateau-like ridge, whose elevation, at the highest point reached by the Tehuantepec railway (Chivela pass) is 735 feet. The northern side of the isthmus is swampy and densely covered with jungle. The whole region is hot and malarial, except the open elevations where the winds from the Pacific render it comparatively cool and healthful. The annual rainfall on the Atlantic or northern slope is 48 in. (10 year average) and the maximum temperature about 95° in the shade. The Pacific slope has a light rainfall and dryer climate.

Since the days of Cortés, the Tehuantepec isthmus has been considered a favourable route, first for an interoceanic canal, and then for an interoceanic railway. Its proximity to the axis of international trade gives it some advantage over the Panama route, which is counterbalanced by the narrower width of Panama. When the great cost of a canal across the isthmus compelled engineers and capitalists to give it up as impracticable numerous projects for the construction of a railway were undertaken and abandoned. At last, in 1899 work was undertaken for the Mexican Government and was finished to a point where its formal opening for traffic was possible in 1907.

The railway is 192m. long, with a branch of 18m. between Juile and San Juan Evangelista. The minimum depth at low water in both ports is 33ft., and an extensive system of quays and railway tracks at both terminals affords ample facilities for the expeditious handling of heavy cargoes. At Santa Lucrecia, 109m. from Salina Cruz, connection is made with the Vera Cruz and Pacific railway (a government line), 213m. to Cordova and 311 m. to Mexico city.

TEHUELCHE, an almost extinct Indian tribe once occupying the plains of Patagonia from the Río Negro to the Straits of Magellan. Their great stature and physical vigour have created a giant-tradition in European literature. As the arid, wind-swept nature of Patagonia unfits it for agriculture, the Tehuelche necessarily were nomadic hunters. Before the 16th century they lived much as did their kinsmen, the Ona, in Tierra del Fuego, but the advent of the horse resulted in greatly enlarging their sphere of action and in various cultural changes.

See G. C. Musters, *At home with the Patagonians* (London, 1871); F. F. Outes, *La edad de piedra en Patagonia* (Buenos Aires, 1905).

TEIGNMOUTH, JOHN SHORE, 1st Baron (1751–1834), governor-general of India, was born on Oct. 8, 1751, the son of Thomas Shore, a supercargo in the service of the East India company. He was educated at Harrow, and went out to India as a writer in the Bengal Civil Service in 1769. He became a member of the Supreme Council (1787–89) and assisted Lord Cornwallis in introducing many reforms, but did not approve his permanent settlement of Bengal. On the retirement of Cornwallis, he was appointed governor-general (1793–98), adopting a policy of non-interference, but he deposed Wazir Ali, for whom he substituted Saadat Ali as nawab of Oudh. He met a mutiny of the officers of the Indian army with concessions. He died on Feb. 14, 1834.

See *Memoirs of Lord Teignmouth,* by his son (1843).

TEIGNMOUTH, a seaport, seaside resort and market town in the Totnes parliamentary division of Devon, England, at the mouth of the river Teign, on the English Channel, 15 m. south-by-east of Exeter, by a branch of the G.W. railway. Pop. of urban district (1921) 10,970. Two parishes, East and West Teignmouth, form the town. It lies partly on a peninsula between the river and the sea, partly on the wooded uplands which enclose the valley and rise gradually to the high moors beneath Heytor.

Teignmouth (*Teinemue, Tengemue*) possessed a church of St. Michael as early as 1044, when what is now East Teignmouth was granted by Edward the Confessor to Leofric, bishop of Exeter. In the middle ages Teignmouth was already a flourishing port, able to furnish 7 ships and 120 mariners to the Calais expedition of 1347, and depending chiefly on the fishing and salt industries. Teignmouth was burned by French pirates in 1340, and was again devastated by the French on the 26th of June 1690.

See *Victoria County History, Devonshire; The Teignmouth Guide and Complete Handbook to the Town and Neighbourhood* (Teignmouth, 1875).

TEIRESIAS, in Greek legend, a famous Theban seer, son of Eueres and Chariclo, a descendant of the *Spartoi* (*see* Cadmus). He was blinded early in life either because he saw Athena (or Artemis) bathing naked, or because he told Zeus and Hera that women had far more pleasure of love than men, thus bitterly offending the latter. At all events, he was comforted by the gift of seer-craft and granted a very long life, finally being allowed, even in Hades, to retain his wits and not be a mere phantom. As a result of killing coupling snakes he turned into a woman; years later he repeated the action, and became a man again. He died just after the capture of Thebes by the Epigoni (*q.v.*). His grave was at the Tilphusian spring; but there was a cenotaph of him at Thebes, and also in later times his "observatory," or place for watching for omens from birds, was pointed out (Pausanias ix. 16; Sophocles, *Antigone,* 999). He had an oracle at Orchomenus, but during a plague it became silent and remained so in Plutarch's time (*De Defectu Oraculorum,* 44).

TEISSERENC DE BORT, LEON PHILIPPE (1855–1913), French meteorologist, was born in Paris on Nov. 5, 1855, the son of an engineer. He began his scientific career in 1880, when he entered the meteorological department of the Bureau Central Météorologique in Paris under E. E. W. Mascart. In 1883, 1885 and 1887 he made journeys to north Africa to study geology and terrestrial magnetism, and during this period published some important charts of the distribution of pressure at a height of 4,000 metres. In 1892 he became chief meteorologist to the Bureau, but resigned in 1896, and founded a private meteorological observatory at Trappes, near Versailles, where he carried out investigations on clouds and the problems of the upper air. In 1898 he published an important paper in *Comptes Rendus* detailing his researches by means of balloons into the constitution of the atmosphere. His discovery of the so-called isothermal layer, or stratosphere, as it is now generally called, will always stand out as one of the most important events in the study of the upper atmosphere. He also carried out investigations in Sweden and over the Zuider Zee, the Mediterranean and the tropical region of the Atlantic, and fitted out a special vessel in order to study the currents above the trade winds. He collaborated with Hugo Hildebrandsson in *Les Bases de la météorologie dynamique* (1900–05). He died at Cannes on Jan. 2, 1913.

TEKTITE, the name given by F. E. Suess to the glass bodies occurring isolated on the surface or in gravels, in Moravia and Bohemia, where they are called moldavites, the East Indies, where they are known as billitonites, and Australia, there known under the name of australites and obsidianites (from Gr. τηκτός, melted). In Tasmania, an exceptional type is met with in the Mt. Darwin region on the west coast; these glass bodies are known as Darwin glass (or queenstownite). Isolated types of tektites have also been seen in Sweden and Colombia (South America).

In the Moldau district of Bohemia the moldavites occur as flat, rounded or ellipsoidal bodies of a bottle-green colour, and usually with a pitted or corrugated surface. The homes of these tektites are river gravels or deposits of late Tertiary or Recent age. The colour of this material led to its being commonly called *Bouteillenstein.* Australites are found distributed over wide areas remote from volcanic regions in Australia, principally in Victoria and the central goldfields of Western Australia. They exhibit a great variety of curious forms suggestive of flight and rotation while in a molten or plastic state. These shapes are ellipsoidal, pear-shaped or button-like with a projecting rim like a saucer. They are darker and less transparent than moldavites. Billitonites resemble australites more than moldavites, being dark like the former. They occur in river gravels in the island of Billiton, and are for the most part roughly spherical or ellipsoidal and possess glossy, deeply sculptured surfaces. Billitonites reach in size up to 3 in. in diameter and in weight to 16 ounces.

Composition.—While possessing the silica content of natural obsidians (70–90% SiO_2) the tektites contain a higher percentage of iron and magnesium, and excess of calcium and potassium over sodium. Nor do they contain, with one doubtful exception, signs of incipient crystallization as is common in obsidians. The distinctive chemical composition of these bodies is reflected in their specific gravity and light refraction, which enables them to be separated from rhyolite and trachyte obsidians. They have been claimed as originating by the fusion of dust in the air by lightning and that they are really fulgurites, but little can be said for this view. Though they are of widely different composition from the iron or ultrabasic meteorites, a meteoritic origin remains as the least objectionable of all theories.

Analyses of some typical tektites are given below.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O
1.	77·75	12·90	..	2·60	0·22	3·05	0·26	2·58
2.	70·92	12·20	1·07	5·42	2·61	3·78	2·46	2·49
3.	68·91	15·02	0·40	4·65	2·47	3·20	1·29	2·56
4.	89·81	6·21	0·26	0·89	0·73	..	0·01	1·05

1. Moldavite—Radomilitz, near Budweis, Bohemia.
2. Billitonite—Tebrug, Dendang, Dutch East Indies.
3. Australite—Uralla, New South Wales.
4. Darwin glass—Ten-Mile Hill, Mt. Darwin, Tasmania.

See F. E. Suess, *Mitt. Geol. Gesell.*, vol. vii., pp. 51–121 (Wien, 1914); C. E. Tilley, *Min. Mag.*, vol. xix., pp. 275–294 (1922). (C. E. T.)

TELAMON (mod. TALAMONE), an ancient city on the coast of Etruria, 11 m. N. of Orbetello. It was an Etruscan harbour, and the decorative terra-cottas of a temple which was restored in the 3rd century B.C. have been found. Marius disembarked here on his return from Africa in 87 B.C.; and the harbour, which is well protected, was of some importance in the Middle Ages. It is now used only by the Italian navy.

TELANG, KASHINATH TRIMBAK (1850–1893), Indian Orientalist, was born at Bombay on Aug. 30, 1850. In 1889 he became a judge of the high court, where his judgments are recognized as authoritative. He was a great Sanskrit scholar, his translation of the *Bhagavadgita* into English is a standard work, and he criticized Professor Weber's theory of Homeric influence on the *Ramayana.* He died at Bombay on Sept. 1, 1893.

See R. West's *Telang's Legislative Council Speeches* (Bombay, 1895).

TELAV, a small town in the Georgian S.S.R., on the Alazan river, alt. 2,420 ft., in 41° 55′ N., 45° 24′ E., on a branch railway from Tiflis. Its population (8,766 in 1926) is mainly occupied in silk weaving and wine production. Founded in 893, it was the capital of Kakhetia until 1797 and the ruins of its forts still exist. In its environs are religious foundations of great antiquity, the 6th century Ikaltoi monastery, the Alaverdi church founded in the 10th century and the 16th century Shuanty monastery.

TELECHRON, an electric timekeeper invented by Henry E. Warren which is operated and regulated by alternating current. The motive power is a small self-starting motor running in exact synchronisation with a central station generator. A telechron will not operate on direct current nor will it keep correct time on an unregulated alternating current service, but many power companies are holding their frequency so close that the instantaneous error is never great. Telechrons are connected to electric outlets in exactly the same manner as any other electric device.

TELEGRAPH. (*See* also SIGNALLING.) Before the Christian era the bounds of electrical knowledge were confined to two facts: the attracting properties of rubbed amber, and the magnetic attraction of the lodestone; but although these phenomena were noted by Homer in the 12th century B.C. and others in later years, no attempt was made to explain them until the 13th century A.D. In 1267 Roger Bacon published his theories on the polar attraction of the lodestone. Following upon this publication rumours appear to have been circulated in connection with "a certain sympathetic needle" with which it was possible to converse over long distances. The *sympathetic telegraph* was first described in print by Porta in 1558. It consisted of two needle-shaped pieces of steel, each mounted at the centre of a dial with letters equally spaced around the periphery. Having "magnetized both needles by the same lodestone" by rubbing, a movement of the needle of one instrument was supposed to cause a synchronous movement of the needle on the other instrument, and communication, it was thought, could thus be set up between two distant points. Two experimenters who may be said to have laid the foundation for scientific electrical research were Gilbert and Cabeo; in 1600 the former found that a large number of substances which he called "electrics" *attracted* light bodies when rubbed, and that a bar of steel heated and cooled while in the magnetic meridian acquired magnetic polarity, *i.e.*, pointed north and south; the latter went a step further when he described in 1629 his theory of electrical *repulsion* in similarly electrified bodies. In 1650, von Guericke devised the first electrical machine, consisting of a sulphur ball which was revolved and rubbed with the hand. Newton in 1675 substituted a glass globe for the sulphur ball, and in 1720 Gray and Wheeler discovered and tabulated the electrical conductivity of different bodies. No practical results were obtained, however, until the principle of the Leyden jar—the forerunner of the modern electrical condenser—was demonstrated by Musschenbroeck in 1745. He found that the effect of a charged Leyden jar may be conveyed to a distance by means of a wire conductor. That same year Franklin in America communicated to Collinson in England the results of his investigations in connection with electricity and its place in nature. A year later Watson in England demonstrated that an electric current can be transmitted through 10,600 ft. of wire, using the earth for the completion of the circuit.

Pithball Telegraphs.—Seven years after Watson's discovery the first practical suggestion for an electric telegraph was made in Scotland by an anonymous writer to the *Scots Magazine* signing himself C.M., who advised using an insulated wire for each letter of the alphabet. At the receiving end of each wire a light ball was to be suspended above a piece of paper marked with an alphabetical letter. As a charge was sent along a given wire the ball would attract the paper beneath it, and by observing the movements of the paper words could be spelt out. He further suggested that bells might be substituted for the papers, which could be struck in turn by the ball as a charge was sent along any desired wire. The idea was carried out by Le Sage in Geneva in 1774 and similar telegraph systems were also suggested by Betancourt and Lomond in 1787. An important advance was made in the latter's instrument as only one wire conductor was employed, and an alphabet of motions; but he employed a return wire instead of the ground to complete the circuit.

Spark Telegraphs.—Then followed the spark telegraphs of Reizen (1794), Salva (1798) and Ronalds (1816), who each proposed a system of visual telegraphy by interrupting electric circuits, causing an electric spark to appear at the point of dis-

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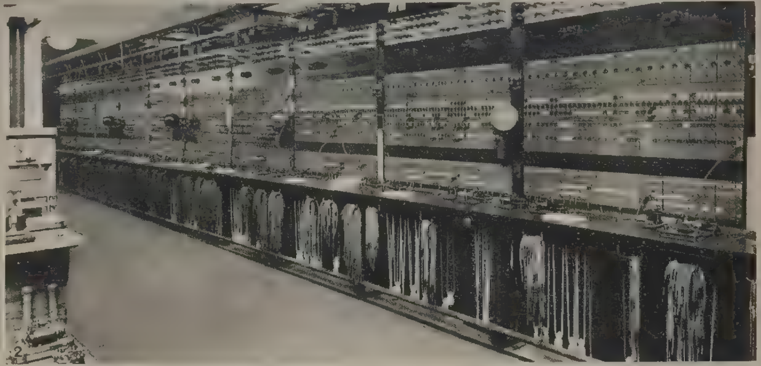
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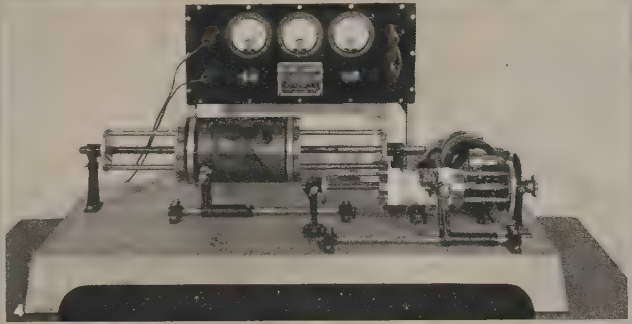
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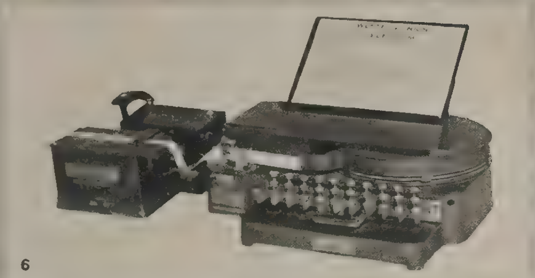
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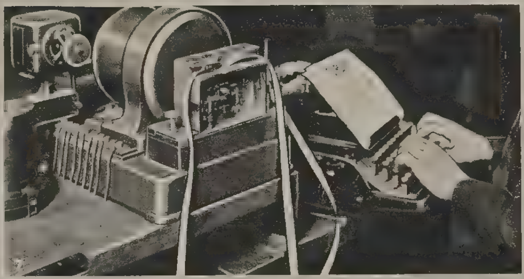
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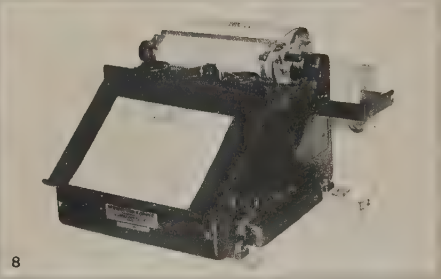
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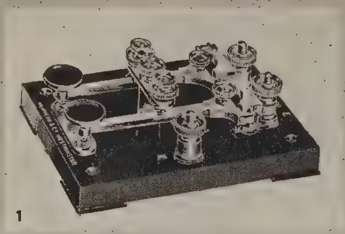
BY COURTESY OF THE WESTERN UNION TELEGRAPH COMPANY

TELEGRAPHIC EQUIPMENT

1. Distributing frame, where the incoming wires (usually in cables) are cross-connected to the office equipment
2. Telegraph switchboard
3. A late model electric tape printer
4. Combined transmitter and receiver for Telephotographic system
5. Cable code perforator
6. Transmitter and perforator; five unit code
7. Cable perforator and transmitter
8. Page printer

TELEGRAPH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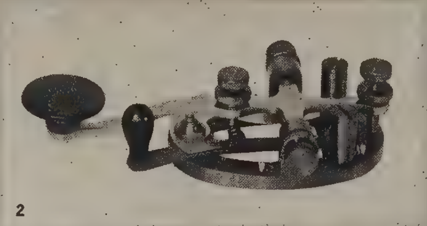
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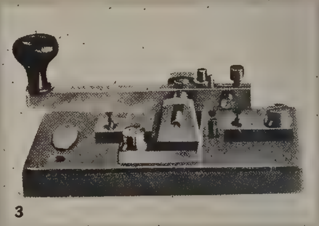
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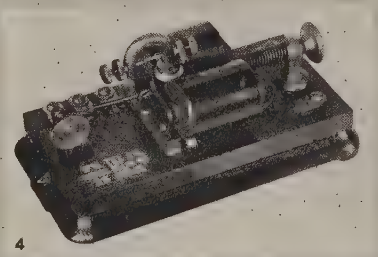
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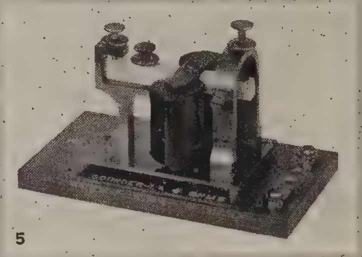
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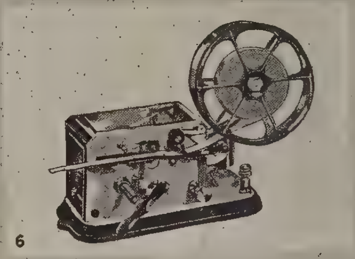
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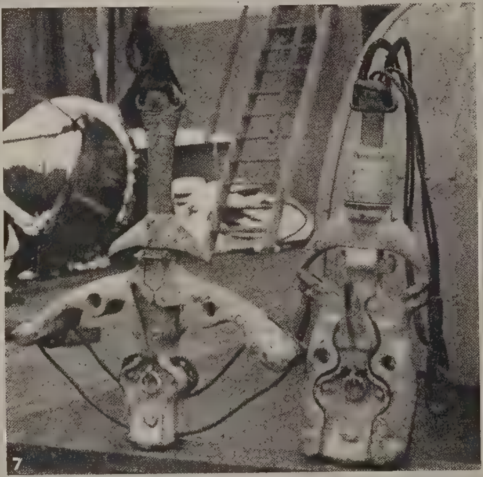
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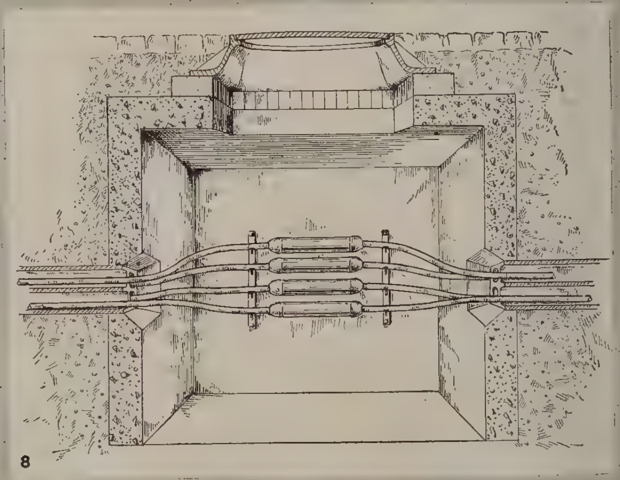
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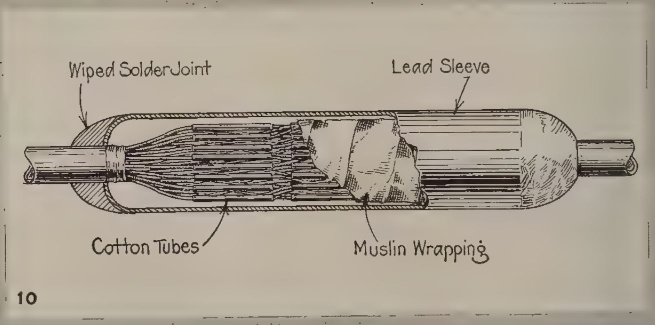

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BY COURTESY OF THE WESTERN UNION TELEGRAPH COMPANY

EQUIPMENT USED IN TELEGRAPHY

1. Double-lever sending key
2. Modern American Morse sending key, single lever showing horizontal knife switch for making and breaking the circuit
3. European open-circuit key, single lever
4. Modern American Morse relay. An electromagnet receives current from the line and its armature lever is thereby actuated to open and close a circuit in which local battery furnishes to the receiver a current of requisite strength
5. Modern American Morse sounder or receiving instrument employed in connection with the relay for enabling operators to read by sound only
6. Morse register or recorder. The telegraphic-code message is written, printed or embossed upon the paper tape
7. An improved Lucas cutting grapnel, showing open and closed position used in submarine cable work where the depth is 1,000 fathoms or more
8. Cross-section of a manhole showing the cable ducts and joint rack
9. Cross-arms showing units and insulators used on open-wire pole lines
10. Standard cable splice. The wires are soldered intertwisted and insulated from each other by cotton tubes. A lead sleeve is soldered over the splice to the lead cover of the cable for protection

connection of each wire as desired. In Reizen's instrument each letter was represented by spaces cut out of parallel strips of tin foil pasted upon a glass table. Upon the passage of an electric current a spark appeared at each point of disconnection directly behind the cuts in the tin foil, thus rendering the whole letter visible. Seventy-two wires connected the receiving and sending stations, which consisted of two identical tables placed at separated points. The apparatus was not tested to any extent. In Salva's instrument six to eight wires by different combinations could be arranged to indicate the 26 letters of the alphabet. Ronalds's telegraph was worked in England in 1823. The transmitting and receiving apparatus consisted of circular brass plates on which were inscribed letters, figures and code letters; in front of each plate was a disc with an aperture which allowed one letter and its corresponding figure to be visible. The plates rotated by clockwork at the rate of one revolution per minute, the same letter being displayed simultaneously at both ends. A crude electrical machine charged the line as desired and the divergence of a pair of pith balls in front of the disc indicated to the receiving operator that the letter or sign visible at that moment was to be recorded. In these experiments frictional electricity was employed which was fitful and difficult to insulate on account of its high tension.

Towards the end of the 18th century, however, Galvani and Volta conducted electrical experiments which revolutionized preconceived ideas of electricity and its effects. In 1786 Galvani accidentally discovered that it was possible to cause a direct or continuous flow of current along an electrical conductor by bringing two dissimilar metals into contact with a moist substance, such as animal tissues. This led Volta in 1800 to introduce an electric battery which became known as the *voltaic pile*, the principles of which are still embodied in the modern battery; and that year Salva demonstrated that voltaic currents could be used for transmitting signals.

Electrolytic Telegraphs.—An immediate result of the introduction of the voltaic pile was the discovery by Nicholson and Carlisle in 1801 that the passage of an electric current caused decomposition of liquids into their constituent elements. Based on this principle, Salva, in 1805, and Soemmering, in 1809, each introduced an apparatus in which a voltaic pile was used for sending signals whose presence were indicated at the receiving end by the liberation of bubbles of hydrogen. In the latter's instrument 35 wires, each allotted to the German alphabet and the ten numerals, terminated in a receptacle containing water (fig. 1). At the sending station a key which brought a voltaic battery into circuits was connected, as required, to each of the line wires, and the message was read by observing at which end of the terminals the bubbles of gas appeared. The later researches of Davy on the decomposition of chemical compounds by the electric current were applied in America to another type of telegraph by Coxe in 1816, and Dyer in 1828, who each operated a signal telegraph using the electric current to produce electrical decomposition at the end of the wire conductors. In the former's apparatus a voltaic current was employed. He used 36 wire conductors and 36 "return wires." Dyer, who operated his telegraph line over 8 m. on a racecourse in Long Island, used a single wire and ground circuit, and obtained red marks on litmus paper by discolouration, but he used frictional electricity, and the system was abandoned in 1830.

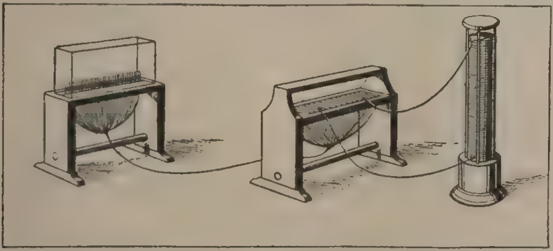


FIG. 1.—SOEMMERING'S ELECTROLYTIC TELEGRAPH

Electro-magnetic Needle Telegraphs.—At the beginning of the 19th century a new set of ideas followed the introduction of the electro-magnet. In 1819 Oersted discovered that a magnetic needle could be deflected from its normal position by passing a current through an adjacent wire; and that the deflection was to the right or left, according to the direction of the current. Schweigger a year later found that the deflection of the needle could be increased by surrounding it with a number of separated turns of naked wire. Following upon these experiments Sturgeon in England, in 1825, produced and named the electro-magnet (fig. 2). This consisted of a piece of soft iron in horseshoe form which was surrounded by a number of turns of wire. Upon the passage of a current through this wire the soft iron horseshoe attracted a smaller bar or armature of soft iron towards it. Four years later Henry, in America, improved Sturgeon's magnet by surrounding it with nine coils, each composed of 60 ft. of insulated wire, thus greatly increasing the power with which the armature was attracted. In 1831 Henry constructed and successfully operated an electro-magnetic signalling apparatus which consisted of a magnetized steel bar 10 in. in length, which was supported on a pivot in an horizontal position with its north end between the two arms of a horseshoe magnet. When the latter was energized by the current, the end of the bar was attracted by one arm of the horseshoe and repelled by the other, causing its further extremity to strike a suitably adjusted bell, and a code was arranged by varying sound combinations.

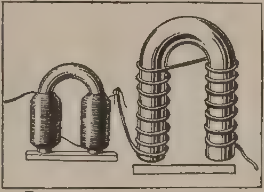


FIG. 2.—ELECTRO-MAGNETS

The action of the electric current on a magnet was first applied to electric telegraphy by Ampère, in 1820, at the suggestion of Laplace that the deflections of small magnets placed at the receiving ends of 26 wires could be used to indicate the letters of the alphabet. Ampère's apparatus was the pioneer of a number of needle instruments which came into extensive use between the years 1829 and 1841. The names of Gauss and Weber, Cooke and Wheatstone, and the brothers Highton, are associated with some of the more important needle instruments. Gauss and Weber also conducted important experiments on line conductors, in which they demonstrated that the conductor need not be insulated over its entire length. In their experiments they used a single-needle telegraph to communicate with each other and proved that by proper combination five signs are sufficient for communication. In the early experiments of Cooke and Wheatstone five needles were employed; the number was afterwards gradually reduced to two, which indicated letters by their separate and combined movements. In the single-needle instruments a magnetic needle was pivoted in the centre of a wire coil and a pointer, attached to the needle, swung in front of a dial. Deflections to right or left signified given letters. These deflections were produced by sending over the wire pulsations of one polarity, or alternations of both, as required by the letter to be transmitted.

Morse Electro-magnetic Recording Telegraph.—Morse of America conceived the idea of the first practical recording telegraph while returning from Europe on the packet-ship "Sully" in Oct. 1832. In the course of conversation on board ship Faraday's recent (1831) publication on magneto-electric induction—the current being induced by passing a magnet through a helix of wire forming part of a closed circuit—was discussed, and the fact that a charge of electricity can thus be almost instantaneously passed along a length of wire was referred to by Dr. Watson of Boston. These two facts led Morse to the conclusion that if the presence of electricity could also be detected in any desired part of the circuit it should be possible to record signals instantaneously by opening and closing the circuit. Before his arrival in New York on Oct. 13, Morse had made his plans for a telegraph recording instrument, and laid the principles for his dot-dash-space code based on the duration or the absence of the electrical impulse over a circuit. Three years later Morse constructed an experimental model of his telegraph (fig. 3) which, by the mechanical action of an electro-magnet *A*, operated a lever *B* carrying a pencil *C* at one extremity. The passage of electrical impulses through the electro-magnetic circuit caused the pencil to move in contact with a paper tape *D* passing over a revolving cylinder *E* directly under the pencil, thus drawing an undulated line embodying his code. The speed of the paper was regulated by clockwork *F*. A single wire conductor connected one pole of the battery *G* to one end of the helix of the electro-magnet; the other end of the helix was connected to one of two cups of mercury on the "port rule," the second cup being connected to the second pole of the battery, so that the only part of the circuit not complete was between the two cups of mercury *H*. The electric impulses were imparted to the wire at the sending end by causing the metallic projections at the end of the lever *J* to dip into the two mercury cups, thus closing the circuit. The projections *K* arranged on the 3 ft. piece of wood *L* actuated the lever and were so spaced as to form his code. This crude model was privately exhibited at New York University in 1835, and enlisted the interest of Gale and Vail. The latter subsequently furnished Morse with the means, material and labour for an experiment on a larger scale.

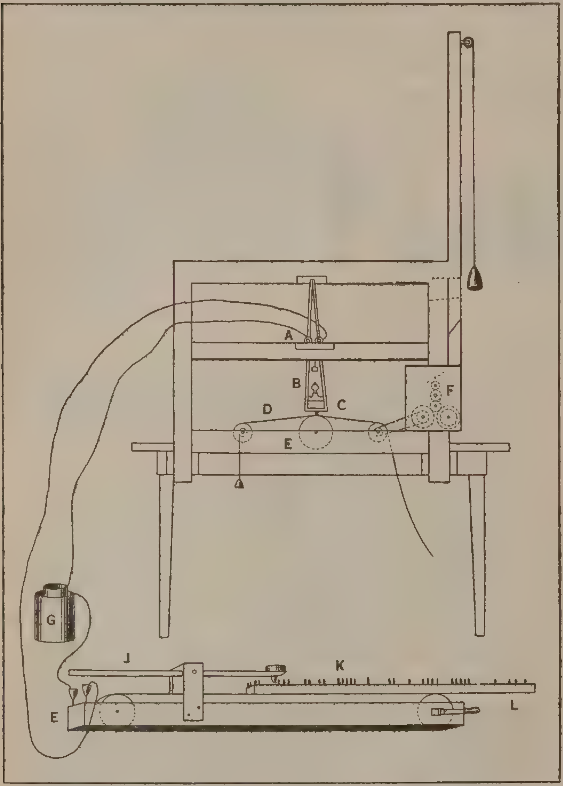


FIG. 3.—EXPERIMENTAL MODEL OF MORSE ELECTRO-MAGNET TELEGRAPH

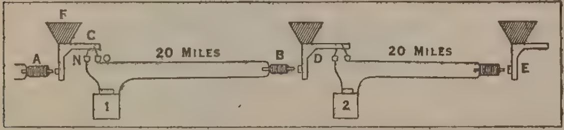


FIG. 4.—DIAGRAM OF THE MORSE RELAY

Morse Relay.—In 1836 Morse constructed duplicate apparatus so that the telegraph might be operated in either direction. As the experiments progressed it was found that the electric current, after passing over a wire 20 m. or so in length, became too feeble to operate the receiving apparatus directly. With the assistance of Gale and Henry, Morse devised a relay which would automatically repeat signals into another section of line and join circuits in this manner for any desired distance. The application of these relays is shown in fig. 4. Suppose the sent current is received in relay magnet *A*, energization of this magnet will cause its armature to be rotated against the retractile force of counterweight *F*, causing the wire *C* to dip into mercury cups *N* and *O*, thus closing the circuit through battery I, relay magnet *B*, and the second section of line. The second relay actuated by magnet *B* will respond in a similar manner and repeat into a third section, etc., until the receiving apparatus is finally actuated.

Morse Key.—In the improved apparatus, for which Morse filed a caveat in the U.S. Patent Office on Oct. 6, 1837, a number of modifications had been made by Vail. The port rule was abandoned in favour of a simple circuit closer or key, by which the signals could be formed by hand. For the original pencil-marking method could be substituted any one of three recording methods: a fountain pen (fig. 5), an inked wheel (fig. 6) or a stylus which indented the paper (fig. 7).

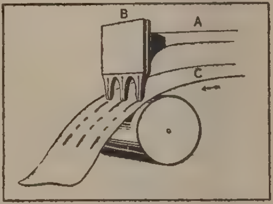


FIG. 5.—FOUNTAIN PEN RECORDING

The Sounder.—In April 1844, however, Vail made the valuable discovery that it was possible to read messages by sound. He found that as a dot or dash is recorded the lever makes two distinct sounds, one as it strikes against the stop which limits its motion in one direction and again as it strikes in retreating against the stop which limits its motion in the other direction; when a dot or short line is recorded the interval is shorter than when a long line is recorded, and signals can thus be read by the length of the intervals between sounds. Following upon this discovery the Morse register or recording instrument passed into disuse.

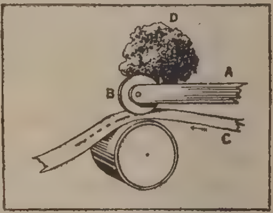


FIG. 6.—INKED WHEEL RECORDING

On April 7, 1838 Morse made formal application for a patent which was granted on Oct. 24, 1848. On Feb. 21, 1838 he had demonstrated his telegraph before the U.S. president and his cabinet, and a bill was subsequently passed appropriating $30,000 to be expended on a series of experiments to test its practicability. About a year after the passage of the bill an experimental line was completed between Washington and Baltimore, a distance of 40 miles. The line was opened for public business and its immense value to the State became apparent; but when Morse offered the telegraph to the Government for $100,000 his offer was refused upon the recommendation of the postmaster-general, as he was "uncertain that the revenues could be made equal to its expenditures." Morse then enlisted private capital and in 1844 a company was organized to erect a telegraph line between New York, Baltimore and Washington. By 1851, 50 companies using Morse telegraph patents were in operation in the United States and by 1861 Morse patents were in operation in Europe.

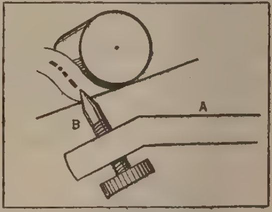


FIG. 7.—STYLUS RECORDING METHOD

GENERAL EQUIPMENT

Morse Systems, Circuits and Apparatus.—Many telegraph circuits in various parts of the world still employ the fundamental principles of the original Morse system. Upon circuits of this class, which are operated by the single current method, signals in accordance with the Morse code are transmitted as short and long pulses of current separated by intervals of various lengths during which no current flows. The short and long pulses of current are termed respectively dots and dashes.

Morse Code.—The dot is a very short signal; when made by hand on a telegraph key the lever is depressed for about $\frac{1}{24}$th of a second. The dash lasts about $\frac{3}{24}$ of a second. These periods of time correspond to 30 average words per minute on land lines. The dot is the unit by which the length of the dashes and spaces are measured. The dash is equal to the length of three dots. The space between components of a letter equals one dot, except in certain dot letters in American Morse which contain a space equal to two dots. The space between the letters of a word is equal to one dash. The space between words is twice one dash.

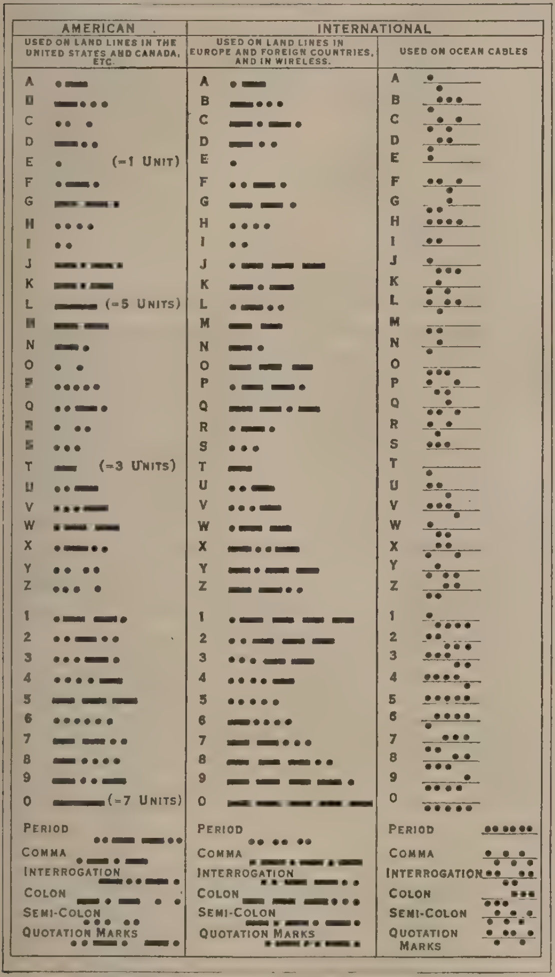

AMERICAN
USED ON LAND LINES IN THE UNITED STATES AND CANADA, ETC.
INTERNATIONAL
USED ON LAND LINES IN EUROPE AND FOREIGN COUNTRIES, AND IN WIRELESS.
USED ON OCEAN CABLES
(=1 UNIT)
(=5 UNITS)
(=3 UNITS)
(=7 UNITS)
PERIOD
COMMA
INTERROGATION
COLON
SEMI-COLON
QUOTATION MARKS

FIG. 8.—ADAPTATIONS OF THE MORSE CODE

Fig. 8 shows the American and the International adaptations of the Morse code as used on land lines and on submarine cables. The cable code, adapted from the International, employs signals of dot duration only. These short signals are distinguished by their position on a tape; a short signal above the central line corresponds to a dot; an equally short signal below, a dash. On land lines signals are usually received by sound on a Morse sounder; on submarine cables the Kelvin syphon recorder is used. The speed of manual working on land lines ranges from 20 to 40 words a minute, a fair average being 25 to 30 words a minute. On moderately long ocean cables, operated by hand on the syphon recorder system, somewhat similar speeds are obtained.

Various codes of abbreviations are applied to telegraphy, consisting of single Morse letters and combinations of two or more letters that arbitrarily represent figures, words and phrases, to reduce the cost of telegraphing.

In double current operation the current pulses representing the dots and dashes traverse the circuit in one direction and the space pulses in the opposite direction. This is readily accomplished by connecting the negative pole of the transmitting battery to the line for each dot or dash, and the positive pole for each space.

Instruments.—The accompanying illustrations show several kinds of telegraph instruments commonly used on Morse circuits. Plate II., 1, 2 and 3 are keys or transmitting devices, of the three types adapted respectively to closed circuit working as practised on American lines, and to the open circuit method used in Europe and elsewhere. Plate II., fig. 6 shows a modern form of Morse register or recorder; such instruments, however, are now used on comparatively few circuits. Instead of the register, the receiving instrument employed upon nearly all Morse circuits is the sounder as shown in Plate II., fig. 5. The intervals of time between the various clicks and the lengths of the clicks given out by the sounder enable a skilled operator to distinguish the dots, dashes and spaces of the signalling code and thus to read by sound the message being received. On circuits of such a character that the received currents are too weak to operate directly, the register or sounder, a relay (Plate II., fig. 4) may be used to receive the signals and, in responding, to control the application to the register or sounder of suitable power from a local source.

The instruments described and illustrated above are for single current operation. Those used in double current working are somewhat different, the receiving instruments usually being fitted with a permanent magnet to polarize the armature, while the sending instruments have means for reversing the direction of the current instead of merely opening and closing the circuit.

Single Current Working.—The single current Morse system most used in Europe employs an open circuit arrangement, fig. 9, so designated because no current passes over the circuit while it is idle. Sending and receiving instruments are connected to the line at each station, however, and whenever the transmitting key at any station is depressed, a battery at that station is connected to the line and the resulting current causes the receiving instrument at all other stations to respond. American single current Morse circuits are generally operated upon the closed circuit plan (fig. 15) under which current traverses the entire circuit at all times, when the line is idle as well as when a dot or a dash signal is being transmitted. The only periods during which no current flows are those corresponding to the spaces between the dots and dashes, this condition being effected by the opening of the transmitting key at one of the stations. At such times the armature levers of the receiving instruments at all stations are released.

The reading of the received signals and the manipulation of the sending key by the operator are practically the same under both open and closed circuit arrangements. An advantage of the open circuit scheme is its economy in using electrical energy only while signals are actually being sent, but this is offset in many cases by the cost of providing at each station a battery or other source of power sufficient to operate the entire circuit. The closed circuit plan permits the entire power to be supplied at one or two stations, and this advantage generally outweighs the cost of supplying current to the circuit almost continuously, particularly where many intermediate stations are connected. It is not uncommon to have 30 to 40 stations upon one circuit in America.

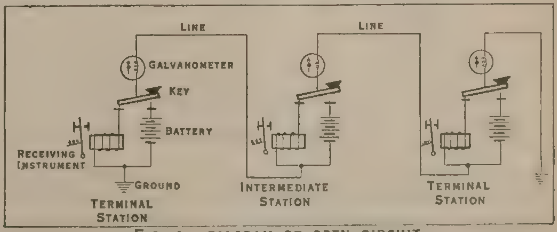


FIG. 9.—DIAGRAM OF OPEN CIRCUIT

Double Current Working.—Double current Morse circuits (fig. 11), like those operated by the single current open circuit method, require at each station a source of power capable of operating the entire circuit. The double current scheme has the great advantage over any single current arrangement, however, of operating more reliably, and with less need of readjustments of apparatus, upon circuits of inferior transmission qualities, such as those due to excessive length of line, poor insulation, or the inclusion of long sections of cable.

Duplex and Quadruplex Systems.—In the telegraph systems so far described only one message can be transmitted over the line at a time, although the sending may be from any station to any other station as desired. The economic advantages of being able to send two messages simultaneously over one line have led to much invention and development, particularly of duplex systems in which the two sendings are in opposite directions, one from each end of the circuit. The first duplex arrangement was devised by Dr. Gintl of Vienna in 1853. Outstanding developments were made by Frischen of Hanover, who introduced the artificial line in 1854, and by Stearns of Boston, Mass., who improved Frischen's artificial line in 1868 and invented the bridge duplex. Frischen invented the double current duplex in 1863, and this later improvement was taken up and further developed in England by Varley, Heaviside and others, between 1863 and 1872. An essential feature of any duplex system is the provision at each station of a relay or other receiving instrument, so arranged as to be unaffected by any signals sent out from that station, but fully responsive to all signals received from the distant station.

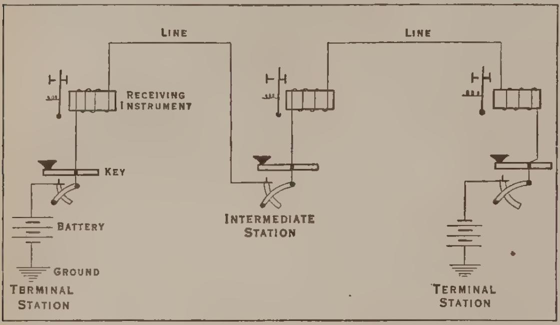


FIG. 10.—DIAGRAM OF CLOSED CIRCUIT

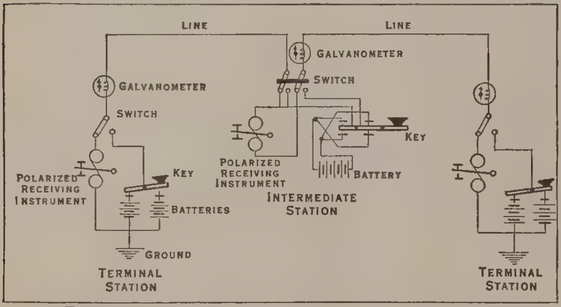


FIG. 11.—DIAGRAM OF DOUBLE CURRENT MORSE CIRCUIT

Artificial Line.—Practically all modern duplex schemes employ the principle of having the signalling pulses of current issue from the transmitting apparatus in duplicate, one pulse going over the line to the distant station and a second identical pulse traversing a branch circuit, known as an artificial line, which is associated with the duplex equipment. To maintain substantial identity between the characteristics of the two sets of pulses, it is important that the artificial line shall closely resemble the real line in the values of, and connections between, its electrical resistance and capacity. With all outgoing signals represented by duplicate pulses of current, the relay or other receiving instrument may be made irresponsive to such signals in either of two ways:

Differential Duplex.—In the first method, fig. 12, the electromagnet of the relay is wound with two separate but equal coils or helices of insulated wire. The current going over the line to the distant station passes through one of these coils, while the current which traverses the artificial line passes through the other coil, but in the opposite direction around the electro-magnet to that of the line current. The magnetic effects of the two currents thus neutralize each other, and the result is that the relay is unaffected, just as if no current from the outgoing transmission were passing through either of the coils.

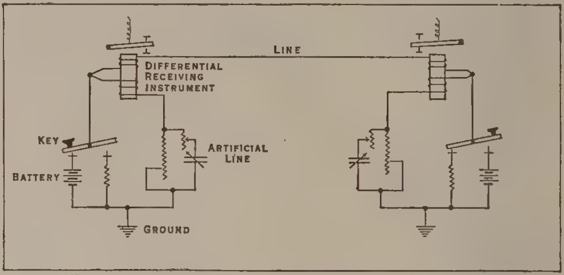


FIG. 12.—DIAGRAM OF DIFFERENTIAL DUPLEX CIRCUIT

In the preceding paragraph it was assumed that the transmitting apparatus at the distant station was applying no current to the line. The effect of such a current application, which occurs whenever a signal is being sent from the distant station, will always be to increase or decrease the strength of the current in the line coil of the relay at the station first considered, without, however, making any great change in the current in the artificial line coil of that instrument. The relay is then operated because of the greater current in one coil than in the other, and thus responds to the signals being received from the distant station. With apparatus arranged in this way at each end of a line, both stations may send to each other at the same time without interference. Because each relay is operated by the *difference* between the currents passing through its two coils, this method of working is known as the differential duplex.

Bridge Duplex.—The second method of duplex working in common use employs the principle of the Wheatstone bridge. (*See* ELECTRICITY.) In this plan, fig. 13, the duplicate pulses of current for outgoing signals pass to the line and the artificial line, respectively, through equal bridge arms, and have no effect upon the relay or other receiving instrument forming the cross-wire at the extremities of those arms. The relay is, however, responsive to the unbalancing effect of any application of current at the distant station, and thus responds to all signals received from that station.

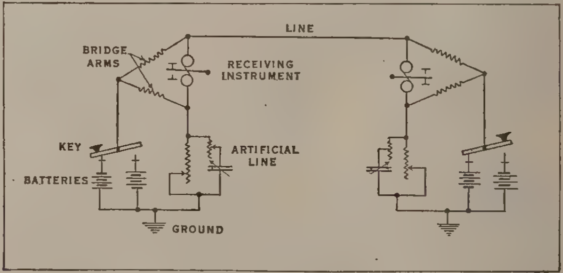


FIG. 13.—DIAGRAM OF BRIDGE DUPLEX CIRCUIT

Quadruplex.—It is possible to operate both differential and bridge duplexes by either single current or double current methods, but in modern practice the double current scheme is generally preferred. By combining a modified single current system with a double current duplex, Edison produced in 1874 the quadruplex. With this scheme four messages, two in each direction, may be simultaneously transmitted over a one-line wire. The two relays at each terminal of the line are arranged to be unresponsive to outgoing signals by either the differential or bridge methods. In receiving signals one of the relays responds only to reversals of current effected by the distant double current transmitter. The other relay responds only to increases and decreases in current strength, regardless of the direction in which the current is flowing; these variations in the applied power are controlled by a single current key or equivalent means, at the distant station. Fig. 14 is a diagram of a modern quadruplex circuit.

Automatic Telegraphs.—The classification of automatic telegraphs may broadly include all systems in which signals are transmitted by machine methods and automatically recorded. Automatic means of transmitting and recording had been proposed prior to Morse's invention, and Morse employed them in his first models, but it is only within the last 50 years that printing systems have been used to any great extent.

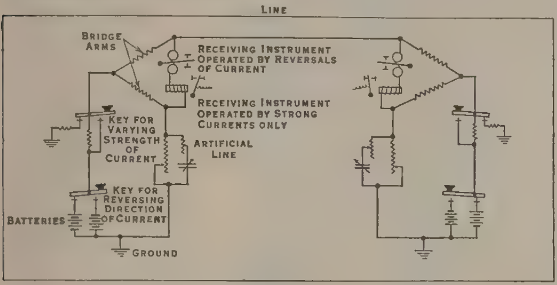

LINE
BRIDGE ARMS
RECEIVING INSTRUMENT OPERATED BY REVERSALS OF CURRENT
RECEIVING INSTRUMENT OPERATED BY STRONG CURRENTS ONLY
KEY FOR VARYING STRENGTH OF CURRENT
ARTIFICIAL LINE
KEY FOR REVERSING DIRECTION OF CURRENT
BATTERIES
GROUND

FIG. 14.—QUADRUPLEX CIRCUIT

Between the years 1840 and 1855 a series of instruments was worked out by Wheatstone in England, Froment and Bréguet in France, Siemens in Germany and House in America, with the object of producing a letter-printing instrument, and although these early instruments never came into very extensive use the principles involved are embodied in the modern systems.

The chief advantages of automatic operation of telegraphs are: increased accuracy and greater output with attendant labour saving and cost reduction. The modern automatic systems fall generally into three classifications: (1) signals are recorded in code form and must be transcribed; (2) a facsimile of the original is reproduced; (3) the message is received in printed form.

Recording Systems.—In general, the recording systems employ an automatic transmitter, controlled by a perforated tape, which sends to the line impulses corresponding to a dot-dash code. These line signals are received and recorded in code form on a moving paper tape. In the Wheatstone system marking impulses are transmitted for long and short intervals to form dots and dashes. An electro-magnet in the receiver forces an inked wheel against a moving strip of paper, drawing an interrupted straight line composed of dots and dashes. This receiver is essentially a refinement of the early Morse recorders.

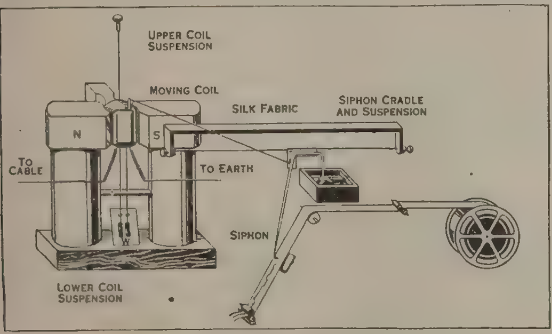


FIG. 15.—KELVIN'S SYPHON RECORDER

The recording systems commonly used on older types of ocean cables are developments of ideas proposed by Siemens and Halske, and Lord Kelvin. In these systems the dots and dashes are transmitted as impulses of equal duration but opposite in polarity, while spaces are intervals of no current. The recorder is a galvanometer with an ink syphon attached to the moving coil. The syphon rests against a moving tape, drawing a continuous line which is undulated above or below the centre by deflections of the galvanometer when impulses of dot or dash polarity are received. (*See* fig. 15.)

Various chemical recorders have been proposed by Dyer, Bain, Edison and others and are used to a limited extent. They consist of a metallic wire resting upon a moving, chemically treated tape. The wire and tape form a part of the circuit and when current passes through them an electrolytic decomposition of the wire occurs which causes discolouration of the tape, fig. 16. Signals are usually recorded as long and short lines. The modern transmitters used with these systems are motor-driven mechanical devices arranged so that the perforations in the tape control the motion of levers which actuate contacts, sending the proper impulses to the line. The older types simply permitted a brush to make contact through the perforations with a metallic bed or roller. The perforated tape used for transmission in the above systems is prepared in various types of perforating machines, the more modern of which are provided with keyboards like a typewriter, and are so arranged that the depression of a key will perforate the proper combination of dots and dashes for that character. (*See* Plate I. fig. 5.) The first suggestion for a perforator was made by Bain in 1846.

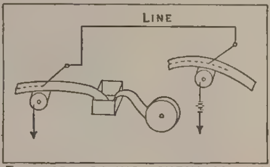


FIG. 16.—BAIN'S CHEMICAL RECORDER

Facsimile Systems.—Among the facsimile systems may be included the writing telegraphs, such as the telautograph invented by Prof. Elisha Gray. (*See* fig. 17.) The transmitter for these systems consists of two rheostats which are varied through suitable linkages by the motion of a stylus. Each rheostat is connected to a separate line wire which terminates through an electromagnet at the receiving end. The armatures of the magnets are connected by similar linkages to a recording pen. As the sending stylus is moved to form a letter the vertical components of the motion are caused to vary one of the rheostats, while horizontal components vary the other, changing the currents in the two line wires. In this way the attractive forces of the two receiving magnets are changed in proportion and the receiving pen is caused to duplicate the motion of the sending stylus.

The more modern facsimile systems are properly regarded as systems of telephotography. They are developments of earlier systems, such as Blakewell's and d'Alincourt's copying telegraphs and the Casilli pantelegraph. (*See* Plate I. fig. 4.) In these systems the picture is specially prepared for transmission by a photographic process and then exposed, a minute area at a time, to a transmitting device by means of which the line current is varied proportionately with the degree of shading in the exposed area. At the receiving end equivalent minute areas of a sensitized paper are synchronously exposed to discolouration, the degree being controlled by the variations in line current, thus duplicating the contrasts of the original picture. Among the systems now in use may be mentioned those developed by the American Telephone and Telegraph Company, The Radio Corporation of America, and Siemens and Halske, together with the Bartlane, Belin and Ferreegraph systems.

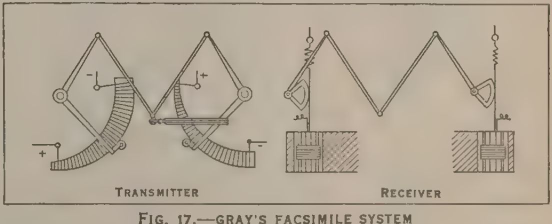


FIG. 17.—GRAY'S FACSIMILE SYSTEM

Printing Telegraphs.—Many of the early printing telegraphs were developments of the step-by-step principle as incorporated in present-day stock quotation tickers. Printers operated by this principle are provided with a rotatable type-wheel upon which the characters are evenly spaced around the periphery. This type-wheel is provided with a stepping device, operated by an electro-magnet and so arranged that each impulse received from the line will rotate the type-wheel one character. Assuming that the initial position and arrangement of the type-wheel are known, the sending operator may transmit a sufficient number of impulses to move any desired character into the printing position. When this has been done, an impulse of a different character is transmitted which energizes a print magnet to make the impression. These systems are commonly provided with an automatic keyboard transmitter containing a motor-driven commutator which, in the interval between the depression of any two keys, will send the required number of impulses to move the type-wheel from its previous position to the character corresponding to the key next to be depressed. The most important improvement of this principle was contributed by Hughes, who materially speeded up the system by causing the sending and receiving apparatus to maintain constant synchronism. Line impulses were transmitted only for the purpose of making an impression when the type-wheel reached the desired position. Other improvements were contributed by Phelps, Wright, Burry and Scott.

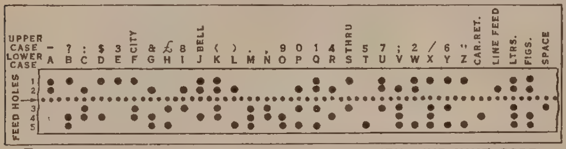

UPPER CASE
LOWER CASE
– ? : $ 3 CITY & £ 8 BELL ( ) . , 9 0 1 4 THRU 5 7 ; 2 / 6 "
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
CAR. RET.
LINE FEED
LTRS.
FIGS.
SPACE
FEED HOLES
1
2
3
4
5

Fig. 18.—Transmitting Tape Perforated with Five Unit Code

The majority of the modern printing systems make use of the Baudot or five-unit code. In these systems five impulses, any one of which may be either selecting or non-selecting, are transmitted for each character. With such a code it is possible to obtain 31 different combinations, 26 of which are assigned to the letters of the alphabet, leaving five for functions such as line feed, space, etc. (fig. 18). The five impulses making up the code are sent to the line, successively, by means of a rotating distributor or commutator, and are distributed at the receiving end, by means of a similar device, to five receiving magnets. These magnets, through any one of several selecting mechanisms, determine which one of the characters of a typewriting machine is to be printed. In order that the first impulse may operate the first receiving magnet, etc., each magnet must be connected with the line while the corresponding impulse is being transmitted, *i.e.*, the sending and receiving distributors must rotate in synchronism. This is accomplished in several different ways with different systems. In some, extra impulses are transmitted for this purpose, while in others the signals themselves are used. The printers used in connection with these systems are arranged to record the message on a page in final form for delivery (fig. 23) or to record on a gummed paper tape which is pasted on a blank by the receiving operator. (*See* Plate I., fig. 8.)

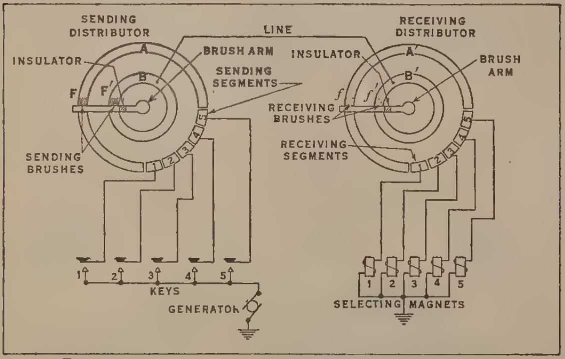


Fig. 19.—Diagram Showing the Multiplex Theory

Various methods of transmission are used with these systems: one involves the use of five keys which must be set up in their various combinations by the operator; another employs a direct keyboard like a typewriter, each key acting upon five transmitting keys to set up the combinations. The most common method uses a keyboard perforator which prepares a paper tape to be sent through an automatic transmitter. (*See* Plate I. fig. 3). The perforations in the tape actuate five key levers in the transmitter.

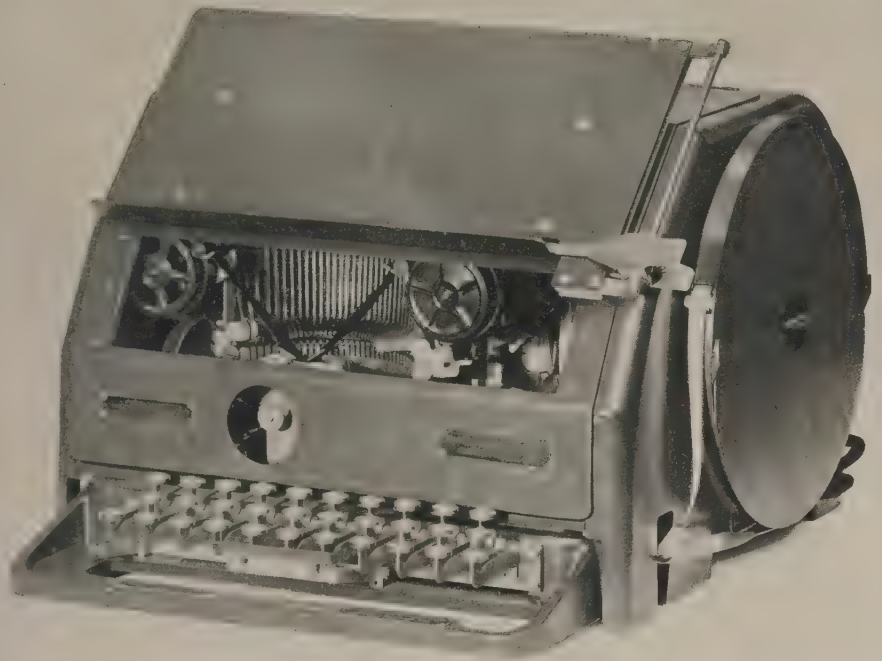
Among the printing systems—exclusive of multiplex—employing the five-unit code (Plate I. fig. 6) may be mentioned the Murray, Morkrum, Kleinschmidt, the Siemens and Halske and Creed systems. Other printing systems have been developed by Buckingham, Creed and Barclay, which use the dot-dash code.

Multiplex Methods.—It is possible, with the printing systems employing synchronous distributors, to provide additional transmissions or channels of communication. This is accomplished by dividing the use of the line between the several channels, the distributors being made use of for this purpose. The multiplex principle may be illustrated by fig. 19, which shows a sending and receiving distributor, the brushes of which are rotated in constant synchronism and phase. The sending distributor is provided with five segments to which are connected five keys, which may be operated manually or by automatic means, to set up the five-unit combinations of the Baudot code. Five corresponding segments on the receiving distributor are connected to the five selecting magnets of a printer. Assuming that a combination corresponding to the desired character has been set up on the transmitting keys, signals forming this combination will be transmitted to the line as the sending brushes pass over the sending segments. At the instant when the sending brush is in contact with the first sending segment the receiving brush will be in contact with the first receiving segment; and if No. 1 key is in an operated position the circuit will be completed and the first selecting magnet will be energized. As the sending brushes pass to the succeeding segments the remaining selecting magnets will be operated or remain inoperative, depending upon the position of the corresponding key at the sending station; thus in each revolution an entire character is transmitted by the transmitter and received by the printer. While the diagram illustrates only one channel of communication it is obvious that the section of the rings *A* and *A′* between segments 5 and 1 may be provided with additional groups of five segments which can be connected to other sets of keys and selecting magnets to provide additional channels of communication. The character of transmission is such that duplex methods may be applied to permit simultaneous operation in both directions. This principle is widely employed and the modern multiplex systems ordinarily provide from two to five separate transmissions in each direction simultaneously. These systems are usually designed for a maximum speed of about 360 letters per minute per channel, that being considered as the maximum speed at which operators can economically work for extended periods.

Multiplex methods were first introduced by Farmer in America. He suggested the division of line time between two or more operators. Myer and Delaney endeavoured to improve the system, but it was Baudot who developed the first practical multiplex printing system using the five-unit code. This system has become the basis of the other modern multiplex systems, such as the Murray, American and Morkrum multiplex systems. Multiplex systems developed by Rowland and Potts employ eleven and eight unit codes, respectively.

The growth of automatic telegraphy has been particularly rapid during the past 20 years. Practically all ocean cables are operated by automatic methods and approximately 70% of land line traffic in America is handled by printing systems.

Repeaters.—All telegraph circuits are subject to certain transmission difficulties which limit the length of line over which direct working is practicable. The resistance of the line conductor and its imperfect insulation tend to reduce the strength of the current available to operate the receiving instruments. In addition, and what is frequently of greater importance, the current pulses representing signals are distorted from their original form by the electrostatic capacity of the line conductor and any inductance, such as that of the electro-magnets of instruments in the



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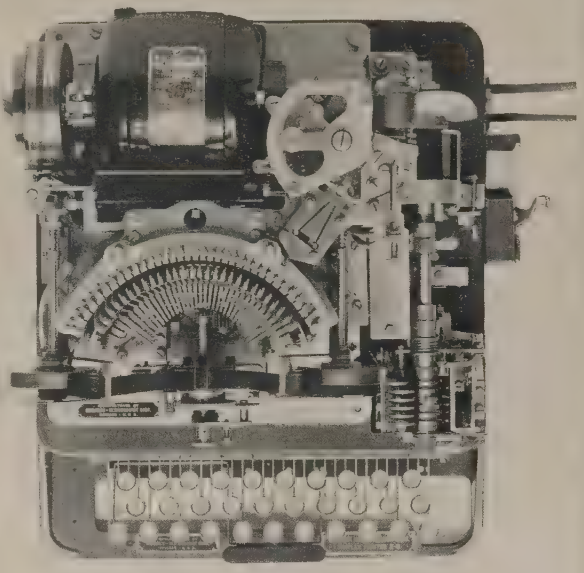

2

BY COURTESY OF WESTERN UNION TELEGRAPH COMPANY

VIEW OF AUTOMATIC TELEGRAPH PRINTING MACHINE

1. Western Union Simplex Printer consisting of an electrically operated typewriter with standard keyboard. Messages transmitted and received are printed on a gummed tape. In received messages the tape is first passed through a specially devised moistener before it is affixed to a regular telegraph blank

2. View of the same Western Union Simplex Printer with the cover removed and showing the mechanism of the machine. The electric motor at the top operates the keyboard

circuit (see *Theory of Transmission* below). Because of these difficulties it is the practice to break up long telegraph circuits into two or more sections, each of which is relatively easy to operate. These sections are then connected together by repeaters which receive the signals from one section and automatically retransmit them into the next section.

Morse Circuit Repeaters.—A very simple form of repeater consisting of only two relays may be used in single-current open-circuit working. Each of the two lines is connected through the contacts and armature lever of one relay to the electro-magnet coils of the other relay. When a pulse of current representing a signal is received over either line the electro-magnet of one relay is energized and its armature lever, in responding, applies a battery or other source of current to the other line, thus repeating the signal into the latter.

For closed-circuit working a more complex arrangement is necessary in order to avoid the tendency of each relay to repeat signals back into the line from which they were received. This interference is overcome by interlocking electro-magnetic devices.

To facilitate adjustments many repeaters employ additional relays or transmitters to control the circuit into which signals are being repeated, thus relieving the receiving relay in each case of any duty other than the control of such a transmitter.

Duplex Repeaters.—The repeating elements of duplex repeaters are very similar to those of open circuit Morse repeaters, usually comprising a receiving relay for each of the two line sections. This relay, either directly or by means of a transmitter which it controls, re-transmits into the other line section the signals by which it is operated. An artificial line must be provided for each of the two sections of line connected to the repeater, and each relay must be arranged differentially or in accordance with the bridge method so as to respond only to incoming signals. Various auxiliary devices are also required to permit observation of the passing signals in both directions by an attendant and to facilitate necessary readjustments of the apparatus.

Regenerative Repeaters.—Recent years have witnessed much development of regenerative repeaters by which the signals are not only repeated with renewed power but are also corrected and reformed, so that they leave the repeater with all the characteristics of the original signals, or, in some cases, with even better qualities than in the initial transmission. The general principle upon which regeneration is based is to select from each received signal a small portion—usually near the centre of the time interval occupied by the signal unit—which is most likely to be of full strength and free from imperfections. By using this fraction of the signal to operate a relay and other mechanisms which control the pulses to be applied to the outgoing line, the re-transmitted signal can be made practically perfect.

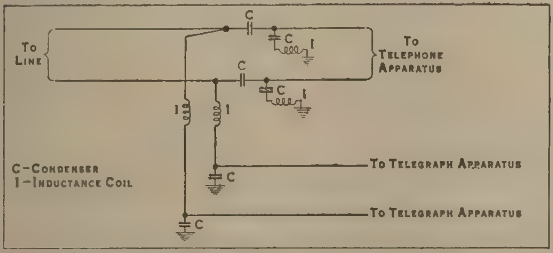

FIG. 20.—DIAGRAM OF A COMPOSITE ARRANGEMENT

Simultaneous Telegraphy and Telephony.—Two methods are in extensive use for superposing telegraph circuits upon wires already arranged for use as telephone circuits.

Composite Method.—In the composite arrangement (fig. 20) two ground return telegraph circuits are obtained from the two wires forming a metallic return telephone circuit. This is accomplished by taking advantage of the facts that a condenser offers little impedance to the alternating currents of relatively high frequency which operate the telephone, but is an almost impassable barrier to the much slower changes of current used in telegraphy, and that an inductance in the form of an electromagnetic coil can be so constructed that it will oppose greatly the flow of the telephone currents but will readily pass the telegraph currents. By forming a network of such condensers and inductances an electrical filter is obtained which guides the two classes of currents into their proper channels for the operation of the telegraph and telephone apparatus.

Simplex Method.—The simplex method of superposing permits only one ground return telegraph circuit to be operated over the two wires used to form a metallic return telephone circuit. In a common form of simplexed circuit (fig. 21), a repeating coil or transformer (*see* ELECTRICITY) is interposed at each terminal between the telephone apparatus and the line. The winding of this transformer, which is connected to the line wires, is tapped at its centre and this tap is connected to the telegraph apparatus. By this arrangement the telegraph currents are divided, one-half passing over each of the two line wires. These currents produce no effect upon the telephone apparatus because in dividing at the centre tap of the transformer winding the two equal parts must pass around the core in opposite directions and thus neutralize each other's magnetic effects. On the other hand, the alternating currents of the speech transmission so traverse the line windings of the transformer as to cause the maximum magnetic effect, and are thus repeated to the telephone apparatus.

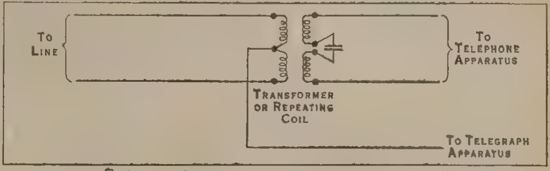

FIG. 21.—DIAGRAM OF THE SIMPLEX CIRCUIT

Carrier Currents.—In recent years it has become practicable to increase greatly the traffic capacity of certain classes of telegraph circuits by the use of alternating or pulsating currents of different frequencies for each message channel operated. In systems employing this principle each transmitter controls the application to the line of current at a certain frequency. At the receiving station the complex line current composed of these numerous components is passed through electrical filters, each of which excludes all other frequencies and delivers to the receiving instruments only the signals represented by the particular frequency assigned to that "channel." As many as 10 to 12 channels are often obtained on one metallic circuit by this means.

Subsidiary Systems.—Most telegraph administrations have established methods of distributing time signals to facilitate setting clocks and other timepieces in agreement with some recognized standard of correct time. In the United States one of the telegraph companies distributes over a very extensive network of circuits the "noon signals" furnished by the Naval observatory at Washington. These signals are used to check the operation of master clocks of great accuracy and reliability in all the principal cities. The master clocks in turn control the operation of large numbers of transmitting instruments which send out hourly synchronizing impulses to over 115,000 electrically driven clocks.

Another adjunct to commercial telegraph service for which wide use has been found is the provision of means whereby a patron may readily summon to his place of business or residence, a messenger who will carry to the nearest telegraph office any messages which the patron may desire to have transmitted. Over a quarter of a million "call boxes" for this purpose are provided by one system in the United States. Each call box is essentially an automatic telegraph transmitter which, when operated by the turning of a crank, sends to the telegraph office code signals which identify the patron to whom the box is assigned. These signals are received upon a Morse ink-writing register and in response a messenger is promptly started for the office or residence indicated as the source of the call. The circuit arrangements are characterized by ingenious devices which ensure the reception of the signal even under very adverse conditions due to faults upon the line conductors used.

AUXILIARY EQUIPMENT

Central Office Equipment.—In any large telegraph system it is necessary to concentrate the operating equipment at certain points in what are called central offices. These act as clearing houses for a definite area, collecting all the business from that area and despatching it to destination. Such offices vary considerably in size, the variation being dependent on the area served and the volume of traffic that such area produces, ranging from one small operating room to the 155,000 sq. ft. of operating space in the new Western Union building in New York. Special attention must be paid to the design of central office buildings. The operating rooms must be in large units and be adequately provided with light and air. Properly designed illumination is a large factor in increasing the speed and accuracy of operators, and, owing to the inevitable concentration of workers, the condition of the air is important. The greater part of a central office is taken up with operating rooms. (*See* Plate II.) In the smaller offices it is usual to collect all the operating equipment in one room, but where the size of the office prohibits this, the equipment is divided according to its method of operation. Thus those circuits which are manually worked, with a key and sounder, will be found on one floor, multiplex circuits will form a second group and short-line printer or simplex a third. Furthermore, the building must provide quarters for switchboard and testing equipment, for the service department—which deals with questions of accuracy, obtaining better address, etc., after a message has been sent—and for rest rooms and lavatories for the operators.

Power Supply.—The power required for the operation of telegraph circuits is divided into *local* and *main line*, the former supplying the current which operates all the local circuits of Morse and automatic sets, and the latter that which goes out over the lines to the distant station. The local power in any one office is a fixed potential, but the main line power must be of two or three different voltages to satisfy the various requirements of the circuits. In a very small office, where the power demands are slight, and usually of only one voltage, primary batteries are in some cases used. This type of battery was widely employed in the past, but is now rapidly becoming obsolete. Much more general is the use of storage batteries, which in some countries are used to supply telegraph power for the largest offices. They have the advantages of complete reliability and steady voltage. In the United States, the general practice is to use motor generators in all but the smaller offices. Power is purchased from the local supply company and is converted to the potentials required. If the local supply is direct current and is sufficiently steady and free from interruption it may be used directly and booster sets installed to give such variations in voltage as are necessary. If the local supply is subject to frequent interruptions storage batteries are customarily employed. Three main line voltages are provided in the Western Union system, 110, 160 and 240 volts, with separate machines for positive and negative current and a third, reserve, machine at each voltage. These machines have been specially designed to give constant voltage under all load conditions, a result obtained by using compound-wound machines with a flat-compounded series field. Motor generators have the advantage over storage batteries of requiring less space and costing less to maintain. To guard against temporary failures of the main source of supply an emergency supply is always furnished. This may take the form of a storage battery or may be a generator set driven by a gas or gasolene engine. The emergency engine generator must be sufficiently large to provide all the telegraph power required and also to maintain sufficient lights to enable work to be carried on and, in some cases, to keep running essential services such as message conveyors and pneumatic tubes. In some offices a storage battery has been provided to take care of the interval between the failure of the main power and the starting of the emergency engine.

Switchboards.—All the telegraph wires which enter an office are grouped in a switchboard which also accommodates conductors to all the telegraph apparatus in the office. This switchboard (Plate I. fig. 2) is usually a collection of jacks arranged in groups or singly. Each jack or group of jacks is connected to one line wire or one operating set and the two are joined by plugs and cords. Line wires and wires to operating sets do not terminate directly on the switchboard, but instead go to a distributing frame (Plate I. fig. 1) placed immediately behind the switchboard. The distributing frame has connecting blocks in vertical rows on one side and in horizontal rows on the other. On the vertical side are all wires from the outside and from the operating sets. The horizontal side has permanent connection with all the jacks of the switchboard. The two sides, vertical and horizontal, are joined by cross-connection wires which may be rapidly changed if required. Normally, each particular wire is assigned to some particular set. If a temporary change is necessary owing to the failure of a set or a wire it is made by means of the plugs and jacks on the switchboard. If the change is to be permanent it is made on the distributing frame by moving the cross-connecting wire. On the front of the switchboard is a shelf which is equipped with the necessary apparatus for testing wires and locating faults, consisting of a Morse set and plugs and a volt-milammeter for the former and a Wheatstone bridge set for the latter. Records are kept at the switchboard of all the outside lines connected to it, their length, the route they follow and the material of which they are made. Periodical measurements are made of the resistance of each line and recorded on a special form. If a fault develops in any circuit the attendant can determine at once if it lies inside the office, at the switchboard or in the set, or outside on the line. If the latter, he can discover by means of the volt-milammeter the nature of the fault (*open, cross* or *ground*, etc.) and with the Wheatstone bridge the location of the fault.

Grounds and Protection.—Telegraph operation is almost always carried on by means of an earth return, *i.e.*, one wire only runs between the two points and the electrical current returns by way of the earth. This feature makes it imperative that each telegraph office be provided with a good *earth* or *ground*. The requirements are that the resistance shall be low—for the larger offices not more than 1 ohm—and the connection as direct as possible. A public water-supply system, with its large quantity of metal piping laid in the soil, offers the best ground and is always used where available. Gas pipes are nearly as good but their use is attended with the risk of a spark igniting an escape of gas. Where neither water nor gas are attainable *made* grounds must be constructed by sinking iron pipes or metal in the earth. Made grounds are never as satisfactory as water or gas pipe grounds owing to the smaller areas of contact. Connection is made to the ground by means of large size rubber-covered wire, run without splices, kinks, coils or sharp bends. These last considerations are important from the point of view of the protection of the office from lightning and other electrical currents that may come in contact with the wires and cables entering the building. Before being carried into the switchboard each wire is provided with an arrester and fuse. The arrester consists of two small carbon blocks separated from each other by only a few thousandths of an inch of air, one side being connected to the line and the other to earth. Fuses are placed in the line to prevent a foreign current, which may have been picked up by the outside wire or cable, from damaging the instruments in the office. The arrester limits the voltage that can reach the wiring or apparatus by diverting to earth potentials that would injure the apparatus or wiring or the employees.

Message Conveyors.—In any central office means must be provided for carrying messages between different parts of the room. A message received on a wire in one corner may be sent out again on a wire in another corner and a rapid method of transference is necessary. The messages are conveyed mechanically from the operating tables to a distributing centre, where they are sorted and sent out on other conveyors to different sections of the room. Many types of conveyor are in general use, moving belts being the most common. The main considerations are speed and accessibility, with all features eliminated that would tend to lose, mutilate or delay a message. Belts are run at speeds of from 200 to 250 ft. per minute. Other types of conveyors have been developed with speeds as high as 500 ft. per minute. The distributing centre is the focal point of the operating room and is placed in a central position. Pneumatic tubes (*q.v.*) are also widely used both for carrying business within the confines of an office and for connection with other offices near by.

Telegraph Wires and Cables.—The conductors necessary to establish connections between various telegraph offices consist either of bare wires supported overhead on poles, or of groups of insulated wires held together by a common covering or sheath, to form cables. Cables may be carried overhead on poles or they may be laid underground. Overhead lines constitute the larger portion of the plant used to connect offices in one town with those in another town, although the use of cable is increasing rapidly. Connections between offices in the same town, and between offices and patrons, generally require the use of underground cable, since space is usually not available in towns for overhead wires or cables.

In general, bare wires consist of hard-drawn copper, although galvanized iron wire has been used quite extensively, and bronze wire is now being tried out with considerable success. The advantage of copper for line conductors is its high conductivity. Iron wire, while cheaper than copper, corrodes more rapidly except in dry climates and is not suitable for long or high speed circuits, because of its high resistance. Bronze wire is stronger than copper and less subject to mechanical injury, but its resistance is somewhat greater and it is slightly more expensive than copper. The copper wire ordinarily used for overhead telegraph lines has a diameter of 0·114 in. and weighs 210 lb. to the mile. Other sizes of copper wire are employed to a limited extent, the largest having a diameter of 0·165 inch. The most common size of iron wire used to-day has a diameter of 0·165 in. and weighs 380 lb. to the mile.

Conductors in cables designed for telegraph service are of soft-drawn copper varying in diameter from 0·036 in. to 0·102 inch. Ordinarily, cable conductors are separated and insulated by means of paper wrapped spirally about them, although cables having rubber-insulated conductors are often used for short distances. The insulated conductors are arranged in pairs, which consist of two conductors twisted together or in quads each consisting of two pairs twisted together. These pairs or quads are arranged compactly in layers. Paper-insulated conductors are always enclosed in a lead sheath $\frac{1}{8}$ in. in thickness; rubber-covered conductors may be enclosed either in a lead sheath or in a covering of heavy braid. The number of conductors provided in telegraph cables varies, the largest now in common use being 404 pairs of paper-insulated conductors 0·036 in. in diameter. The outside diameter of this cable is $2\frac{5}{8}$ in. and the weight is $7\frac{3}{4}$ lb. per foot.

Overhead Lines.—Poles used to support wires and cables are usually of wood, although steel and concrete poles have been used. They are of such height as to provide a suitable clearance from the ground for the wires and cables. The size of poles required and the distance they are placed apart depends upon the geographical location of the line and upon the number of wires and cables carried. Lines situated in sections of the country where ice or snow is apt to collect upon the wires require the use of larger poles placed closer together than lines in portions of the country where ice never or rarely forms. In more favourable climatic locations and if only a few wires are supported poles are often placed 175 ft. to 200 ft. apart. It is not considered in general good practice to place more than sixty wires on a pole line, although eighty or even a hundred wires are sometimes carried for short distances where it is not too expensive to place the poles close together.

It is common practice to impregnate wood poles used in telegraph lines with some form of preservative in order to retard decay. Until recently creosote was used almost exclusively as a preservative for poles, but certain insoluble arsenic compounds are now employed extensively. (*See* Timber Preservation.) Bare wires are supported on insulators usually made of glass and held in position by wire ties. These glass insulators are mounted on either wood or steel pins which are set vertically in crossarms of wood.

Crossarms are normally 10 ft. in length and accommodate ten pins spaced approximately 12 in. apart. For lines carrying a small number of wires 6 ft. crossarms carrying six pins are often used. These crossarms are securely fastened to the pole, the top one approximately 12 in. below the top of the pole and additional arms each 2 ft. below the next higher arm. Cables when placed on poles are supported by suspension strands, consisting of seven high-strength galvanized steel or bronze wires twisted together. The weight of the cable to be supported determines the strength of suspension strand used, the heavier cables requiring strands having a maximum strength exceeding 18,000 pounds.

Cables are hung from suspension strands by means of metal rings clamped on the strands from 1 to 2 ft. apart. The suspension strands are fastened to the poles by means of strong metal clamps bolted to the poles. At corners, along curves, and at the ends of lines, it is often desirable to strengthen the line by the use of guys of steel strand similar to that used for supporting cables. These guys are fastened at the upper ends to the poles and at the lower ends to logs or other substantial objects buried in the earth. The purpose of these guys is to prevent the poles from being pulled over or broken by the constant pull of the wires.

Underground Construction.—Where cables are placed underground some form of conduit, with independent duct space for each cable, is usually employed to permit the cables to be readily installed and removed. The ducts are usually of hollow tile, creosoted wood or fibre. Iron pipe is used in special situations. All ducts are 3 in., or slightly more, in diameter. The conduit is buried to a depth of at least 2 ft. in the ground. As the length of cable which can be pulled through a duct is limited, splicing chambers or manholes are provided at intervals of 500 ft. to 600 feet. Manholes are normally at least 3 ft. wide, 5 ft. long and $4\frac{1}{2}$ ft. deep, although in many cases considerably larger sizes are required. They are usually constructed of brick or concrete with a removable cover.

Cable is pulled into conduits one length at a time and then the ends are spliced together. In splicing paper-insulated cables a foot or more of the sheath is removed from the end of each of the cables to be spliced, and a few inches of the insulation is removed from the conductors. The conductors are then joined by twisting, soldering or other means, and the joints are insulated by being covered with small paper or impregnated cotton tubes. After all conductors are joined the splice is wrapped with strips of muslin and a lead sleeve is slipped over it. This sleeve is sealed at each end to the cable sheaths by means of wiped solder joints.

At points where overhead wires connect to paper insulated cables, it is usually necessary to provide electrical protection to prevent high voltages, due to lightning or to accidental contact with power wires, from puncturing the insulation of the cables. Accordingly arresters similar to those used in offices are commonly placed on poles, at which junctions between wires and cables occur. Where large currents are apt to result from contact with power wires, fuses are also used to prevent the cable conductors from being burned out. Protector equipment is usually housed in boxes mounted on the junction poles.

THEORY OF TRANSMISSION AND INTERFERENCE

Transmission.—The fundamental requirement of a telegraph system is a source of energy controlled in accordance with the code and the characters to be transmitted, which sends sufficient energy through a line wire to operate a suitable receiving or recording device at the distant end. Where some interference is present, as is usually the case, the received energy must be sufficiently greater than the interference to enable the signal to be distinguished. The sending source of energy usually consists of a direct current battery or generator, under proper control. From what follows, however, it will be evident that the transmission of telegraph characters requires the use of apparatus and lines capable of transmitting sine wave alternating currents of various frequencies, *i.e.*, a band of frequencies, within a certain range. A communication circuit of any kind is thus fundamentally different from a circuit for transmission of energy for power or lighting, in which direct current or alternating current of only a single frequency need be transmitted.

In a telegraph system the signals sent, of course, are continually changing in character, and there will be times when several consecutive dots or reversals are sent at the highest fundamental frequency of transmission for the given circuit. The number of such complete reversals per second may be spoken of as the *fundamental signalling frequency* or the *dot frequency*. Common fundamental signalling frequencies for various circuits are tabulated below:—

Messenger call circuits	2	cycles per sec.
Key operated Morse	6 to 18	„ „ „
Automatic telegraph systems . . .	15 to 60	„ „ „
Submarine cables, non-loaded . . .	4 to 15	„ „ „
Submarine cables loaded	30 to 80	„ „ „

The alternating current characteristics of signal combinations may be most readily considered by examining a number of typical combinations of signals, such as in fig. 22, the combinations being assumed to repeat themselves again and again. Such combinations may be analysed by the ordinary Fourier method into a series of sine wave components. Analyses of a considerable number of these recurring combinations show that all frequencies from zero to infinity—excluding even multiples of the fundamental signalling frequency—are present in the transmitted signals. In order to operate a receiving instrument at the distant end, it is not necessary that all of the above frequencies be transmitted through the line. In a submarine cable system, which ordinarily is operated quite efficiently, it is usually sufficient to receive frequencies from zero up to about 1·6 times the fundamental signalling frequency. Since the higher frequencies are more difficult to transmit through the line this condition facilitates operation. In a land line telegraph system operated with less complex equipment it is preferable that frequencies from zero to about three times the fundamental signalling frequencies be received.

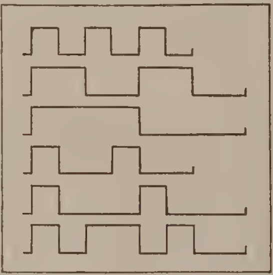
FIG. 22.—EXAMPLES OF RECEIVING SIGNALS

The voltages and currents originating at the transmitter may be modified by any impedance at the sending end of the line, by the line itself, and by the receiving equipment. The effect of the line is ordinarily to reduce the amount of higher frequencies transmitted, thus limiting the speed of transmission. This is particularly true in the case of the submarine cable, in which frequencies in the neighbourhood of the fundamental signalling frequency are received with only a small fraction of the magnitude of frequencies much lower than this value. In order partly to counteract this difference a condenser is customarily placed in series at the sending end of a submarine cable, thus reducing the magnitude of the lower frequencies and thus reducing distortion of the received signal. Various special devices are used at the receiving end of such a cable for the purpose of strengthening the higher frequencies and reducing lower frequencies in order to reduce distortion.

In order to decrease the loss of signalling energy in the line its inductance may be increased by artificial means known as *loading*. This is especially successful with long submarine cables. The effect of the inductance is particularly to sustain the higher frequencies. The velocity of propagation is decreased, and the signal, arriving slightly later, is received with much increased energy.

Interference.—Telegraph operation is more or less affected by parasitic currents from various outside sources. These sources include: (1) earth potentials arising from natural causes (*see* MAGNETISM); (2) earth potentials arising from electric railway systems; (3) induction from one telegraph circuit to another; and (4) induction from electric railway or power supply systems. The relative susceptiveness of the several forms of telegraph operation is as follows, expressed in order of decreasing susceptiveness: (1) submarine cable; (2) quadruplex; (3) multiplex; (4) duplex; and (5) single Morse. Because of the extensive use of multiplex telegraphy interference with circuits of that type is by far the most serious. Small amounts of potential from extraneous sources result in impairment of the maximum speed at which these circuits may be operated; large amounts render the circuits inoperative. With extremely high potentials persons operating the circuits may suffer bodily injury, or property dam-

	Miles of telegraph wire	Telegrams sent ('000s omitted)
Europe:		
Austria	48,538	4,016
Belgium	25,901	5,700
Bulgaria	12,477	2,814
Czechoslovakia	44,204	5,043
Denmark	9,011	2,237
Finland	8,985	898
France	441,638	54,606
Germany	561,183	36,324
Great Britain and N. Ireland (March 31, 1927)	354,000	57,984
Greece	29,799	6,138
Hungary	51,439	5,062
Irish Free State (March 31, 1927)	23,660	3,083
Italy (June 30, 1927)*	70,000	..
Yugoslavia	54,940	16,076
Latvia (March 31, 1927)	5,439	482
Netherlands	29,218	5,455
Norway (June 30, 1926)	25,034	3,788
Poland	54,420	13,784
Portugal*	20,000	..
Rumania	46,904	9,960
Russia†	413,800	28,976
Spain	74,914	13,075
Sweden	54,970	3,946
Switzerland	23,431	2,942
Other places in Europe*	14,295	..
North America:		
United States	2,020,000	215,000
Canada	305,933	13,219
Central America	21,205	6,766
Mexico	84,292	5,803
West Indies:		
Cuba	12,231	2,719
Porto Rico	1,072	325
Other W. I. places*	4,196	..
Other N. American places*	10,000	..
South America:		
Argentina	203,502	12,997
Bolivia	7,150	476
Brazil	102,362	7,610
Chile	45,342	6,056
Colombia	18,973	4,992
Ecuador	4,555	718
Paraguay	2,223	158
Peru	11,929	1,292
Uruguay	6,404	823
Venezuela	6,281	2,038
Other places	786	95
Asia:		
British India (March 31, 1927)	383,941	19,022
China*	85,000	..
Japan (March 31, 1927)	183,478	60,891
Other places in Asia*	115,041	..
Africa:		
Egypt	27,750	..
Union of South Africa (March 31, 1927)	49,042	6,056
Other places in Africa*	127,147	..
Oceania:		
Australia (June 30, 1926)	118,141	18,334
Dutch East Indies	20,597	2,738
New Zealand (March 31, 1927)	26,336	16,372
Philippine Islands	9,694	4,793
Other places in Oceania*	1,352	..

*Partly estimated.
†Including Siberia and associated republics.

age may result. To mitigate the interference from these parasitic currents various means may be applied to the telegraph circuit or to the source of the interference, if this be an electric railway or power supply system. In application to telegraph circuits these mitigative devices may take the form of impedances whose function is to filter out the extraneous current, or of transformers or generators whose function is to interpose in the circuit a potential to counteract that from the outside source. In application to electric railway or power systems, impedances inserted at appropriate points, selection of proper transformer connections, favourable operating methods or transpositions may often be advantageously employed to reduce the inductive influence of the interfering system. Sometimes, however, an increase in the physical separation between systems is the only practicable remedy.

Telegraph Statistics.—The tabulated statement on p. 890 shows the telegraph wire mileage of the world and the number of messages transmitted. The wire mileage in all cases, except where otherwise indicated, is as of Jan. 1, 1927, and the number of messages transmitted is for the year 1926, except in the cases of Brazil, Ecuador, Paraguay and Guatemala, for which countries statistics for 1926 are not available. In the cases of a few countries there are no statistics of telegrams transmitted, and the space for such statistics in the table is left blank.

SUBMARINE TELEGRAPHY

History.—Although suggested as early as 1798 by the Spanish scientist Salva, and made the subject of several experiments in the early part of the 19th century by Morse, Wheatstone and others, which demonstrated the possibility of submarine telegraphy, it was not until the introduction of gutta-percha as an insulator and the invention of a machine for applying it to wire, that the submarine cable became commercially attractive.

In 1850 a cable was laid between England and France, but it was broken shortly after communication was established because of its inherent physical weakness. The addition of galvanized iron armour wires, wound with a long spiral lay on a cushion of jute yarns around the central gutta-percha-covered copper conductor, contributed the necessary strength when the next attempt was made in 1851, and this cable, between Dover and Calais, proved successful. In the next few years a number of cables were laid between England and adjacent shores, between Denmark and Sweden, and in the Mediterranean. The first attempt to lay a cable across the Atlantic in 1857 ended in failure when the cable broke at a depth of 2,000 fathoms. In the absence of any means of recovering the end the project had to be abandoned. In Aug. 1858 a cable was successfully laid between Valentia, Ireland, and Hearts Content, Newfoundland. This was operated for about three months, when it became interrupted in deep water and could not be repaired. In the years 1865 and 1866 two more cables were laid; the first broke when about two-thirds laid, but the second was successfully laid, and soon afterwards the end of the 1865 cable was picked up with difficulty and its laying was completed.

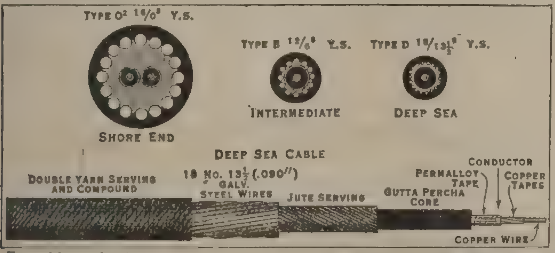
TYPE O^2 $^{16}/_{0^8}$ Y.S.
SHORE END
TYPE B $^{12}/_{6^8}$ Y.S.
INTERMEDIATE
TYPE D $^{18}/_{13\frac{1}{2}^8}$ Y.S.
DEEP SEA
DEEP SEA CABLE
DOUBLE YARN SERVING AND COMPOUND
18 No. $13\frac{1}{2}$ (.090″) GALV. STEEL WIRES
JUTE SERVING
GUTTA PERCHA CORE
PERMALLOY TAPE
CONDUCTOR
COPPER TAPES
COPPER WIRE

FIG. 23.—CONSTRUCTIONAL DETAILS OF A MODERN SUBMARINE CABLE

These cables, with which the names of the American financier, Cyrus Field, and the British scientist, Lord Kelvin, are closely associated, were operated by the Atlantic Telegraph Company without competition until 1869, when the French Atlantic Telegraph Company opened a cable for traffic. With the success of the Atlantic cables established, the growth of submarine cable systems was rapid until at present (1929) there are 21 cables across the Atlantic between North America and Europe alone, and there is a total of about 3,500 cables in the world, with an aggregate length of over 300,000 miles.

It was early realized, even before the first Atlantic cable was laid, that a very sensitive instrument would be needed for the reception of signals on long cables. The mirror galvanometer, invented by Prof. William Thomson, later Lord Kelvin, filled this need for many years. The syphon recorder invented in 1867, which had the advantage of leaving a written record, gradually replaced the mirror galvanometer, and in its improved form is still largely used on long cables. In 1871 the duplex system was introduced, permitting simultaneous transmission of messages in both directions, and the speed of operation has been gradually increased from the initial 15 letters per minute of 1858 to the successful transmission of upwards of 2,500 letters per minute in recent years, while the rate charged dropped from a minimum of about $100 per message to a maximum, between New York and London, of 25 cents per word.

Construction.—Fig. 23 shows the constructional details of a modern submarine cable. The conductor is made of copper, stranded or having a central wire surrounded by strips wound spirally. Over this is moulded the insulation. Some of the shorter cables have made use of india rubber as an insulator, but although progress has been and is still being made to develop substitutes, gutta-percha remains the best material for the purpose.

The operating characteristics of a cable depend upon the size of the conductor and the thickness of the insulating wall. Some of the very recent cables are loaded by means of a thin ribbon or thread of highly permeable nickel-iron alloy wound around the copper conductor, which has the effect of greatly increasing the speed at which the cable can be worked. To protect the insulation against injury by marine borers, such as the teredo worm, a brass tape is wound around the gutta-percha on all cables except those lying in very deep water. Next comes a filler of jute yarns which acts as a cushion for the armour or sheathing wires. These are wound on with a long spiral lay. For cables used in the deeper portions of the ocean it is the practice to use galvanized steel wires of high tensile strength, and as the depth of water decreases the steel wires are replaced by galvanized wrought iron wires of larger size. As the cable approaches the shore the armouring is made heavier until at the shore it is doubly sheathed. This added protection in shallow water is necessary to prevent damage by ships' anchors, trawling gear, rocks and, in northern latitudes, icebergs. An outer double wrapping of tarred jute yarn, or tape steeped in a compound of tar and pitch, preserves the armour from corrosion. So efficacious is this covering that lengths of cable have been picked up in deep water after more than 40 years of continuous submersion with the jute wrapping and compound still adhering to the armour wires, the latter being to all intents and purposes as good as ever. In addition, extra protection is now given to deep-sea armourings by taping each individual armour wire. The outside diameter of the ordinary deep-sea type of cable is about 1 in., and the weight in air about two tons per nautical mile. The shore-end types run as large as $3\frac{1}{2}$ in. in diameter and weigh as much as 30 tons per nautical mile.

Cable Laying.—It is the usual practice for the manufacturer to lay the cable and test it to ascertain whether the specified electrical characteristics have been met before turning it over to the operating company. The ships used for laying are specially constructed to carry cable in cylindrical tanks which are built into the ship's structure. The largest ship of its kind, the C.S. "Dominia," owned and operated by the Telegraph Construction and Maintenance Company, to which reference was made in the preceding paragraph, has four of these tanks, with a total net coiling capacity of 190,000 cubic feet. In them may be stowed away a cable over 3,000 m. long. The cable is coiled down around a central hub-shaped cone in horizontal layers, starting at the tank wall and coiling in toward the centre. When the cone is reached the cable is run out radially to the wall, again with wedge-shaped strips of wood, called "feather-edges," on either side to protect it from the weight of the layers above, and the process is repeated. When paying out the cable it is pulled through a circular hatch in the deck above the cone, several hands being stationed in the tank to guard against kinks forming, or the cable fouling. In loading the vessel the cable from the top of one tank is led over into the bottom of the adjacent tank, making it necessary only to slacken the speed of paying out when changing over from one tank to the next.

From the tank the cable passes to the paying out gear. This machinery for controlling the stress on the cable is placed both at the bow and stern. All long pay-outs are made over the stern, but it is often more convenient to pay out short sections over the bow, as it is to this point that the cable is brought for splicing. The machine consists of a large drum 6 ft. in diameter, around which several turns of cable are taken to provide the necessary friction. On the same shaft is a series of water-cooled adjustable band brakes and connected to it is a large fan brake. The cable then passes through a dynamometer, which gives an indication of the stress, leaving the ship over the bow or stern guide, as the case may be. It is not uncommon for the stress on the cable in paying out in deep water to amount to as much as two tons. In order to check the amount of slack in the cable there is paid out at the same time a taut steel piano wire which is carefully measured and compared with the length of cable paid out. When passing over fairly smooth bottom the amount of slack paid out rarely exceeds 10%, but care is taken not to leave the cable in a state of tension on an uneven bottom, or suspended in bights over rocks, etc., as injury to the cable would result.

The heavy shore end of the cable is landed from a smaller ship which is moored close to the beach and a line sent ashore, supported by barrel floats. When enough of the cable has been landed the barrels are cut away. The remaining length on the smaller ship is then paid out and the end buoyed in water sufficiently deep to permit the deep sea ship to approach. The latter takes the buoyed end aboard over the bow, a splice is made, and the cable transferred to the stern. The ship then starts on her long voyage. When approaching her destination the cable is cut and the end buoyed in deep water. When this shore end of the cable has been laid out to meet the buoyed deep-sea end, both ends are taken aboard and tested; the final splice is then made and the cable dropped over the bow. During cable laying testing is carried on continuously by a staff of electricians, whose duty it is to detect and report any fault in the cable.

Should the cable develop a fault or break while being laid, the ship is equipped with special means of coping with the trouble. From the results of electrical testing it is possible to arrive at the length of cable between the ship and the fault.

Cable Repairing.—When trouble develops in a submarine cable it is usually possible to localize the fault or break with a fair degree of accuracy by determining the electrical resistance or capacity of the core between the testing point and the point of failure by the Wheatstone bridge method. Knowing the characteristics of the cable it is possible to deduce the distance in miles, which interpreted in conjunction with the charted route enables the navigator of the repair ship to place a mark buoy within working range. In deep water it is necessary to use a cutting grapnel which automatically grips the cable and cuts away one end when it is lifted. The very ingenious construction of the Lucas grapnel permits it to be set so as to cut away whichever end is desired. A suddenly increased stress on the grapnel rope which passes through the dynamometer gives an indication when the prongs of the grapnel encounter an obstacle. The vessel is stopped and the picking-up gear is started. When the cable has been raised to the surface it is secured with a rope, or chain stopper and taken aboard. Test leads are attached to determine the electrical condition of the cable and the fault is localized. When the line is electrically clear to one of the shore stations the end is buoyed. Should the cable be in danger of parting, a length of new cable from the ship's tanks is spliced on and paid out until all the cable suspended off the bottom is new. The ship is then free to go after the cable on the other side of the fault. When this end has been raised and the tests indicate its continuity and satisfactory insulation all the way to the shore station, cable from the ship's tanks is spliced on and paying out commences towards the buoyed end, which, when it is reached, is taken aboard. Final tests are taken in both directions; the cable from the ship's tanks is stoppered off and cut, and the final splice is made on the ship's deck in a bight both sides of which are secured with stoppers, by means of which it is eased over the bow and the lines holding it are cut away.

OPERATION

Simplex.—The simplex method—sending single messages in one direction only—of operating submarine cables is not generally employed except where it is difficult to maintain a duplex balance. The cable capacity when using the simplex method is approximately 40% lower than when operated by the duplex method. When it is considered that a modern cable of about 2,000 m. in length costs about $4,000,000 and that the annual expense for maintenance and operation is approximately $600,000 it can be readily seen that the highest possible traffic-carrying capacity is essential in reducing operating costs.

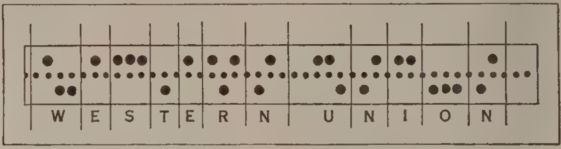

FIG. 24.—PERFORATED CABLE SENDING TAPE

Duplex.—Duplex operation, or the transmission of messages in both directions at the same time, is made possible by so arranging the recording instruments that while responding to signals from the distant end of the cable they do not respond to signals sent into the end of the cable at which they are located. There are several methods of duplexing, all of which depend upon the use of an artificial line for balancing, as is the case in land line duplex operation. The artificial line for ocean cable operation must more nearly duplicate the real cable in electrical characteristics and it is therefore designed and built to suit the cable which it is to balance.

Transmission.—Transmission of messages over ocean cables may be accomplished manually or by automatic means. The common code employed is an adaptation of International Morse in which dots and dashes are transmitted as impulses of equal duration but opposite in polarity. The manual means of transmitting the international code makes use of a double lever key, which is so arranged that the depression of one key connects one polarity of battery to the line to form a dot, and a depression of the other key connects the other polarity of the battery to make the dash. In automatic transmission signals are transmitted by means of a motor-driven transmitter controlled by a perforated paper tape. The tape is prepared in a keyboard perforator (Plate I., fig. 7) by means of which the depression of a single key will perforate the entire combination of dots and dashes corresponding to the letter. This tape (fig. 24) is then passed through the transmitter in which transmitting contacts for either dot or dash polarity are controlled through mechanical levers by the perforations in the tape. The transmitter is operated at the highest speed permitted by the electrical characteristics of the cable.

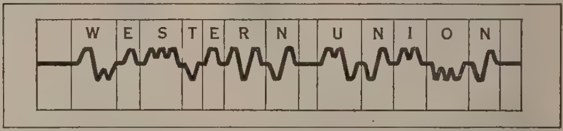

FIG. 25.—UNDULATING LINE EMBODYING CODE

Receiving.—The reception of submarine cable signals necessitates the use of extremely sensitive and delicate instruments. The underlying principle of older types of cable receiving apparatus is that of the galvanometer, an instrument whose function it is to determine whether an electric current is present in a given conductor and in what direction it is flowing. The recorder commonly used consists of a galvanometer, to the moving coil of which is attached an ink syphon resting upon a moving paper tape. When no signals are being received the syphon will draw a continuous straight line along the centre of the tape. As signals are received the resulting deflections of the galvanometer will cause the syphon to move above or below its normal position, causing undulations in the line. Undulations above the centre indicate dots and those below the line indicate dashes.

For operating cables up to approximately 600 m. in length at a speed of about 200 letters per minute the received signal is of sufficient strength to operate the recorder directly from the cable. In order to increase the operating speed of a long cable above a point where satisfactory results can be obtained with a syphon recorder alone, it is necessary to magnify the weakened incoming signals before passing them through the recorder. The instrument most extensively used for this purpose is known as a magnifier, the application of which is similar to that of a Morse relay in land line operation. The magnifier, like the recorder, comprises a galvanometer which is so arranged that deflections of the galvanometer control current in a local circuit containing a recorder. The important feature of the magnifier is maximum sensitivity and to obtain this functional losses and inertia of moving parts are kept at a minimum. Several means are employed for accomplishing this purpose. In one type the armature of the galvanometer carries a small mirror which deflects a beam of light so that it will fall on a light-sensitive cell connected in the local circuit containing the recorder. Variations of light intensity falling on the cell cause its resistance to be varied, resulting in corresponding variations in the local current through the recorder. In another common type the galvanometer moves a fine light wire carrying a portion of the local currents into proximity with a heating coil or blast of air, so that it becomes heated or cooled, thus varying its resistance and causing variations in the local current. In recent installations magnifiers have been replaced by vacuum tube amplifiers associated with shaping networks to amplify and improve the shape of the received signals.

Automatic Relays.—In many cases it is desirable to repeat signals automatically from one section of cable into another rather than to record them. It is essential that a cable relay used for this purpose shall have a reliable method for making electrical contact. All of the standard types of cable relays employ the principle of the moving coil galvanometer, and differ only in the method of making contact. A relay may be used with or without a magnifier in the circuit, the relay alone being approximately as sensitive as a syphon recorder. The relay in passing signals merely strengthens the current for the next cable section.

If the signals to be repeated are being received from a cable section approximately 100 m. or more in length, they will be so distorted that the use of a relay of the type described above would be impracticable. In such instances a regenerative type of repeater is used, similar to the regenerative repeaters employed on land lines.

Chief Submarine Cables of the World

Company or system	Number of cables	Length in nautical miles
African Direct Telegraph Co.	8	2,882
All America Cables, Inc.	46	24,887
British Imperial Cable	4	6,388
Cie. Française des Cables Télégraphiques	29	14,657
Commercial Cable Co.	26	24,801
Commercial Cable Company of Cuba	2	1,553
Commercial Pacific Cable Co.	6	10,042
Cuba Submarine Telegraph Co.	11	1,482
Direct West India Cable Co.	2	1,267
Eastern & Westernafrican Telegraph Co.	18	12,010
Eastern Extension, Australasia & China Telegraph Co.	34	31,455
Eastern Telegraph Co.	110	53,962
German Atlantic Cable Co.	1	1,660
Great Northern Telegraph Co.	38	8,421
Halifax & Bermudas Cable Co.	1	852
Italian Cable Co.	10	9,307
Mexican Telegraph Co.	7	2,670
Pacific Cable Board	15	18,282
West African Telegraph Co.	6	1,474
Western Telegraph Co.	43	28,883
West India & Panama Telegraph Co.	22	4.355
Western Union Telegraph Co.	40	28,620
United States & Hayti Telegraph & Cable Co.	1	1,432
United States Military Cables	26	3,772

In recent years printing systems have been applied to ocean cables, and on the high-speed loaded cables an adaptation of the American multiplex system is being used.

Chief Submarine Cables of the World.—There are at the present time upwards of 3,000 submarine cables in the world with an aggregate length of more than 300,000 nautical miles. The preceding table shows the number and length of important cables operated by Governments and the principal cable companies or systems. Short channel and harbour cables are omitted. Almost 75% of the total cable mileage is privately owned and operated.

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(N. C.)

TELEKI, PAUL, COUNT (1879–), Hungarian politician and geographer, studied jurisprudence and geography in Budapest. After being elected to Parliament in 1905 he spent some years in geographical study abroad, and published *Atlas zur Geschichte der Kartographie der Japanischen Inseln* (Budapest, 1909), crowned with the Prix Jomard by the French *Société de Géographie*. He was foreign minister in the cabinet of Admiral Horthy (April 1920), and in July of the same year became prime minister. He resigned in 1921 after the first attempt of King Charles to regain his throne. Later in the year he was appointed professor of economic geography in the University of Budapest. In 1924 he served in a scientific capacity on the commission appointed by the League of Nations to enquire into the Mosul frontier dispute between Great Britain and Turkey.

TEL EL AMARNA, the name now given to a collection of ruins and rock tombs in Upper Egypt near the east bank of the Nile, 58 m. by river below Assiut and 190 m. above Cairo. The ruins are those of Akhet-Aton, a city built *c.* 1360 B.C. by Ikhnaton (Amenophis IV.) as the new capital of his empire (in place of Thebes) when he abandoned the worship of Ammon and devoted himself to that of Aton, *i.e.*, the sun. Shortly after the death of Ikhnaton the court returned to Thebes, and the city, after an existence of perhaps only twenty years—of fifty years at the utmost—was abandoned. Not having been inhabited since, the lines of the streets and the ground-plans of many buildings can still be traced. The chief ruins are those of the royal palace and of the House of the Rolls; there are scanty remains of the great temple. In the palace are four pavements of painted stucco work in fair preservation. They were discovered in 1891–92 by Prof. Flinders Petrie. In the Rolls House were discovered in 1887 by the fellahin some 300 clay tablets inscribed with cuneiform characters. They are letters and state documents addressed to Amenophis IV. and his father, from the kings of Babylon, Assyria, etc., and from the Egyptian governors in Syria and neighbouring districts. The greater part of them were purchased for the Berlin Museum, but a large number were secured for the British Museum. Their contents proved invaluable for the reconstruction of the history, social and political, of Egypt and Western Asia during that period.

Hewn out of the sides of the hills on the east are two groups of tombs; one group lies 1½ m. N.E., and the other 3 m. S. of the city. The tombs, all of which belong to the time of Ikhnaton, are full of interesting scenes in the peculiar style of the period, accompanied by hymns to the sun god. The most important tomb is, perhaps, that of Meri-Ra, high priest of the sun, which has a façade nearly 100 ft. long and two large chambers. In the early centuries of Moslem rule in Egypt the northern tombs were inhabited by Copts, one tomb, that of Pa-Nehesi, being turned into a church.

The tombs and the great stelae sculptured on the cliffs which mark the bounds of the city of Akhet-Aton have been the object of special study by N. de G. Davies on behalf of the Archaeological Survey of Egypt. The results, with numerous plates and plans, are embodied in a series of memoirs, *Rock Tombs of El Amarna* (six parts, 1903–08).

TELEMACHUS, in Greek legend, son of Odysseus and Penelope (*Odyssey*, i.–iv., xv.–xxiv.; Hyginus, *Fab.* 127). When he reached manhood he visited Pylos and Sparta to make inquiries about his father. On his return, he found that Odysseus had reached home before him. Then father and son, aided by Eumaeus and Philoetius, slew the suitors of Penelope (*see* ODYSSEUS). According to later tradition he married Circe (or Calypso) after Odysseus' death.

TELEMARK or **THELEMARK,** a district of southern Norway, in the *amt* (county) of Bratsberg. It covers the uplands and fjelds of the southward projection of the country, having its highest point in the Gaustafjeld (6,200 ft.); and contains several large lakes, as Nordsjö, Bandaksvand, Tinsjö, Mjösvand and Totakvand. The two first are connected by the Bandaks canal, giving access from the port of Skien to Dalen at the head of Bandaksvand. From Dalen, a driving road much frequented by travellers runs north-west, through beautiful scenery. It crosses the fjelds at a height of 3,085 ft. on the way to Röldal from which branches run to Odde and through Bratlandsral respectively. One of the finest waterfalls in Europe, Rjukanfos (415 ft.), provides power for nitric acid works, and Ulefos, near the Bandak canal, for pulp mills. Notodden is a growing town with saltpetre works. Skien, the capital (*q.v.*) is a port; also Kraguö, Porsgrund (pop. 8,850), and Brevik.

TELEOLOGY, in philosophy and biology, means explanation by reference to the realisation of some purpose or end (Greek τέλος, an end), contrasted with explanation by efficient causes only. Teleology is one of the oldest, probably the oldest, mode of explanation. Human conduct is nearly always explained by reference to the ends pursued, or alleged to be pursued; and the tendency to explain everything else after the analogy of human behaviour is very old, as old probably as human nature itself. The method of explanation by reference to ends received formal and explicit recognition in Aristotle's list of four causes which included "final" causes. Aristotle, of course, insisted on the importance of discovering the "material," "formal," and "efficient" causes as well as the "final" causes. But during the middle ages the others tended to be ignored more or less, and too much attention was paid to "final" causes even in physical and chemical investigations, which consequently became rather fantastic. The founders of modern science had a hard struggle to instate or reinstate the "mechanical philosophy" at least side by side with teleological explanation. The pendulum naturally swung to the other extreme. Not only physical and chemical phenomena, but even biological phenomena were explained mechanically. Descartes, for example, regarded the lower animals as mere automata. In time, however, it was found impossible to explain biological facts adequately by means of mechanical conceptions only, and teleology of one kind or another has met with increasing recognition in recent times.

See MECHANISM; EMERGENCE; EVOLUTION; METAPHYSICS; SCIENTIFIC METHOD; L. T. Hobhouse, *Development and Purpose* (1913, etc.).

TELEOSTEI. In the classification issued in 1846 by Johannes Müller, the recent bony fishes were arranged in three sub-classes, Dipneusti, Ganoidei and Teleostei, the last including the great majority of the fishes, all those with a homocercal caudal fin. Subsequent work, especially on fossil fishes, has shown that the ganoids are not a natural group, some being related to very primitive fishes, others approaching the teleosts, namely the Holostei, which include the recent *Amia* and *Lepidosteus.* The extinct Pholidophoridae and Oligopleuridae are exactly intermediate in structure between the Holostei and Teleostei, and have been included by some authorities in the one group, by others in the other. This has led C. T. Regan to combine the Holostei and Teleostei to form one sub-class, termed Neopterygii. (*See* FISHES.)

TELEOSTOMI, a name given by some authorities to the bony fishes, either with or (usually) without the lung-fishes; in the former sense it is equivalent to the class Pisces, above the level of the Selachians. (*See* FISHES.)

TELEPATHY was defined by F. W. H. Myers, who invented the word in 1882, as "the communication of impressions of any kind from one mind to another, independent of the recognized channels of sense." It is to be noted that Myers does not postulate that both or either of the minds he mentions should be the minds of living persons; for supernormal communication between the minds of living persons the phrase "telepathy between the living" should in strictness be used, but often "telepathy" by itself is loosely used in this sense. "Thought-transference" is a less technical word with the same meaning. (*See* also CLAIRVOYANCE, PSYCHICAL RESEARCH.)

TELEPHONE. In a broad sense, the term telephone or telephony includes the entire art of speech transmission with the many accessories and operating methods which research, development, and invention have supplied to facilitate and extend conversation at a distance by electrical means. The telephone was invented in 1876, at Boston, Mass., U.S.A., by Alexander Graham Bell (*q.v.*). While endeavouring to construct a "harmonic telegraph" with which he hoped to send several telegraphic messages simultaneously over a single wire, Prof. Bell was also trying to transmit speech electrically. On June 2, 1875, he succeeded in transmitting by wire the sound of a twanging clock spring. Further experiments produced on March 10, 1876, an instrument which successfully transmitted a complete sentence, Prof. Bell's summons to his assistant in another room: "Mr. Watson, come here, I want you." Bell himself, during his experiments, stated the correct principle of telephone transmission as follows:

> If I could make a current of electricity vary in intensity precisely as the air varies in density during the production of sound, I should be able to transmit speech telegraphically.

Bell was the first to utilize a continuous current, intensified and diminished in proportion to the sound waves projected into the transmitter. Others had predicted the possibility of transmitting speech by wire but had not hit upon the only practicable method. Charles Bourseul, a Frenchman, published an article as early as 1854 in which he described a method that he believed might be used to transmit speech electrically. An Italian named Antonio Meucci, about 1857 sought some way of transmitting the voice by wire. In 1861 Philipp Reis, a German, produced an instrument constructed along lines similar to those laid down by Bourseul, which would transmit sound of a constant pitch, but proved incapable of transmitting continuous speech. In the United States, several other experimenters were working along lines similar to Bell's at about the same time. Prof. Elisha Gray, in fact filed a caveat (*q.v.*) on the subject in the United States Patent Office only a few hours after Bell filed his application for a patent on his "improvement in telegraphy," as he described his invention of the telephone. The claims of Prof. Gray and of other American inventors, notably Prof. A. E. Dolbear and Daniel Drawbaugh, were threshed out in prolonged litigation which resulted in Bell's patent being upheld and his claims to be the inventor of the telephone being officially established.

Introduction.—Public apathy in the United States and in Great Britain and other countries was one of the most disheartening difficulties faced by those who were endeavouring to introduce the telephone. The development of the telephone business was undertaken by a group of Prof. Bell's backers, under the leadership of Thomas Sanders and Gardiner G. Hubbard, whose daughter Bell soon afterwards married. They began renting or lending telephones in pairs to individuals for local communication. The telephoning was all done over a single iron wire connecting the two instruments with grounded return circuits. There were no switchboards to afford communication among a number of users, calling devices were extremely crude and transmission was uncertain and poor at best.

In 1878 the first telephone switchboard for commercial service was placed in operation at New Haven, Conn., with twenty-one subscribers. Those interested in introducing the Bell telephone to public use early adopted the permanent policy of leasing telephones instead of selling them, and granted licenses to authorized agents or licensees for the commercial development of the telephone business in many parts of the United States. These licensee agencies gradually developed into local exchange systems and ultimately into local operating companies. The owners of the telephone patent early incorporated their business, and funds were raised for its progressive development, under the leadership of Theodore N. Vail, who became General Manager in 1878. Within ten years after the issuance of the Bell patent the Bell Telephone System had attained an organization approximating its present form. The local systems were gradually brought together into regional companies operating throughout a state or several states. The telephone systems of these regional companies were linked together by long distance circuits operated by the American Telephone and Telegraph Company. This company was originally formed to build and operate the long lines as a subsidiary of the American Bell Telephone Company, which had become the parent company of the Bell System by acquiring the ownership of the Bell patents and purchasing stock in the regional telephone companies. Later the American Telephone and Telegraph Company exchanged its stock for that of the American Bell Telephone Company and became the parent company of the Bell System.

Growth of the Business.—Following the expiration of the basic telephone patent, a large number of so-called "independent" telephone companies, not affiliated with the Bell System, were established all over the country. In many cases these companies brought telephone service to places in which the Bell System did not operate. Some, however, engaged in competition with the Bell telephone companies in their localities; and it required actual experience of the inconveniences of telephone competition to convince the public of the fact that two telephone companies in a single community are a source of annoyance and unnecessary expense to the telephone-using public. The fact that one had to subscribe for both of the competing telephone services in order to be in communication with all of the telephone subscribers in the locality finally resulted in a popular demand for the unification of the telephone service. In many communities competing telephone systems were consolidated. Other independent companies were afforded facilities for physical connection with the lines of the Bell System. The linking up of these local telephone systems, which are now known as "connecting companies," makes possible interconnection among more than 99 per cent. of all the telephones in the United States. Subscribers of the Bell telephone companies and of the connecting companies are thus alike afforded access over the long distance lines of the Bell System to almost any other telephone anywhere in the United States as well as to other countries in North America and overseas.

On March 31, 1929 the twenty-four Associated Companies, which with the American Telephone and Telegraph Company make up the Bell System, owned and operated 14,784,000 telephones and 6,242 central offices. In addition, the connecting companies, which number nearly 8,300 besides more than 30,000 Bell connecting rural lines, owned and operated 4,670,000 telephones and 13,065 central offices. There were also in the United States at that date 142,000 telephones owned and operated by companies not affording physical connection with the Bell System. The total investment in telephone plant and equipment in the United States was, on March 31, 1929, over $3,850,000,000, of which $3,415,000,000 represented the investment of the Bell System. During the year ending March 31, 1929, the Bell System traffic averaged daily 57,448,000 exchange conversations and 2,902,000 toll conversations, a total of 60,350,000. In addition, the connecting and non-connecting companies transmitted a daily average of 17,900,000 exchange conversations and 370,000 toll conversations, a total of 18,270,000 conversations. The grand total of telephone messages for the United States during that year was more than 78,000,000 completed conversations a day. About 415,000 persons are employed by the telephone industry in the United States, of whom 350,000 are employees of the Bell Telephone Companies. In addition, some 65,000 are employed by the Western Electric Company, which manufactures standardized telephone equipment and apparatus for the Bell System. The Bell Telephone Laboratories, Inc., which conducts research along lines connected with every phase of the electrical transmission of speech, employs a total of about 5,100 people.

DEVELOPMENT AS TO USE

The telephone industry in the United States has attained its present development in response to a rapid and sustained growth in public demand for telephone service throughout the country. This is illustrated in the following table showing the increase in the total number of telephones in the United States since 1877:

Telephone Development in the United States

End of year	Number of telephones	Telephones per 100 population
1877	2,600	0·005
1880	47,900	0·09
1885	155,800	0.27
1890	227,900	0·36
1895	339,500	0.48
1900	1,355,900	1·76
1905	4,126,900	4.85
1910	7,635,400	8·19
1915	10,523,500	10.39
1920	13,329,400	12·43
1925	16,935,900	14.76
1927	18,523,000	15·79
1928	19,341,000	16.32

This growth is evidence of the extent to which the American people have acquired the "telephone habit." In rural sections the telephone has mitigated the discomforts of life in isolated farm houses, and is of assistance in marketing.

The usefulness of the telephone is largely increased by the fact that it has become almost universal, so that practically any point can be reached by telephone. Business concerns find it profitable to make the telephone service an integral part of the organization for the administration of their business, thus keeping their main offices in direct, constant touch with branch establishments and travelling representatives, and making systematic use of the telephone in sales campaigns. The uses of the telephone for business, social and other purposes are, of course, too numerous to be mentioned in detail. In newspaper work, in connection with police and fire protection, in train dispatching, in the operation of taxicabs, in finance, in personal shopping, the telephone is filling an ever wider field of usefulness. It is said that New York brokerage houses do more than 75 per cent. of their business by telephone.

TELEPHONE PLANT IN THE UNITED STATES

The term "telephone plant" includes (1) the telephone apparatus and wiring at the subscribers' premises; (2) the central office switching equipment (with the buildings that contain it) for interconnecting subscribers' lines; and (3) the aerial and underground wires and cables with their pole lines and conduits, which connect the subscribers' stations with the central offices and the latter with each other, whether they be in the same city or in different cities. This plant makes it possible, at the present time, for any user of the telephone service to be connected promptly with any other station of the telephone system, and to converse easily, by electrical means, with the person called, after the connection is established, regardless of distance. The systems which enable this nation-wide service to be rendered are necessarily complex and intricate and they include a multitude of auxiliary devices and appurtenances. The following brief description deals only with the principal kinds of telephone plant.

Plant at Subscribers' Stations.—This includes the sets (of either the "wall" or "desk" pattern); receivers, transmitters, and induction coils; bell boxes, coin boxes, paystation booths and also the private branch exchange switchboards, such as are found in hotels, department stores and large mercantile establishments.

Substation Sets.—There are three types of telephone sets in general use: (1) the "wall set" (Plate I., fig. 4) adapted for attachment, at convenient height, on the wall of a room; (2) the "desk set" consisting of a pedestal, rising from a substantial base, and supporting the transmitter, and the receiver hung on a switchhook; (3) the "hand set" (Plate I., fig. 5) in which a transmitter and a receiver, of suitable design, are attached at opposite ends of a handle. This unit normally rests on a cradle surmounting a circular base. Both "desk" and "hand" sets are provided with flexible connecting cords so that they are movable within the limits fixed by the length of the cord. With them is used a bell box, usually mounted beneath a desk or in some other inconspicuous place, containing the call bell, induction coil and other auxiliary apparatus. For carrying on the telephonic conversation, two instruments are required, the transmitter and the receiver. The former converts the speech waves in the air into their electrical replicas on the wire; the latter performs the reverse operation of converting electrical speech waves into sound waves in the air.

At first, a single instrument, placed alternately to the mouth and the ear, was used for talking and listening. Shortly, however, it was found desirable to provide each subscriber with two identical instruments, one (the receiver) to be used for listening, the other (the transmitter) to be used for talking. Bell's first instruments required a battery in the circuit, but the instruments that were first employed commercially had permanent magnets and the speech currents were generated by the motion of the diaphragm.

The Receiver.—Although the basic scientific principle of the modern telephone receiver follows the original invention of Bell, the structure and design of the instrument have been changed in every essential feature and its efficiency has been greatly increased as the result of continuous experimentation and development work. An early commercial type of receiver was known, from its shape, as the "butter stamp." To the end of a permanent magnet was attached a soft iron pole-piece on which was wound a coil of insulated, fine wire. A circular diaphragm of iron, supported by the case or shell of the instrument, was placed with its center close to the end of the pole-piece, but not in contact with it. Speech currents, passing through the winding, varied the attraction of the permanent magnet for the diaphragm, causing the latter to vibrate and produce sound waves in the air corresponding to the speech currents.

Plate I., fig. 2, shows a cross-section of a type of receiver now widely used in the United States. Among the improvements embodied in it are a bipolar magnet with two pole-pieces and windings, welded construction, dust-proof case, special kinds of steel, accurate spacing of diaphragm and pole-pieces and, throughout, the most effective proportioning of its parts. These features collectively have resulted in increasing its efficiency and the naturalness of its reproduction of the voice.

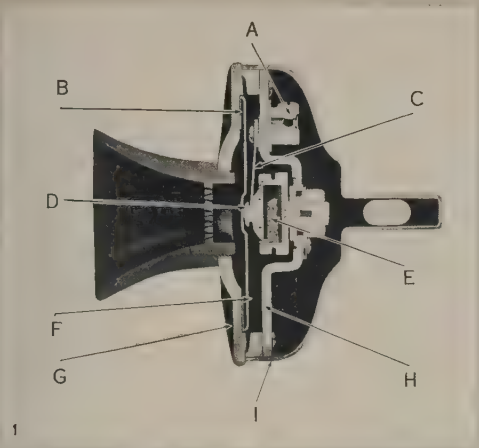
The Transmitter.—The transmitters first used were of the magneto type, similar to receivers, but Bell himself early pointed the way to improvements by his liquid transmitter which contained the principle of the variation of the electrical resistance of the transmitting element under the control of the vibrations of the voice. Important improvements in the transmitter came from the use of the principle of the microphone, employing variable resistance contacts in a battery circuit. Following the Berliner and Edison transmitters of 1877 based on this principle came the Blake transmitter, an improved type, introduced into the Bell System in 1878. These early instruments were superseded by the granular carbon type, growing out of an invention by Hunnings and employing a variable resistance element consisting of a small chamber filled with granules of carbon. The "solid back" type, an improved form of granular carbon transmitter and a prototype of modern instruments, was the invention of Anthony C. White. Scientific research has been continuously, and still is, directed toward the further improvement of transmitters. Plate I., fig. 1, shows a cross-section of a modern telephone transmitter.

Substation Wiring Plans.—In the case of business offices and residences, additional telephone facilities in great variety, beyond the scope of a single set, are frequently employed to meet the ever-increasing requirements of modern life. "Extension" telephone sets, connected with the substation line, enable calls to be originated or received from different points in the subscriber's residence or place of business. By pressing a button, an extension telephone may be cut off when desired and, where several stations, and more than one line are provided, any one of the stations may be connected to any one of the lines. In some cases, means are provided whereby a secretary may answer calls on either of two lines and, by suitable switch keys, perform various operations such as holding a call on one line while the principal is talking on another. Many combinations of master stations, control stations and extension bells in combination with one or more lines are available for the telephone user.

Private Branch Exchanges.—A "private branch exchange" is a switchboard, generally of small size, located at the subscriber's premises. To it are connected the substation sets of the subscriber's establishment and it is connected with the central office switchboard by a sufficient number of trunk lines to handle the traffic. Plate I., fig. 3, shows a private branch exchange switchboard for a small number of stations and trunk lines. This is capable of being placed on a desk and operated by a clerk who may also perform other duties. With this equipment all of the operations of connecting and disconnecting the local stations with each other and with the central office are performed by means of switch keys. Larger private branch exchanges resemble small central office switchboards, and require the attendance of one or more operators. Private branch exchanges are also available which operate in a manner similar to the dial central offices to be described later.

Central Office Switching Equipment.—To enable telephone conversations to take place, two substations must be connected together by a pair of wires constituting an electrical circuit called the "line." If each person having a telephone wished only to talk to one other person and never to any others, the telephone plant would be very simple. Its complications arise from the necessity for connecting together and providing a satisfactory talk between any two of more than 19 million stations in the United States. This is a very important aspect in which telephone service differs from such services as water supply, gas and electric light and power, where each customer satisfies his demands by drawing what he needs from a set of mains, and the demands of other users do not normally affect his own service.

To the central office switchboard runs one line (ordinarily one pair of wires) from each telephone individually served. The switchboard must provide means, such as tiny electric lamps, one associated with each line, whereby the calling party can signal the operator when he removes his receiver from its switchhook to originate a call; means such as a cord and plug and listening key whereby an operator can connect her telephone set momentarily to the calling party's line to receive the call; means such as the multiple and out-going trunk jacks to enable the operator to connect the calling party's line with the line of the person with whom he wishes to talk, whether that line be connected to the same switchboard as is his own, or to some other switchboard in the same city, or whether it must be reached over a trunk line to some suburban point or over a "toll" or "Long Distance" line extending to some remote city or town; means for determining whether the line called for is already in use, or "busy"; means for ringing the bell at the called station and, finally, when signals indicate that the conversation is ended, means for restoring all circuits to a state of readiness for another call. Switchboards may be either manually operated or of the "dial" type. The general



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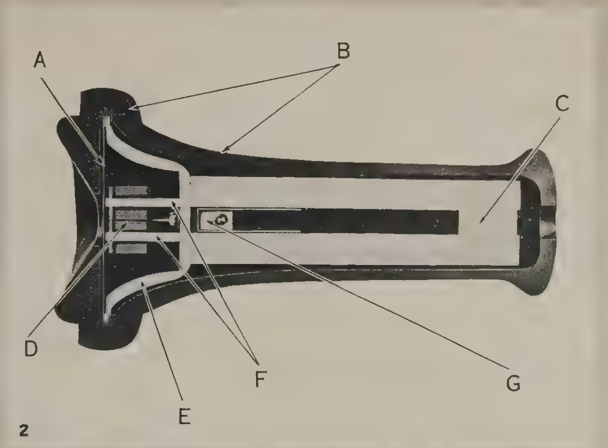

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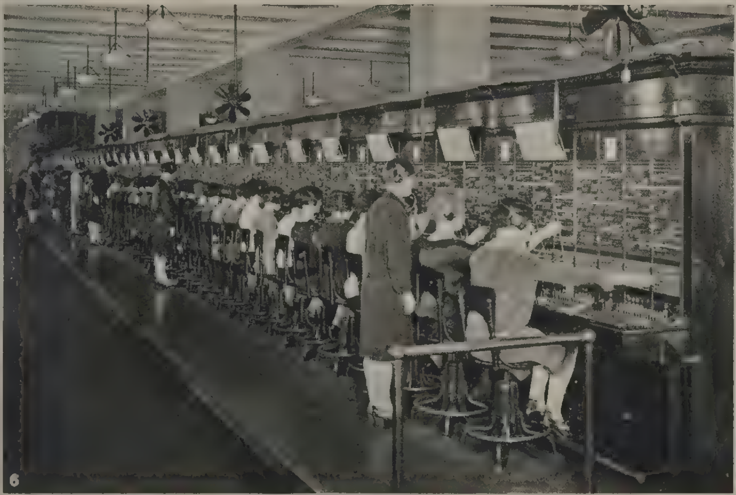

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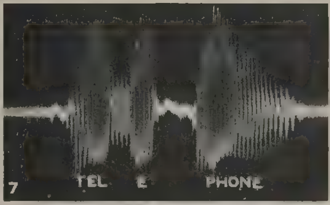

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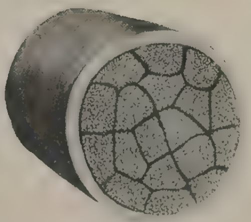

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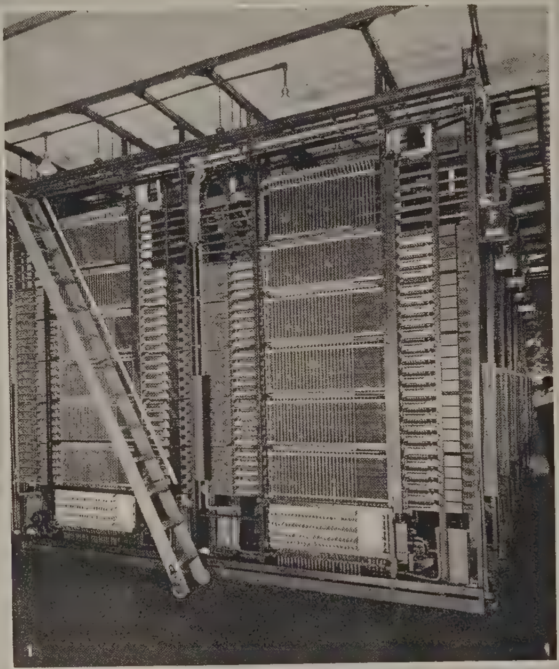
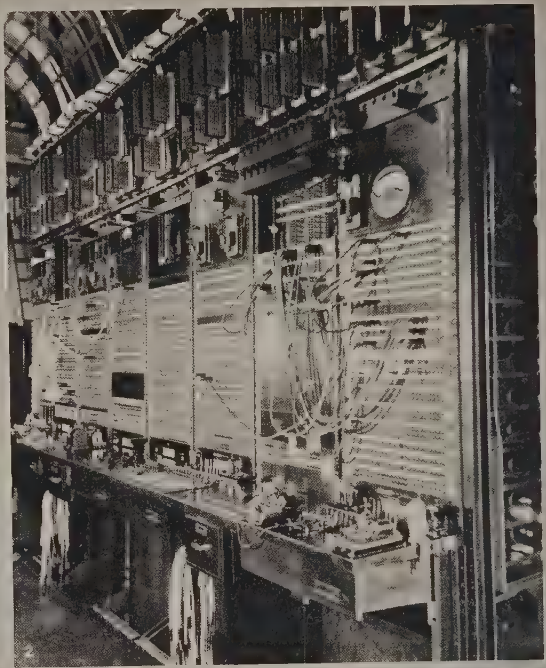
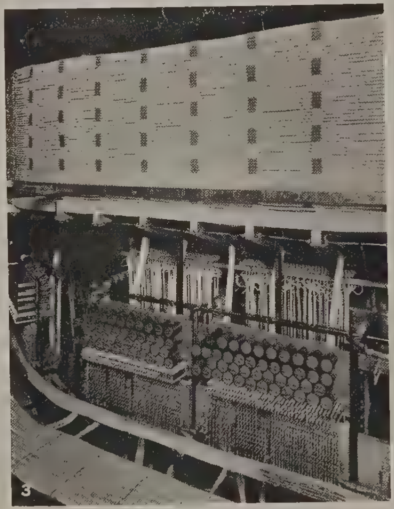
BY COURTESY OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY

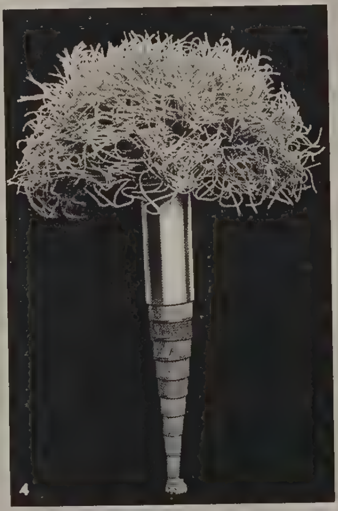
TELEPHONE APPARATUS

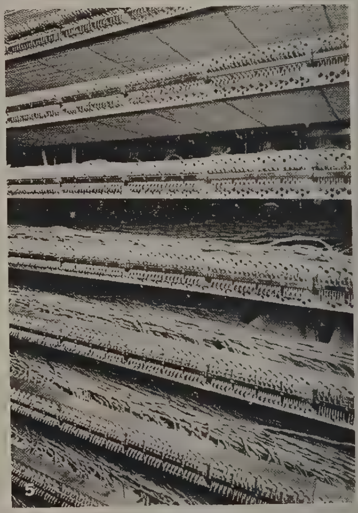
1. Cross-section of telephone transmitter. A. Current carrying terminals; B. Muslin washer; C. Central damping spring; D. Mica disc; E. Carbon granules; F. Aluminium diaphragm; G. Brass face plate; H. Galvanized steel bridge; I. Brass bell. 2. Cross-section of telephone receiver. A. Iron diaphragm; B. Hard rubber case and cap; C. Magnet; D. Coils; E. Brass cup; F. Magnet pole pieces; G. Binding posts. 3. Small cordless private-branch-exchange switchboard. 4. Automatic wall telephone set showing dial. 5. Hand telephone set with dial. 6. Part of telephone central office showing section of manually operated switchboard. 7. Photographic record of electrical undulations in a telephone circuit. 8. Subscribers' multiple unit cable, consisting of 18 units of 101 pairs of 26 gauge wires each







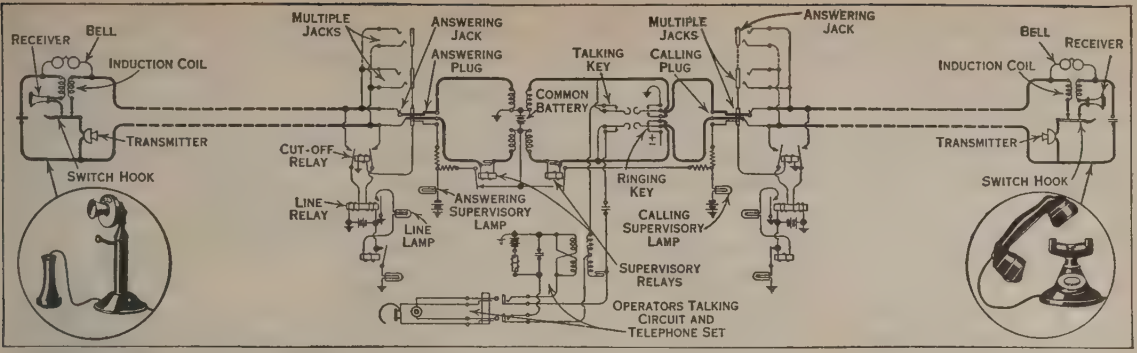




BY COURTESY OF THE NEW YORK TELEPHONE COMPANY

TELEPHONE EQUIPMENT AS USED IN LARGE AMERICAN CENTRAL OFFICE

1. Interior of panel dial office showing frames containing subscribers' multiple terminals and associated selecting apparatus
2. Cable repeater office. Oscillator, and toll test board for telephone and telegraph repeaters
3. Rear view of manually operated switchboard. The heavy cabling at the top is the subscribers' multiple. One of these switchboards may require as many as 120 operators, and frequently contains as much as 4,000 miles of internal wiring, and as many as 2,000,000 soldered connections
4. View of 1,200 pair of subscribers cable fanned out to show wires
5. Section of main distributing frame by means of which the subscribers' lines are connected with the switchboard. It shows the wires cross connecting between incoming cable pairs and interior cable going to the switchboard



BY COURTESY OF THE AMERICAN TELEPHONE AND TELEGRAPH CO.

FIG. 1.—SCHEMATIC DIAGRAM OF TELEPHONE CONNECTION IN COMMON BATTERY EXCHANGE

When the subscriber (left) removes his "Receiver" from the "Switchhook" an electrical circuit is completed through his set, the "Line Relay" and the battery at the Central Office (the several batteries shown are actually one common storage battery). The armature of this relay closes the circuit through the "Line Lamp" associated with his line, causing it to glow and attract the operator. She inserts the "Answering Plug" in the subscriber's "Answering Jack" and by operating the "Talking Key" is enabled to talk with him. Ascertaining the number desired, she touches the tip of the "Calling Plug" to the sleeve of one of the "Multiple Jacks" associated with the line having that number. If the line is "not busy" she inserts the calling plug and uses the "Ringing Key" to call the subscriber. The heavy lines show the paths of the voice currents in the completed connection. The "Cut-off Relay" disconnects the line relay from across the line when a plug is inserted in either the multiple or answering jacks. "Supervisory Lamps" are controlled through the "Supervisory Relays" by the position of the subscriber's receiver or handset. In the circuit shown both lamps are dark showing that the subscribers have their receivers off and are talking. When both supervisory lamps light she knows the conversation is finished and will take down the connection by removing the plugs from the jacks

functions of the dial system are similar to those of the manually operated system, the electro-mechanisms of the former, however, being so contrived that most operations, instead of being performed by human operators, are completed by means of switches set in operation and controlled by the electrical impulses which are sent over the line from the substation dial.

There are certain limits to the number of telephones which can be given service advantageously on one switchboard. One of these is the economic limit which indicates that, in order to keep down the length and cost of the lines connecting the telephones with the central office, the subscribers' stations in certain conveniently sized areas should be grouped to one central office in each area and the several central offices interconnected by trunk lines. The locations for the central offices, the boundaries of their areas, the type of switchboard to employ and the character and number of the trunk lines are all matters requiring careful study and intricate planning. To reach the smaller central offices, in outlying sections of a large city, from central offices in a distant portion of the city, it is sometimes desirable to use two or more trunk lines connected in "tandem" by the various operators at the points between the two offices.

Historical.—The first telephone switchboard was put into service in New Haven, Connecticut, on January 28, 1878, and provided primitive means for accomplishing the fundamental operations of interconnecting substation lines. It served 21 stations on eight grounded lines. In contrast, Plate I., fig. 6 shows a large manually operated switchboard in use in 1928. Such switchboards as this are capable of serving perhaps 20,000 telephones on 10,000 lines and may require as many as 120 operators on duty at the busiest period of the day. One of these large switchboards takes over a year to build and install. It will frequently contain as much as 4,000 miles of internal wiring and as many as two million soldered connections. Plate II., fig. 3 is a rear view of a section of this kind of switchboard and Plate II., fig. 5 shows the "main" frame by means of which the subscribers' lines are connected with the switchboard.

The electrical circuit of the manually operated common battery switchboard is shown diagrammatically in fig. 1, its operation being explained in the text below the figure. Switchboards employing electrical mechanism, controlled by dials at the subscribers' stations, to replace human operators as far as practicable, have come into wide use both in the United States and elsewhere. This "dial" apparatus is the subject of a subsequent section. The "multiple" principle was an important step in the evolution of the modern type of switchboard. It is employed in dial as well as in manually operated switchboards. As the telephone business grew, the number of subscribers which a single operator could serve was soon exceeded. For a time the situation was met by providing trunk circuits from one operator to another, but this reduced the speed of service. The invention of the multiple principle relieved this condition by permitting any one of the operators at a switchboard to establish a connection directly between any subscriber whose line she served and any other subscriber connected with the switchboard.

In the multiple system, a "jack" or switch for every line is placed within the reach of each operator at the switchboard. In practice this means one multiple jack per line for every three adjacent operators. With the provision of this increased facility for interconnecting subscribers' lines, it became necessary for the operator to know whether or not a line, with which connection was desired, was already in use through a connection made at some remote part of the switchboard. The method and means for determining the condition of the line is known as the "busy test." Its invention was a necessary accompaniment to the use of the multiple principle. To accomplish the busy test the operator touches the "sleeve" of the jack with the "tip" of a connecting plug. If the line is busy, a click is heard in the operator's receiver. Plate II., fig. 3, shows the rear of a multiple switchboard; the upper part of the cabling is that used to carry the "multiple" of subscribers' lines through the switchboard.

For many years batteries were required at each subscriber's station to furnish the current for actuating the transmitter. An important forward step was the development of the common, or centralized battery, system of operation in which a storage battery at the central office overcame the necessity for local batteries at the individual substations. The common battery system also provided a way by which the subscriber could signal the operator merely by removing the receiver from its switchhook, thereby lighting a tiny electric lamp associated with his line at the switchboard. Before this system was devised and perfected, the subscriber signaled the central office by turning a crank that caused a small electrical generator to send a current over his line which operated an electro-mechanical annunciator or "drop" at the switchboard. Improved forms of the latter system, known as the "magneto," are still advantageous for use in small communities.

Buildings.—While, in small communities, telephone central office equipment is frequently installed in rented quarters, in the larger places the requirements of the service usually make desirable the erection of buildings specially adapted for telephone purposes. The headquarters buildings, located in the larger cities, generally house not only the central administrative forces of the telephone company, but often several central office switchboards.

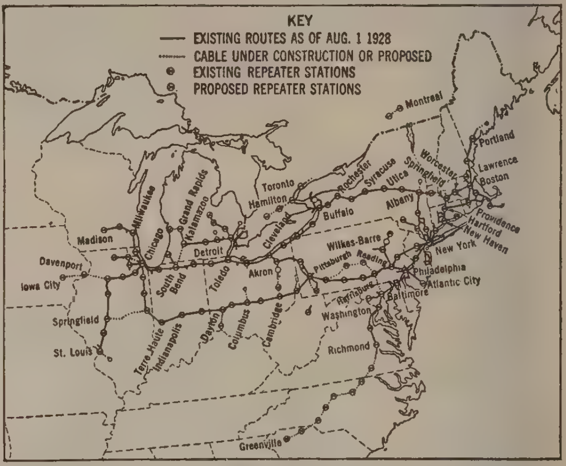
Telephone Lines.—Telephone lines connect (1) each telephone to a central office; (2) each central office in a city to every other central office in that city; and (3) all cities, towns, villages and community centres, by means of a vast network of wires. These wire lines are of two forms—cable and open-wire. Cable consists of insulated copper wires, twisted in pairs and assembled into a core which is covered with an envelope of lead alloy. Ninety per cent. of the telephone wire mileage in the United States is in cable placed either in ducts beneath the streets or suspended aerially by means of steel rope attached to poles. Open-wire lines consist of bare wires, generally of copper, attached to glass insulators supported on pins in crossarms attached to the tops of poles. The lines in a city area may be divided into two classes: (1) Subscribers' lines connecting the subscribers' stations to a central office and (2) trunk lines which connect the offices together. In a typical city installation, a rubber covered pair of wires, known as the "drop" wire, runs from the subscriber's premises to a cable terminal. In densely built blocks the connection is frequently made by wires attached to the walls of buildings. From the cable terminal, the line is continued toward the central office in a small cable, often containing 25 or 50 pairs of wires and known as "block" cable, which connects with the larger "feeder" cables that run as directly as practicable to a central office. In densely built areas the feeder cables are generally placed in underground ducts; elsewhere they are placed overhead.

As the result of the cable development work described in a later section, telephone cables containing many hundreds of pairs of wires are now available and are employed in the more congested districts. Plate I., fig. 8 shows a cable, of the type used for main feeder routes, containing 1,818 pairs of 26-gauge wires. The installation of the subscribers' cable distribution plant, consisting of block cables, and main and subsidiary feeder cables is preceded by a careful engineering study of the present and probable future demand for telephone service in order that the plant may be so planned as to enable these demands to be adequately met.

Trunk cables usually contain larger wires than subscribers' cables. In large metropolitan districts, where there are many central offices, the number of trunk circuits required is very large; sometimes as high as one trunk circuit for each eight subscribers' lines. Trunk routes are usually "double-tracked," *i.e.*, two groups of circuits (one for traffic in each direction) are ordinarily required between each pair of central offices, except where tandem or intermediate switching is employed. To provide adequate transmission efficiency in the case of the longer trunk circuits, it is frequently economical to "load" them, as described in a subsequent section. The loading coils are contained within large iron cases. The cable pairs used for subscribers' line distribution and inter-office trunking form the great bulk of the 70 million miles of wire used for telephone purposes in the United States.

Toll and Long Distance Lines.—Until comparatively recently, the toll and long distance plant was composed largely of open-wire lines, the largest size of hard drawn copper wire employed being 165 mils in diameter, weighing 435 pounds to the mile. Within recent years, radical improvements in the telephonic art have permitted the use of long intercity cables in increasing amounts until, at the present time, fully two-thirds of the toll and long distance wire mileage is in cables which cover important backbone routes. Fig. 2 shows present and proposed routes in north-eastern United States. One of the first of these long intercity cables was placed in service in 1906, between New York City and Philadelphia. In 1913 an underground cable was provided between Boston and Washington to care for the rapidly increasing traffic and to insure service under such weather conditions as might affect open-wire lines adversely. This cable was equipped with loading coils. It provided a storm-proof route along the northern Atlantic coast. Many of the more recent long cables shown in fig. 2 have been of the aerial type except where passing through urban areas. They have combined the use of loading coils and telephone repeaters and, for the longer distances, so-called "four-wire" circuits have been used in which a separate pair of wires is utilized for transmission in each direction.

The sheath of a typical long cable is about $2\frac{5}{8}$ in. in outside diameter. The conductors placed in such a cable are usually either 51 mils in diameter, weighing 41 lb. to the wire mile or 36 mils in diameter, weighing $20\frac{1}{2}$ lb. In the construction of this type of cable, two wires, each insulated with dry paper, are first twisted together to form a "pair." Then two of these pairs are twisted together to form what is termed a "quad." Each quad furnishes three talking paths:—two "physical" circuits and one "phantom" circuit, the latter resulting from a combination of the two physical circuits. Approximately 140 of these quads formed together and enclosed in a metallic sheath make a full-sized cable which, in a typical case, furnishes about 300 telephone circuits and an equal, or even greater, number of telegraph circuits. The cable is attached to a steel wire strand of high tensile strength strung on short stocky poles. Nothing short of a storm of most unusual severity can interrupt service with construction of this type. In passing through cities, the cable is usually placed in underground ducts. Loading coils are connected in each telephone circuit a little over a mile apart and, at intervals of about 50 miles, "repeater" stations for amplifying the speech currents are placed along the route.



BY COURTESY OF THE AMERICAN TELEPHONE AND TELEGRAPH CO.

FIG. 2.—MAIN TOLL CABLE ROUTES IN THE NORTH-EAST SECTION OF THE UNITED STATES

EXAMPLES OF IMPROVEMENTS

Many times during the more than 50 years that have elapsed since the invention of the telephone, scientific research and engineering development have not only found the way out of difficult situations which threatened to hamper the growth of telephone service but, in advance of immediate needs, they have often created new instrumentalities which, in turn, have led to further extensions and improvements of the service.

Cables.—Telephone cables not only provide the sole means for placing a large number of telephone circuits compactly either overhead or underground, but they enable the lines to be carried across the beds of rivers and other waterways. In the cables first employed, single wires with a ground return were used and the wires were insulated with either gutta-percha or rubber. It was soon found, however, that such cables were not well suited for telephone purposes. After experiments with many kinds of insulating materials it was found that dry paper was the best for telephone cables. This discovery and the concurrent development of means for encasing the paper insulated wires in a metallic sheath or tube which protected them from moisture laid the foundation for the modern telephone cable. Research and development covering many materials and processes have made it possible gradually to increase the number of pairs of wires, in a full-sized cable for subscribers' lines, from a maximum of 50 in the year 1888 to 1,800 in 1928. This progress has resulted in a greatly increased effectiveness of utilization of the space in underground ducts in addition to other marked advantages, including a reduction in the cost per mile of cable pair (including ducts) to less than one-tenth of its cost in 1888. The increase in the number of pairs in a single cable has been accompanied by a reduction in the size of the wires, those used in the 1,800-pair cable, for example, weighing only about 4 lb. per wire mile, while those used in the 50-pair cable, of 1888, weighed about 25 lb. per wire mile. Such fine wires could not be used had it not been for improvements in many other parts of the telephone plant, such as transmitters, receivers and coils. Plate II., fig. 2 shows a 1,200-pair subscribers' cable with its wires fanned out. The design, manufacture, laying and splicing of cables, as well as the choice of a type to meet a given set of conditions, have required a large amount of engineering study. A typical problem has been the prevention of "cross-talk," or overhearing, between the pairs necessarily placed close together in a large cable. This has been accomplished by twisting the wires together according to various plans.

Loading.—For some time prior to the year 1900, it had been known to those technically skilled in the art of telephony that the transmission efficiency of long telephone circuits could be improved by increasing their electrical property known as the "uniformly distributed inductance." This knowledge did not, however, lead to practically beneficial results because no one was able to suggest any feasible method of increasing this property of a telephone circuit without bringing in, at the same time, difficulties of one kind or another which were fatal. Numerous investigators sought unsuccessfully to simulate the beneficial effect of increasing the uniformly distributed inductance by introducing, into the circuit, inductance concentrated, or lumped, in the form of coils. It was reserved for Professor Pupin of Columbia University to discover, in 1900, that the proper spacing of the coils along the telephone circuit was the key to the solution and it was from failure to establish this that earlier workers had failed.

The term "loading" comes from the mechanical analogy of a "loaded" string, the study of which was utilized in developing the theory of electrical "loading." When a series of small weights was placed at intervals on a string it was found that mechanical waves, produced in the string, did not die out as quickly as when the string was not weighted. The mechanical loading reduced the dying out of the waves in the string and the analogous electrical loading reduces the attenuation of the waves of speech current in the telephone circuit. It makes the line a better path for electrical waves. To indicate its practical value, it can be stated that, under favourable circumstances, a loaded cable circuit is as good a conductor for telephonic currents as would be a non-loaded circuit of conductors weighing about eight times as much.

Loading, in telephony, is accomplished by inserting coils of wire, wound on toroidal iron cores, into the telephone line at regular intervals. In addition to reducing the attenuation of the electrical waves, loading has another beneficial effect. Telephony requires the transmission of waves having frequencies ranging from about 200 cycles per second to more than 2,000 cycles per second. Plate I., fig. 7, is a photograph of an oscillogram showing the electrical waves produced when the word "telephone" was spoken into a transmitter. Good voice reproduction from the receiver requires that the complex wave shape of speech, including the entire "band" of frequencies, must be transmitted over the line with as little distortion as possible. Loading assists to an important degree in accomplishing this. The principal fields of application for loading are (1) in the case of the longer trunk circuits interconnecting the central offices in the larger cities and (2) in association with telephone repeaters permitting the use of cables, instead of wires spread out on crossarms, for the groups of circuits that link distant cities together.

The latest improvement in loading coils is the result of a basic scientific discovery by G. W. Elmen, in the Bell Telephone Laboratories, of a material called "permalloy" having new and unusual magnetic properties peculiarly suited to the requirements of telephony. The permalloy used in the cores of loading coils is an alloy of about four-fifths nickel and one-fifth iron, specially heat treated. The use of this material has made possible not only a reduction in the size of loading coils to about one-third of their previous size, accompanied, in spite of the more expensive material, by a reduction in cost, but also, due to the reduction in size, smaller cases can be used to contain the coils, resulting in space economies in the underground vaults.

Repeaters.—As the telephonic currents pass over the line, they decrease in strength so that, after travelling a distance which varies with the character of the line, they become too weak to actuate properly the telephone receiver. The idea of inserting one or more repeaters in a line for the purpose of reinforcing the telephonic currents from some local source of energy is almost as old as the telephone itself, but many years elapsed before the quest for a satisfactory repeater culminated in success. The solution of this problem involved the production of a repeater element which, when actuated by weak telephonic currents, is capable of emitting greatly strengthened currents without appreciable loss in the clearness of voice transmission. A so-called "mechanical" element was first used but this presented inherent limitations owing to the mechanical inertia of the moving parts. A satisfactory solution of the problem was found by improving and utilizing the three-electrode vacuum tube in which the weakened speech currents control a local source of energy by means of a practically weightless stream of electrons. The three-electrode vacuum tube of De Forest, prior to its development for use in telephone repeaters, was employed for radio telegraph reception. In the form in which it was used for that purpose it was found to be quite unsuited to meet the rigid requirements of telephony. A large amount of research and development work was required before a satisfactory tube could be produced. The continuing work on the development of tubes has involved the fundamental study of electronic emission from heated filaments together with the study of proper materials and dimensions for the elements of the tube, means for securing a high vacuum and other necessary conditions.

To illustrate the progress that has been made it can be stated that the life of the vacuum tube most commonly used in 1917 was about 1,000 hours. Tubes of a new type first introduced in 1927, have a life of fully 25,000 hours, which is equivalent to about three years of continuous operation. In addition, the first cost was reduced by more than one-half and the power required to heat the tube filaments was also reduced to less than one-half of that required in 1917. The amount of testing needed to secure good operation was likewise decreased. As an indication of the extent to which repeaters are used in the telephone plant in the United States, there were more than 90,000 vacuum tubes in use for this purpose at the end of 1928, and it is estimated that 90,000 more will be placed in service during 1929. The repeater element would have been of little use without the concurrent development of efficient and convenient circuits and auxiliary equipment to enable the repeater element to be associated properly with the line circuits. This problem was partially solved as early as 1904 when an elementary form of mechanical repeater was first used commercially. The development of a satisfactory repeater has carried with it the necessity for extensive investigations of the characteristics of telephone lines in which the repeater must work. Not only must the electrical characteristics of the line be accurately known but the use of repeaters has a bearing on the type of line circuit selected and on the type of loading employed. A long cable with its repeaters, loading, associated switchboard apparatus, echo suppressors and temperature controlled transmission regulators must be engineered as a unit in order to obtain the best overall results.

Dial Telephones.—As progress was made in the improvement of manually operated switchboards, the tendency was constantly toward the substitution of automatic devices for human labour. The accomplishments in this direction became more marked after the introduction of common battery operation with lamp signalling. After a time, so much progress in this direction had been made that the question began to be raised whether ultimately in large cities it might not be possible to eliminate the operator entirely by the substitution of electrically controlled machinery. The development of automatic switching has paralleled that of other forms of switchboard. Basically, all forms of automatic switching involve the substitution of electrical impulses for the voice of the subscriber in making known his desires and the use of electrical machinery instead of human operators at the central office as the means for interpreting these desires and performing the desired switching operations. Modern panel type automatic switching equipments such as are employed in great metropolitan areas are so complex as to require the concentrated attention of specialists for their comprehension. All that can be attempted here, therefore, is merely an outline of some of the major steps. U.S. patents covering an automatic switching system were first applied for in 1879, but the system which they described never became a commercial success. In 1889, however, A. B. Strowger, invented a system which was subsequently improved by others and is used successfully at the present time under the name of "step-by-step" system. Other automatic systems containing important features contributing greatly to the success of automatic switching appeared both in America and abroad.

The Bell System became actively engaged in the development of automatic switching equipment prior to 1900. In its desire to perfect and simplify the operation of switching in every practicable way, it sought to determine fundamentally the type of machinery best suited to the needs of a universal service. As a result of protracted and searching inquiry, a large installation of automatic equipment was made in 1914. In this, the central office equipment was of the so-called "panel" type. The installation was designed not as a final test of a complete automatic system but as a trial on a large scale of the efficacy of the machinery which seemed most likely to give the desired results when applied to a complete automatic system. In this trial, the subscribers called the operators in the usual manner but from the operator onward, the connection was completed entirely by the use of automatic switches. As a result of this and subsequent modifications, the details of the panel system were perfected. The first exchange giving complete automatic operation with panel type switches was installed in 1921.

Since that time, the application of dial telephones has grown rapidly until in 1929, about 19 per cent. of the telephones in the United States are operated on a dial basis, through either panel or step-by-step switches. Plate II., fig. 1, shows a portion of dial operated central office equipment. Before dial systems could be widely employed they not only had to work properly within themselves, but means had to be devised whereby they could also be made to work successfully in conjunction with existing manually operated systems.

The foregoing are but a few of the many improvements brought about by development and research. Among others may be mentioned "carrier" telephony, by means of which more than one telephone conversation can be carried on simultaneously over a single line; transatlantic telephony by means of which service is now possible between America and large portions of Western Europe; and telephotography, which enables pictures to be reproduced at distant points.

Extension of Long Distance Communication.—The first "long distance" conversation took place in 1876 over a line two miles in length between Cambridge and Boston, Mass. Conversation by telephone became possible in 1880 between Boston and Providence, R.I., and in 1884 between Boston and New York. The long distance lines reached Chicago in 1892 and in 1911 were extended to Denver, Colo. Salt Lake City was connected with the Eastern Seaboard in 1913. In 1915 the first transcontinental telephone line was opened between New York and San Francisco. As public demand for long distance service grew greater, a second line across the country became necessary and in 1923 a southern transcontinental line was opened to service through New Orleans, La., and El Paso, Tex., to Los Angeles, Calif. A third line across the continent was opened in 1927 by way of Minneapolis, Minn., to Seattle, Wash., and Portland, Oregon. The reliability of the long distance telephone service has been substantially enhanced of late years by the placing of many of the important lines in aerial or underground cables which are practically storm-proof. Out of a total of about 63,515,000 miles of Bell System telephone wire on March 31, 1929 (consisting of 54,448,000 miles of exchange wire and 9,067,000 miles of toll wire), 66%, or 41,908,000 miles, was in underground cable; about 27%, or 16,937,000 miles, was in aerial cable; and the remainder, 4,670,000 miles, was in open wire.

A large part of the most highly industrialized section of the United States is now covered by the spreading network of telephone cables shown in fig. 2. One cable extends from New York to St. Louis, by way of Chicago, and an additional cable has also been placed in service between New York and Cleveland, Ohio. Telephone messages can now be transmitted through cable from Portland, Me., in the northeast, to Madison, Wis., in the northwest, 1,371 miles; to St. Louis, Mo., in the west, 1,538 miles; and to Petersburg, Va., in the south, 683 miles. The cable between New York and Cleveland when utilized to capacity provides facilities for the transmission of 250 telephone conversations and at least as many telegraphic messages simultaneously. The New York–Chicago–St. Louis telephone cable is 1,204 miles in total length, containing 1,036 miles of aerial sections and 168 miles of underground sections. Its total weight is 50,800,000 lb., and it consists of 14,205 sections, having 7,441,000 separate wire splices. The aerial sections are supported on 50,700 poles.

Chicago and New York were connected in 1928 by the following telephone cable routes:

(1) New York–Pittsburgh–New Castle–Cleveland–South Bend–Chicago.

(2) New York-Pittsburgh-Wheeling-Indianapolis-Terre Haute-Chicago.

(3) New York–Albany–Buffalo–Cleveland–South Bend–Chicago.

Canada was brought into communication with the United States many years ago. A telephone cable under the Florida Straits between Key West and Havana was opened to service in 1921, making it possible to talk between the North American Continent and Cuba. Six years later connection was made with land lines reaching the principal cities of Mexico. Transatlantic telephone service was opened to the public early in 1927 through co-operation between the American Telephone and Telegraph Company and the British Post Office. Eastbound transatlantic messages are transmitted over the land lines of the American Telephone and Telegraph Company to Rocky Point, L.I., near New York, where a powerful radio transmitting station puts them "on the air" for the long journey across the Atlantic Ocean. The message is then picked up by the British Post Office radio receiving station at Cupar, Scotland, whence it is transmitted over the land telephone lines of the British Post Office. Messages in the opposite direction are sent over the wires to Rugby, England, whence they travel 2,930 miles by radio to the American receiving station at Houlton, Me. At Houlton they are again placed on the telephone wires for transmission to their destination. The scope of this transatlantic service has gradually been extended to afford communication from all points in the United States and from Canada, Cuba and Mexico to all points in England, Scotland and Wales, and to a large part of Western and Central Europe including France, Germany, Spain, Belgium, Holland, Switzerland, Denmark, Norway, Sweden, Hungary, Austria, Czechoslovakia, Danzig, and Ceuta, Spanish Morocco, Africa. Thus three continents, North America, Europe and Africa, are now joined by the transatlantic telephone service.

TELEPHONE IN VARIOUS COUNTRIES

The introduction of the telephone and the development of the business in countries other than the United States will be briefly outlined in the following paragraphs. The post-war expansion of international telephone communications in Europe, the recent development of long distance telephone cable facilities in the various European countries, and statistics reflecting the present status of telephone development throughout the world will be presented in the remaining sections of this article.

Great Britain.—Earnest efforts were made by the early backers of the telephone in America to introduce it to use in Europe. Prof. Bell himself visited England and Scotland on his wedding trip in 1878 in the hope of developing a demand for the telephone in his native country. Queen Victoria congratulated Bell upon the success of his invention and offered to purchase a pair of telephones, but the inventor made her a present of two instruments especially done in ivory. This assisted in bringing the telephone to public attention and in 1879 the first telephone exchange was opened in London with seven or eight subscribers. Several companies were established for the purpose of introducing the telephone in various parts of the United Kingdom, but in 1880 the British courts held that the telephone system was legally a telegraph system within the meaning of the Acts of Parliament making the telegraph a monopoly of the Postmaster General. The British Post Office thereafter issued licenses on a royalty basis to several private companies, which were ultimately consolidated into a single large company. Licenses for the establishment of municipal telephone systems were also issued to a number of cities and several such systems were established.

In 1896 the Post Office bought the long distance lines throughout the United Kingdom and after that the privately owned telephone company confined its activities to the operation of local exchanges. The Post Office, however, began establishing its own local telephone exchanges in London in 1902 and these were connected with the company's system. Upon the expiration of the company's license on December 31, 1911 the Post Office acquired its entire telephone properties by purchase and now operates all telephones in Great Britain, with the exception of the municipal systems at Hull, and the Channel islands of Guernsey and Jersey. Upon the establishment of the Irish Free State the British Post Office transferred to the Free State Government its telephone system in Southern Ireland. In most of the continental countries, as well as in Great Britain, the telegraph system was already a government monopoly when the telephone was introduced. The government telegraph officials in Continental countries, apparently regarding Bell's invention as a possible competitor of the telegraphs, were therefore reluctant to encourage it. In most cases, moreover, the government officials did not feel justified in undertaking the risks of attempting to develop this new means of communication. The usual procedure, therefore, was to allow the private companies to do the pioneer work of bringing the telephone into use under licenses imposing more or less restrictive conditions. However, as the potential factors of telephone communication gradually were appreciated, most of the governments on the Continent took over the company-operated systems and the telephone service was thereafter administered as a part of the postal and telegraph system. Of later years a tendency to turn again to private enterprise for the provision of more adequate telephone facilities has been manifest in Italy, Spain and elsewhere. Motives of military preparedness unquestionably actuated government officials in taking steps in the early days of the telephone to secure full control of all means of communication.

Experience with the telephone in the World War practically revolutionized military practice in the maintenance of communications. The Signal Corps of the United States Army, for example, constructed during the war 1,990 miles of permanent pole line with 28,000 miles of wire, put up 3,230 miles of wire on French poles and installed approximately 40,000 miles of combat lines. American military telephone exchanges on permanent lines in France numbered 273, and those in the advance section numbered 123, besides small temporary field installations. About 1,600,000 long distance telephone calls were handled by the Signal Corps, in addition to local telephone calls estimated at 47,000,000. Other belligerent countries as well drew heavily upon the equipment and personnel of their home telephone organizations to meet the greatly expanded requirements of their military communication systems during the war. For example, about 13,000 out of the 20,000 men in the engineering department of the British Post Office joined the colours.

Germany.—In Germany the telephone was a government monopoly from the very beginning. Heinrich von Stephan was Postmaster General of Germany and Manager of the Imperial Telegraphs at the time when the telephone was first brought to public notice. He was an active administrator, founder of the Universal Postal Union, and was quick to grasp the possibilities of the new invention. In 1877 he wrote enthusiastically to the Imperial Chancellor, Prince Bismarck, of experiments in the establishment of telephone communication between Berlin and Friedrichsberg. He suggested that the telephone be utilized as an adjunct of the telegraph service in rural post offices where there was not sufficient traffic to require the services of a trained telegraph operator. The first public use of the telephone in Germany was along these lines which, it will be noted, differ from its early utilization in the United States. In America exchange service between persons in the same community was the basis of the early public service, the local areas being gradually linked by long distance lines. In Germany, on the other hand, the toll lines came first as a substitute for the more expensive telegraph facilities. Later, however, the German Government introduced exchange service in Berlin, Hamburg, Cologne, Frankfort, Breslau and elsewhere.

A like policy of government ownership from the first was followed in the German states of Bavaria and Wurttemberg. The German Government proceeded with the development of telephone service more actively than was the case in many other Continental countries and at the present time Germany has more telephones in service than any other nation except America.

France and Switzerland.—In France the telephone was first exhibited at the Paris World's Fair in 1878, where it attracted little interest. In the following year, however, representatives of American telephone manufacturers approached the French telegraph authorities with a view to securing permission for the establishment of telephone service in Paris. The French telegraph officials were unwilling to undertake the development of telephone service themselves, but granted concessions on a royalty basis to several different telephone companies. These concessions were passed about from one concern to another until in 1880 they were all consolidated in a single company called the Société Générale des Téléphones. Public telephone service was opened by this company in Paris early in 1881. The French Government established telephone exchanges at Rheims, Roubaix and Tourcoing in 1883 and in several other commercial centres during the next few years. The private company also established exchanges in some other cities besides Paris, but in 1889 its entire system was taken over by the French Government, which has operated the telephone service throughout France ever since. The French telephone system has been developed to a much greater extent in Paris than in the less densely populated sections of the country.

In Switzerland a concession was granted by the government for the establishment of a privately owned telephone system at Zurich in 1880; and the government itself opened exchanges in Basel and Berne during 1881 and a year later at Geneva, Lausanne and Winterthur. After that the government proceeded rapidly with the establishment of new exchanges and purchased the private system at Zurich upon the expiration of the franchise. Since 1886 the government itself has operated all telephones in Switzerland and the service has been developed to a greater extent than in many other European countries.

Belgium and the Netherlands.—In Belgium concessions were granted to a number of private companies which established telephone systems at various cities, but these properties were bought by the government at the expiration of their respective franchises and since 1896 the telephone has been administered as a government monopoly throughout the country. In the Netherlands a number of concessions were issued, several of the most important ones being ultimately consolidated in a single company which also enjoyed the right to establish inter-urban telephone lines. The competition of these lines with the government telegraphs, however, led the authorities to acquire the interurban telephone lines upon the expiration of their licenses. Municipal telephone systems were established in various Dutch cities succeeding those of the private company. The government acquired the remaining exchanges throughout the country and at present the government and municipal local telephone networks are connected by government owned toll lines.

Austria and Italy.—In Austria concessions were early granted to private companies for the establishment of telephone services at Vienna and a number of other important cities. Long distance lines were constructed by the telegraph authorities, who also opened their first local exchanges in 1887. Subsequently the concessions were bought in by the government and the telephone business became a government monopoly. Much the same course was followed in Hungary. Italy granted a large number of concessions for local telephone companies and telephone competition was inaugurated in a number of the important cities. Ultimately, however, the disadvantages of competition became apparent and consolidation took place, either voluntarily or at the instance of the municipal authorities. In 1883 the concessions were regularized and placed upon a uniform basis surrounded by somewhat onerous conditions. In 1892 the conditions surrounding these concessions were liberalized, but Italy nevertheless failed to keep pace with other great powers in the development of telephone service. After various legislative attempts to encourage the private companies the government in 1907 adopted the policy of buying certain of their systems from time to time. Since the accession of the present régime, however, there has been a return to private ownership in Italy, territorial concessions for the operation of local telephone systems in various sections of the country having been granted to private interests while the government has maintained the operation of the long distance lines.

Scandinavia.—The Scandinavian countries have gone further than any other European community in the development of telephone service. In 1880 the International Bell Telephone Co. of New York secured local franchises for the Norwegian cities of Christiania and Drammen. In the following year local telephone companies undertook the establishment of exchanges in other cities and a competitive system was even opened for service in Christiania. In 1886 the two systems were consolidated and the Bell exchange in Drammen was later acquired by a local company. The telephone soon came to hold much the same place in Norwegian rural life as it does in the sparsely settled districts of America, and although the government did not encourage the construction of lines which would compete with the government telegraphs, the development of telephone networks throughout the rural districts went on apace. Ten years after the introduction of the telephone into Norway it had extended to almost every village and even the small towns were surrounded by lines reaching far into the open country. This remarkable development was secured by local enterprise, independent telephone companies being formed in almost every town or village, and in this respect the Norwegian development was a marked contrast to that obtained in France and Italy. The construction of long distance lines in Norway was finally undertaken by large stock companies and ultimately the state took up the policy of acquiring the more important local telephone systems upon the expiration of their respective franchises. The greater part of the telephone business in Norway, particularly in the larger cities, is now operated by the government.

In Sweden, too, the telephone has attained a higher degree of development than in most European countries. The International Bell Telephone Company opened exchanges in 1881 in Stockholm, Gothenburg and Malmö. A couple of years later mutual telephone associations were established in many rural communities throughout Sweden and the Stockholm General Telephone Company was established under the leadership of enterprising Swedish engineers to compete with the Bell Company. The two systems were finally consolidated; but later telephone competition was renewed in Stockholm, the government opening an exchange system to compete with that of the General Telephone Company. In 1918 the government acquired the company's system and a certain amount of duplication which had resulted from the competitive situation in Stockholm has since been eliminated. The Swedish capital, however, remains the best developed city, from a telephone standpoint, in the world outside of the United States. In Denmark the telephone was introduced and developed by private enterprise and in the year 1928 more than 90% of the Danish telephones are owned and operated by private concerns. Denmark has the highest development in number of telephones per 100 population of any country in Europe.

Spain.—Spain entered upon a new era of telephone development in 1924 when a concession was granted to the National Telephone Company of Spain, a subsidiary of the International Telephone and Telegraph Corporation of New York, for the development of a nation-wide system to supersede the pre-existing governmental and privately owned telephone services which had attained only a relatively limited development. The new company has entered energetically upon the task of providing Spain with an up-to-date telephone system, the equipment being of Spanish manufacture so far as conditions permit. Within a very short time after the concession was granted, telephone communication was established across the Straits of Gibraltar by submarine cable connecting the Spanish wire system with telephones installed in the zone of Spanish military occupation in Morocco. Subsidiaries of the International Telephone and Telegraph Corporation also operate telephone systems in Cuba, Porto Rico, Mexico, Chile, Uruguay, Argentina and Brazil.

Telephone development in the rest of the civilized world may be summarized with the statement that while some sort of telephone service is to be found almost everywhere, the facilities have attained a relatively high development in the English speaking dominions of New Zealand and Australia. Japan has more telephones than any other country in Asia, and although the Japanese system suffered a severe setback in the destruction wrought by the disastrous earthquake of 1923, the opportunity is being taken in rebuilding to introduce thoroughly up-to-date and efficient equipment.

POST-WAR DEVELOPMENT OF TELEPHONE LINES IN EUROPE

Increased interest in telephone communication has been manifest in Europe, also, since the War. Particular attention has been directed to the extension and improvement of long distance facilities, especially as regards the circuits linking up the various countries on the Continent. Much of the impressive progress that has been made in international telephone communication on the continent of Europe since the war may be attributed to the activities of the International Consulting Committee on Long Distance Telephone Communication. This committee was formed as a result of an international conference at Paris in 1923, at which delegates from Belgium, France, Great Britain, Italy, Spain and Switzerland assembled at the invitation of the French Post, Telegraph and Telephone Administration. This conference proposed that a Consulting Committee should be formed which should undertake to unify as far as possible the practices of the various European telephone administrations bearing on international telephone communication, and should gather statistics and prepare technical recommendations to be submitted to the telephone authorities of the participating countries. Nineteen nations accepted the recommendations of the Paris conference of 1923 and their delegates assembled at Paris the following year to form the International Consulting Committee for Long Distance Telephone Communication. A constitution was prepared and a sub-committee appointed to prepare the agenda for the next conference. The recommendations of the preliminary conference were considered and some additional matters were discussed, particularly a proposal for a standard transmission unit and proposals relating to rates for international messages.

In 1925 the Consulting Committee held its second meeting, at which representatives of European telephone manufacturers were present. Transmission and inductive interference problems were added to the subjects to be studied. A number of proposals toward bringing the work of the committee into affiliation with similar activities of the League of Nations were rejected owing largely to the fact that Germany, which occupies a strategic position in regard to the system of international telephone communication on the Continent, was not at that time a member of the League. Subsequently the Consulting Committee has adopted the International Telegraph Regulation, as it was amended by the International Telegraph Conference of 1925, as a guide in its activities. Much has been done in the way of developing recommended standards of service and instructions for the operation of international circuits. Engineering problems in particular have received exhaustive consideration and much attention has been given to the question of suitable rates and classes of service. Further recognition of the importance of long distance telephony was accorded by resolutions which were adopted at the 1925 Congress of the International Chamber of Commerce at Brussels, and at the 1927 convention of the same organization at Stockholm.

This recognition of the importance of long distance telephone communication, supplemented by the concrete recommendations of the International Consulting Committee, has helped to stimulate the European telephone administrations to take advantage of recent improvements in telephone equipment, notably as regards the increased efficiency of long distance telephone cables made possible by loading, the development of the vacuum tube repeater and other advances in the telephone art. Long distance telephone cables have been extensively introduced recently in Austria, Belgium, Czechoslovakia, France, Germany, Great Britain, Hungary, Italy, The Netherlands, Sweden and Switzerland.

European Long Distance Cables. *Austria.*—The first long distance cable from Vienna to Passau on the German frontier was finished early in 1927, covering a distance of 170 miles and containing 114 circuits. Austria has a total of nearly 500 miles of long distance telephone cable and at the completion of present plans this mileage will be greatly increased.

Belgium.—Belgium has had telephone communication with London by submarine cable since 1903. The first cable was supplemented by a second in 1911, and a third in 1927. Long distance cables connect the main centres with the French, German and Netherlands frontiers. The complete system comprises nearly 600 miles of large telephone and telegraph cables.

Czechoslovakia.—A total mileage of over 300 miles is now in service or under construction and plans are under way for greatly extending the existing system.

France.—The Paris-Strasbourg cable opened in 1926, is 308 miles long and connects with the German long distance cable system. Additional telephone cables run from Paris to Havre—130 miles, and from Paris to Boulogne—158 miles, the latter forming part of the main line connecting the British and French telephone systems. In 1927, a new submarine cable of 21 circuits was laid across the English Channel. Construction work was begun in 1927 on a 310-mile cable between Paris and Lyons. In all, France has 738 miles of long distance cable in operation, and 370 miles additional under construction.

Germany.—Extension of long distance telephone cables has been very rapid, the network covering the entire country and linking up practically all important centres. Germany, early in 1927, had about 4,600 miles of long distance telephone cables. The cable system connects with the Swiss, Dutch, French, Austrian, Belgian, Czechoslovakian and Polish systems, and a total of 750 miles of submarine telephone cable connects with Scandinavian countries and with East Prussia. The telephone circuit through cable from Berlin to London passes through the Netherlands and is approximately 860 miles in length.

Great Britain.—Four main cable routes centering in London extend, respectively, to Glasgow via Leeds, Newcastle and Edinburgh, to Manchester and Liverpool, to South Wales via Reading and Bristol and to Portsmouth and Southampton. The international telephone connections with America utilizing the radio receiving station at Cupar, Scotland, and the transmitting station at Rugby, also centre at London, messages over the transatlantic circuit to and from either British or Continental points passing through the metropolis. In 1927, Great Britain had long distance telephone cables aggregating well over 6,000 miles. Direct submarine telephone cables connect Great Britain with France, Belgium and Holland, and British telephone users can talk not only with these countries, but also with Germany, Sweden, Norway, Switzerland, Austria, Hungary, Czechoslovakia, Spain, etc.

Netherlands.—The first inter-urban telephone cable in Holland was opened in 1921. The main cities are now connected by means of cables and a cable has been carried eastward to the German border. A submarine cable connects with Great Britain.

Hungary.—A long distance cable connects Budapest with Vienna and further extension of the cable system is planned.

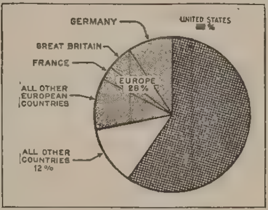
Italy.—In 1924, a long distance cable system totaling 184 miles of cable was opened for service. Extensive expansion of this system is planned together with a submarine telephone cable to the island of Sardinia.

Sweden.—Sweden has a telephone cable 335 miles long connecting Stockholm and Gothenburg. Other cables connecting with the German and Danish systems bring the total length of Swedish long distance cables, including part of the submarine cables, to over 650 miles.

Switzerland.—The Swiss cable network, including more than 1,000 miles of cable, connects the main cities together and by means of connections to the various frontiers provides important facilities for international traffic.

Telephone cable construction in Europe is progressing so rapidly that the gaps in the existing networks are being closed up and already there is a total of 15,152 miles containing 1,692,784 miles of cable pairs in the eleven countries which form a part of the present European long distance telephone cable system.

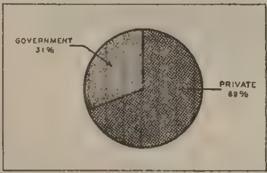
Status of the Telephone Throughout the World, 1929.—Figures 3, 4, 5, 6 and 7 indicate the status of the telephone throughout the world at the latest date for which comprehensive statistics covering practically all countries are available at the time of writing. On January 1, 1928, there were 30,990,304 telephones in service throughout the world, or 1,583,743 more than there were on January 1, 1927. Approximately 60 per cent. of all the telephones in the world on January 1, 1928, were in the United States, the total for that country being 18,522,767. At the same date Europe had 8,623,407 telephones, or about 28 per cent. of the world's total. Of these 2,814,996 were in Germany, about 1,635,000 were in Great Britain and Northern Ireland, and France had approximately 885,000. The remaining telephones were distributed among the countries of Asia, Africa, Oceania, South America and North America outside of the United States. Canada had 1,259,987. Of the remainder 463,810 were in South America, 1,042,399 in Asia (nearly three-quarters of which were in Japan), 203,357 in Africa and 677,727 in Oceania (including somewhat over 442,000 in Australia and about 145,000 in New Zealand).



BY COURTESY OF THE AMERICAN TELEPHONE AND TELEGRAPH CO.

FIG. 3.—DISTRIBUTION OF THE WORLD'S TELEPHONES, JAN. 1928

In proportion to population the United States had, at the date to which these figures relate, 15·8 telephones per one hundred people. The world as a whole had at the same date 1·6 telephones for every one hundred inhabitants. At the beginning of 1928 Canada had 13·2 telephones per hundred people. New Zealand had 10·0 and Denmark 9·3. Sweden had 7·7, Australia 7·2, Hawaii 7·0 and Norway 6·4. Germany, at the same date, had 4·4 telephones per one hundred people and the corresponding figure for Great Britain and Northern Ireland was 3·6, for France 2·2, and for Italy 0·7.



BY COURTESY OF THE AMERICAN TELEPHONE AND TELEGRAPH CO.

FIG. 4.—OWNERSHIP OF THE WORLD'S TELEPHONES, JAN. 1928

The United States has, however, not always been in advance of Europe in number of telephones. In 1885, about ten years after the telephone's birth, there were, to be sure, 155,700 telephones in the United States, or almost twice as many as in Europe. Nevertheless, by the beginning of 1892 Europe had attained a total of 254,900 telephones, which placed it ahead of the United States where there were then only 239,300 telephones. Europe maintained its lead over the United States in telephone totals by a comfortable margin for nearly seven years thereafter, but in the latter part of 1898 the United States again passed Europe and the margin of American leadership has been widening ever since. As will be noted from the tables, the United States has at present considerably more than twice as many telephones as Europe.

Among the South American nations Argentina had a development of 2·2 telephones per hundred people at the date to which these statistics relate.

Japan had attained a development of 1·2 telephones per 100 people by the beginning of 1928.

As regards the distribution of telephones with respect to the size of communities, it may be said that in general the smaller communities in the United States had a larger portion of the total telephones than was the case in Europe. As a rule, the most intensive use of the telephone in countries outside of North America was to be found in the large cities. A third of all the French telephones were in Paris and a third of all the British telephones were in London. Paris had 10·8 telephones per hundred people and London had 7·7 at the date to which these figures relate. New York at the same time had 26·1 telephones for every one hundred inhabitants, Chicago 28·4, and Los Angeles 26·3. San Francisco had 32·8. Stockholm had 28·9 per one hundred inhabitants. Copenhagen had 16·4, Oslo 16·9 and Malmö 13·6. Toronto, Canada, had 26·4 telephones per one hundred people, Berlin had 10·9, Frankfort-on-Main had 11·4 and Hamburg-Altona had 12·2. Tokio had 5·8 telephones for every one hundred population, Wellington, N.Z., had 13·4 and Havana, Cuba, had 8·1.

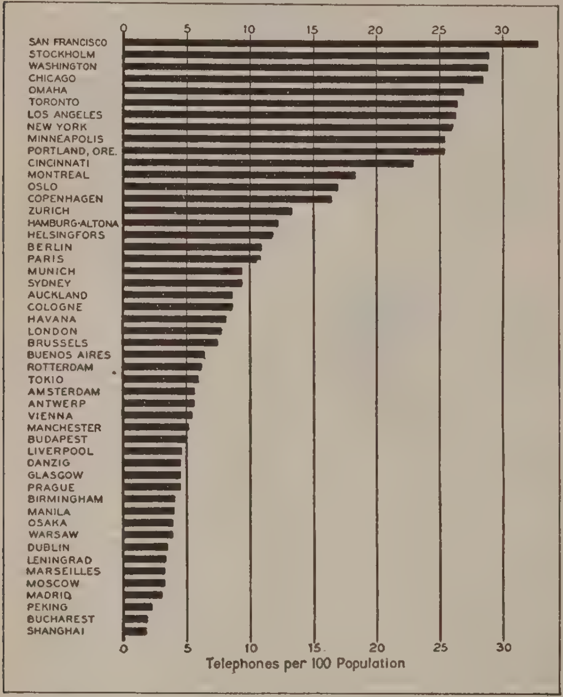


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FIG. 5.—TELEPHONES PER 100 POPULATION OF LARGE CITIES, JAN. 1928

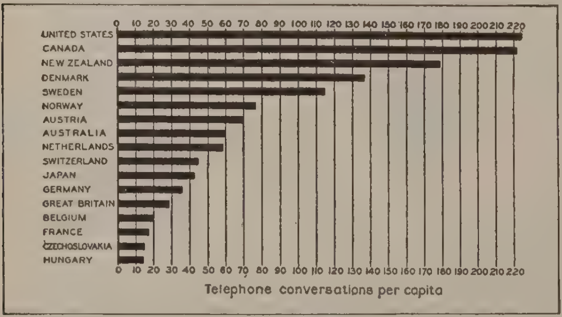

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FIG. 6.—NUMBER OF TELEPHONE CONVERSATIONS PER CAPITA, JAN. 1928

In respect to telephone conversations during the year 1927, the latest period for which comparative data covering various countries are available, the United States had a total of 26,200,000,000. The figures for telephone conversations include both local and toll, or long distance, conversations. So far as they relate to the United States they cover completed messages only. Americans, during the year 1927, used the telephone 224·7 times per capita, while Canada was next with 221·5 conversations per capita. There were 178·9 telephone conversations per person in New Zealand, 136·8 in Denmark, 114·6 in Sweden and 76·2 in Norway during the same period. Germany had a total of 35·5 telephone conversations per capita during that year. Great Britain and Northern Ireland had 28·6 and France had 17·2. In Austria there were 69·5 telephone conversations per person during the year, in Australia there were 59·6 and in the Netherlands 58·4.

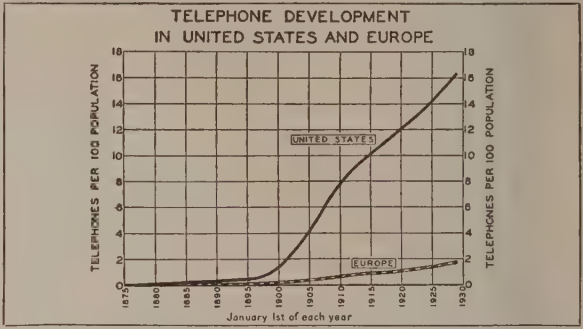

FIG. 7.—TELEPHONE DEVELOPMENT IN THE UNITED STATES AND EUROPE

Much has already been accomplished toward the integration of telephone communication facilities not only in countries like the United States, Canada, Sweden and elsewhere, but also in regard to international communications on the North American and European continents and by the transatlantic radio circuit between America and Europe. The day is probably still far distant when anyone anywhere in the world can communicate by telephone with anyone else anywhere in the world. Progress in extending the range of telephone communication during the past few years has brought this ideal measurably nearer to accomplishment. Present indications point to further progress at an accelerated pace.

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(W. S. G.)

TELEPHOTO: *see* TELEPHONE; TELEGRAPH; BROADCASTING; TELEVISION.

TELESCOPE, an optical instrument employed to view distant objects (Gr. τῆλε, far, σκοπεῖν, to see). The name was adopted by Galileo as early as 1612; it came into English use much later, supplanting the terms *trunk* and *cylinder* which were used at first.

Early History.—The telescope was invented in Holland about 1608. The credit has been attributed variously to three individuals. Hans Lippershey and Zacharias Jansen, spectacle-makers in Middleburg, and James Metius of Alkmaar (brother of Adrian Metius, the mathematician). The common story is that Lippershey, happening one day whilst holding a spectacle-lens in either hand, to direct them towards the steeple of a neighbouring church, was astonished on looking through the nearer lens to find that the weathercock appeared nearer. Accordingly he fitted the lenses in a tube to preserve their relative distance and thus constructed the first telescope. From the archives at The Hague it appears that on Oct. 2, 1608, the assembly of the States-general considered the petition of Hans Lippershey, inventor of an instrument for seeing at a distance. On Oct. 4 a committee was appointed to test the instrument, and on Oct. 6 the assembly voted 900 florins for it. Further, on Dec. 15 they examined a binocular instrument made by Lippershey at their request, and ordered two such instruments at 900 florins each; but, as many other persons had knowledge of this new invention to see at a distance, they did not deem it expedient to grant him the exclusive right to sell such instruments. A petition by Metius (to whom the invention is attributed by Descartes) was presented to the States-general on Oct. 17 of the same year. He stated that he had discovered the instrument by accident when engaged in experiments, and had so far perfected it that distant objects were made as visible and distinct as by the instrument lately offered to the States-general by Lippershey.

Telescopes were made in considerable numbers and found their way over Europe soon after their invention. Galileo, in his *Nuncius Siderius,* states that, happening to be in Venice about May 1609, he heard that a Belgian had invented a perspective instrument for making objects appear nearer and larger, and that he discovered its construction by considering the effects of refraction. The day after his return to Padua he made his first telescope by fitting a convex lens in one end of a leaden tube and a concave lens in the other end. A few days afterwards having succeeded in making a better telescope than the first, he took it to Venice, where he communicated the details to the public, and presented the instrument itself to the doge Leonardo Donato, sitting in full council. The senate, in return, settled him for life in his lectureship at Padua and doubled his salary, which was previously 500 florins and which then became treble that which any of his predecessors had enjoyed. Galileo devoted all his time to improving and perfecting the telescope. He conquered the difficulties of grinding and polishing the lenses, and soon succeeded in producing telescopes of greatly increased power. His first telescope magnified three diameters; but he soon made instruments which magnified eight diameters, and finally one that magnified thirty-three diameters. (This last power is as great as can advantageously be employed with non-achromatic lenses.)

With this last instrument Galileo discovered in 1610 the satellites of Jupiter, and soon afterwards the spots on the sun, the phases of Venus, and the hills and valleys on the moon. He demonstrated the rotation of the satellites of Jupiter round the planet, and gave rough predictions of their configurations, proved the rotation of the sun on its axis, established the general truth of the Copernican system as compared with that of Ptolemy, and fairly routed the fanciful dogmas of the philosophers. These brilliant achievements, together with the immense improvement of the instrument under the hands of Galileo, overshadowed in a great degree the credit due to the original discoverer, and led to the universal adoption of the name of Galilean telescope for the form of instrument invented by Lippershey.

In the Galilean telescope the object-glass is a convex lens and the eye-piece concave. Kepler was the first to explain the theory and some of the practical advantages of a convex eye-piece in his *Catoptrics* (1611). The first person who actually constructed a telescope of this form was the Jesuit, Christoph Scheiner, who gives a description of it in his *Rosa Ursina* (1630). William Gascoigne pointed out one great advantage of the form of telescope suggested by Kepler; viz., the visibility of the image of a distant object simultaneously with that of a small material object placed in the common focus of the two lenses. This led to his invention of the micrometer and his application of telescopic sights to astronomical instruments of precision. It was not till about the middle of the 17th century, however, that Kepler's telescope came into general use, and then, not so much because of the advantages pointed out by Gascoigne, but because its field of view was much larger than that of the Galilean telescope. The first powerful telescopes of this construction were made by Huygens, after much labour, in which he was assisted by his brother. With one of these, of 12 ft. focal length, he discovered the brightest of Saturn's satellites (Titan) in 1655, and in 1659 he published his *Systema Saturnium,* in which was given for the first time a true explanation of Saturn's ring, founded on observations made with the same instrument.

The sharpness of image in Kepler's telescope is very inferior to that of the Galilean instrument, so that when a high magnifying power is required it becomes essential to increase the focal length. G. D. Cassini discovered Saturn's fifth satellite (Rhea) in 1672 with a telescope of 35 ft. and the third and fourth satellites in 1684 with telescopes made by Campani of 100 and 136 ft. focal length. Huygens states that he and his brother made object-glasses of 170 and 210 ft. focal length, and he presented one of 123 ft. to the Royal Society of London. Adrien Auzout (d. 1691) and others are said to have made telescopes of from 300 to 600 ft. focus, but it does not appear that they were ever able to use them in practical observations. James Bradley, on Dec. 27, 1722, actually measured the diameter of Venus with a telescope whose object-glass had a focal length of 212¼ feet. In these very long telescopes no tube was employed, and they were consequently termed *aerial* telescopes.

Reflecting Telescopes.—It was not until the middle of the 18th century that these unwieldy instruments were supplanted by the achromatic telescope. Meanwhile the refracting type of telescope had a rival in the reflecting telescope invented by Sir Isaac Newton. It was in fact Newton who discovered what was the trouble with the refractor, which led to the need for excessive length. It had been supposed that the only imperfection in the image arose from the error known as spherical aberration, and the efforts of opticians were concentrated on devising lenses of suitable forms of curvature to correct this. In 1666 Newton discovered the different refrangibility of light of different colours, and he soon perceived that the fault of the refracting telescope was that the light of different colours followed different paths; so that if, for example, the telescope was focused sharply for blue light—the green image would be altogether out of focus and blurred. He over-hastily concluded from rough experiments (*Optics,* bk. i. pt. ii. prop. 3) "that all refracting substances diverge the prismatic colours in a constant proportion to their mean refraction." If this were true no combination of refracting substances could bend the path of the light without introducing colour, and therefore no improvement could be expected in the refracting telescope. He therefore turned his attention to the construction of reflectors. The form now known as the Gregorian reflector had already been proposed by James Gregory in 1663; but he had not succeeded in constructing the instrument practically.

Newton, after much experiment, selected an alloy of tin and copper for his specula, and he devised means for grinding and polishing them. He did not attempt the formation of a parabolic figure on account of the probable mechanical difficulties, and he had besides satisfied himself that the chromatic and not the spherical aberration formed the chief fault of previous telescopes. Newton's first telescope so far realized his expectations that he could see with its aid the satellites of Jupiter and the horns of Venus. Encouraged by this success, he made a second telescope of 6½ in. focal length, with a magnifying power of 38 diameters, which he presented to the Royal Society in Dec. 1671. A third form of reflecting telescope was devised in 1672 by Cassegrain. No further practical advance appears to have been made in the design or construction of the instrument till the year 1723, when John Hadley (best known as the inventor of the sextant) presented to the Royal Society a reflecting telescope of the Newtonian construction, with a metallic speculum of 6 in. aperture and 62⅝ in. focal length, having eye-pieces magnifying up to 230 diameters. The instrument was examined by Pound and Bradley, the former of whom reported upon it in *Phil. Trans.*, 1723.

Bradley and Molyneux, having been instructed by Hadley in his methods of polishing specula, succeeded in producing some telescopes of considerable power, one of which had a focal length of 8 ft.; and, Molyneux having communicated these methods to Scarlet and Hearn, two London opticians, the manufacture of telescopes as a matter of business was commenced by them. However, it was reserved for James Short of Edinburgh to give practical effect to Gregory's original idea. Born at Edinburgh in 1710 and originally educated for the church, Short attracted the attention of Maclaurin, professor of mathematics at the university, who permitted him about 1732 to make use of his rooms in the college buildings for experiments in the construction of telescopes. In Short's first telescopes the specula were of glass, as suggested by Gregory, but he afterwards used metallic specula only, and succeeded in giving to them true parabolic and elliptic figures.

Achromatic Telescopes.—The historical sequence of events now brings us to the discovery of the achromatic telescope. The first person who succeeded in making achromatic refracting telescopes seems to have been Chester Moor Hall, a gentleman of Essex. He argued that the different humours of the human eye so refract rays of light as to produce an image on the retina which is free from colour, and he reasonably concluded that it might be possible to produce a like result by combining lenses composed of different refracting media. After devoting some time to the enquiry he found that by combining lenses formed of different kinds of glass the effect of the unequal refrangibility of light was corrected, and in 1733 he succeeded in constructing telescopes which exhibited objects free from colour.

The principal development of the achromatic refractor is due to John Dollond who invented it independently (*Phil Trans.*, 1758). In principle his object-glasses were of the pattern mainly used at the present day; viz., convex lens of crown glass combined with a concave lens of flint glass. The concave lens is of less power than the convex, so that the combination converges the light as a single convex lens would do; but the flint glass having much wider difference of refractive index for light of different colours, is able to correct the colour dispersion introduced by the more powerful crown lens. A triple objective, consisting of two convex lenses of crown glass with a concave lens of flint glass between them, was introduced in 1765 by Peter, son of John Dollond. This type is also employed in some modern telescopes.

The subsequent improvement of both reflecting and refracting telescopes has been mainly a matter of technical detail in the making, figuring, and mounting of large lenses and mirrors. At present the largest refractor has an aperture of 40 in. (Yerkes observatory), and the largest reflector an aperture of 100 in. (Mt. Wilson observatory). A limit to the aperture of refractors is set by the difficulty of casting large enough discs of glass of the necessary transparency and homogeneity; moreover, if this were overcome, we should ultimately reach a point at which the strain on the lens caused by its own weight would spoil its optical qualities. The size of reflectors appears to be limited only by consideration of expense, not only of making the mirror, but of providing a mounting for its practical use. Funds have been provided for the construction of a reflector of 200 inches aperture, and it is expected that the instrument will be built in the course of a few years. Pictures of typical modern telescopes are given in the plate illustrating the article OBSERVATORY. Introductory remarks on the general use of astronomical telescopes will be found under ASTRONOMY: *Practical Astronomy.*

THEORY OF THE TELESCOPE

It is important to realize that magnifying power is not the only quality, perhaps not even the chief quality, desired in a telescope. We have to pay attention to (1) magnifying power, (2) resolving power, (3) light-grasp, (4) a wide field of good definition, and (5) suitability for making accurate measurement. Not all of these can be developed to perfection in the same instrument, and accordingly telescopes of different design are employed for different purposes. For example, the ordinary field-glass is useless for viewing the stage in a theatre; and accordingly an opera-glass is employed which gives a more brilliant though smaller image.

In general, resolving power and magnifying power go together. It is little use making the object appear larger if we do not at the same time sharpen the image so that greater detail may appear. We might be content to increase the resolving power (*i.e.*, sharpen the detail in the image) without magnification if that were possible; but optical laws forbid an increase of resolving power without a corresponding increase of magnification. The magnifying power of a telescope can be understood by reference to the theory of geometrical optics alone; to explain the increase of resolving power, reference must be made to physical optics (the wave-theory of light). Light does not consist of strictly linear rays, but of a wave disturbance which tends to spread and blur any image that is being formed; this tendency to spread is not cured by any perfecting of the figures of the lenses and mirrors, but only by increasing the aperture so that a wider area of wave-front is taken in and concentrated into the eye-pupil. The resolving power of a telescope (free from ordinary optical defects) is simply proportioned to the diameter of aperture of the object-glass or mirror. But in order that the beam filling the object-glass may be narrowed down on emergence from the telescope so as to enter the eye, the magnifying power must be not less than the ratio of the aperture of the telescope to the aperture of the eye-pupil; if lower power is used an outer ring of the object-glass is left unused so that its effective aperture and resolving power are reduced. In looking for faint nebulae we should like to use the large object-glass merely to concentrate more light, and not to dissipate the light again by enlarging the image which it forms; this, however, is impracticable because we cannot effectively use the full aperture of the object-glass without employing a corresponding magnification. For this reason comparatively little progress in our knowledge of nebulae can be made by visual observation, and most of the work is done by photography.

Refracting Telescopes.—In its simplest form the telescope consists of a convex lens (object-glass) which forms an image of a distant object at its focus. This image is then magnified by another small lens (eye-piece) which is used just as an ordinary magnifying glass is used. The object-glass is of long focus *F*, and the eye-piece of short focus *f*, and the ratio *F*/*f*, is equal to the magnifying power of the telescope. Since eye-pieces are inexpensive it is usual to provide a number of them, so that different magnifying powers can be used; it may be noted that the smallest eye-pieces have the highest power.

The combination just described is Kepler's form of telescope. The course of the rays is shown in fig. 1. In Galileo's form the eye-lens is concave (or negative), and is placed so as to intercept the rays from the object-glass before they reach the focus (fig. 2). This form is common in binoculars for terrestrial observation, because it gives an erect image, whereas in Kepler's telescope objects are seen upside-down unless a second erecting eye-piece is added. In stellar observation we do not much mind the inversion of the image and Kepler's form is always preferred.

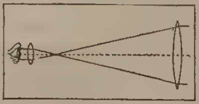
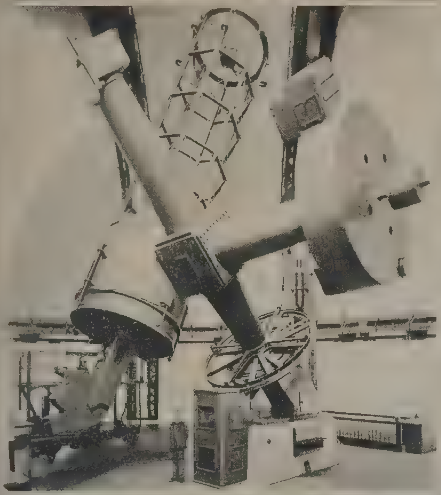
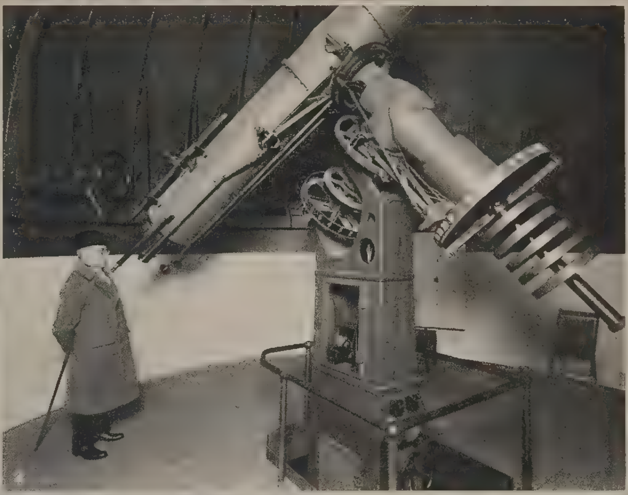
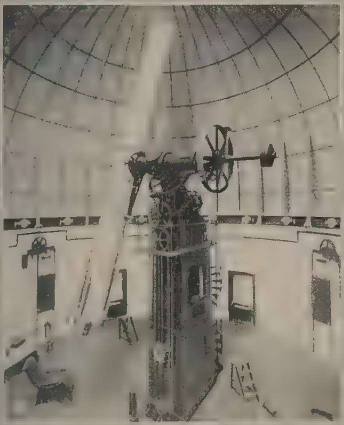


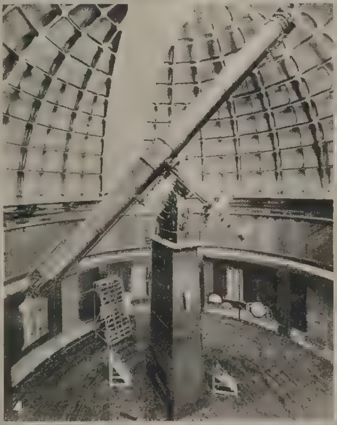
FIG. 1.—DIAGRAM, SHOWING COURSE OF RAYS WHEN THE EYE-LENS IS CONVEX (OR POSITIVE)

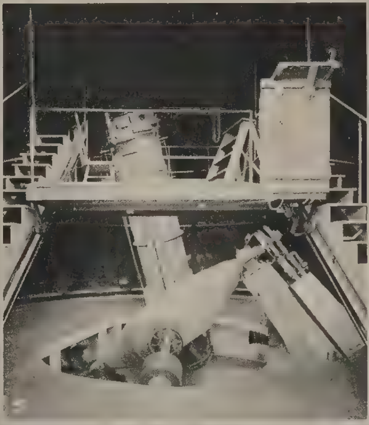
In all modern instruments both the eye-piece and object-glass are compound, consisting of at least two lenses. A single eye-lens would generally give good enough definition at the centre of the field of view, but all the outer parts would be out of focus. Two well-known types of double eye-piece, the Huygens and the Ramsden eye-piece, give a large flat field of view. The construction of eye-pieces for the telescope and for the microscope is essentially the same problem. (*See* MICROSCOPE.) The use of two lenses in the object-glass is necessary in order to correct the defect of colour dispersion already mentioned. In spite of improvements in the manufacture of optical glass, practically the same crown and flint glasses as those used by John Dollond in 1758 are employed in the largest modern telescopes. Owing to what is termed "irrationality of dispersion" no combination of crown and flint lenses will completely get rid of colour dispersion.

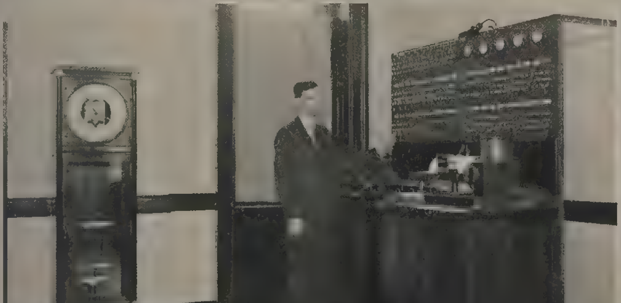


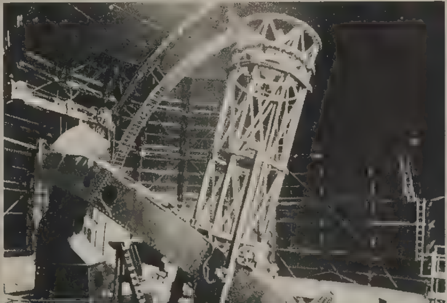








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BY COURTESY OF (2) THE UNIVERSITY OF COLUMBIA, MISSOURI, U.S.A., (3, 6) THE SUPERINTENDENT OF THE U.S. NAVAL OBSERVATORY, (4, 5) THE DIRECTOR OF THE LICK OBSERVATORY

TELESCOPES AND TIME SERVICE APPARATUS IN LARGE OBSERVATORIES

1. Dominion Astrophysical Observatory, Victoria, B.C. Reflecting telescope with 72-in. mirror, mounted equatorially (German type): a Cassegrain spectrograph attached is shown at the lower end. 2. Equatorial at the Laws Observatory, of the University of Columbia, Missouri, U.S.A. (The rising floor is about one-third of its range from its highest position). 3, 6. U.S. Naval Observatory, Washington; 26-inch Equatorial with which the satellites of Mars were discovered in 1877. Time service, transmitting and sending apparatus. 4, 5. The Lick Observatory. 36-inch refractor with spectrograph attached; the Crossley reflector, showing moving observing platform. 7. Mount Wilson Observatory, California. The Hooker reflecting telescope with 100-in. mirror, the largest in the world in 1928, mounted Equatorially (English type)

In some of the newer glasses the irrationality of dispersion has been reduced to a minimum, but they have nothing approaching the same difference of dispersive power as the ordinary crown and flint glass (a difference of 1 to $1\frac{2}{3}$); deeper curves and thicker lenses would be required, which would neutralize all the advantages of using them. Accordingly in practice the achromatism is made as perfect as possible for the part of the spectrum that will chiefly be employed; viz., near the yellow light for visual work, and in the blue and ultra-violet for photographic work. For this reason separate telescopes are used for visual and photographic work, respectively.

By using three lenses to form the object-glass photo-visual telescopes can be made, sufficiently achromatic for all parts of the spectrum. The additional surfaces and thickness of glass, however, involve some loss of light; and the combination has the great drawback that its focal length changes very rapidly when the temperature drops at nightfall.

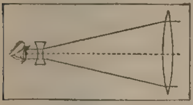


FIG. 2.—DIAGRAM SHOWING COURSE OF RAYS WHEN THE EYE-LENS IS CONCAVE (OR NEGATIVE)

Reflecting Telescopes.—The following are the various forms of reflecting telescopes:

The Gregorian telescope is represented in fig. 3. *A A* and *B B* are concave mirrors having a common axis and their concavities facing each other. The focus of *A* for parallel rays is at *F*, that of *B* for parallel rays at *f*—between *B* and *F*. Parallel rays falling on *AA* converge at *F*, where an image is formed; the rays are then reflected from *B* and converge at *P*, where a second and more enlarged image is formed. Gregory himself showed that, if the large mirror were a segment of a paraboloid of revolution whose focus is *F*, and the small mirror an ellipsoid of revolution whose foci are *F* and *P* respectively, the resulting image will be plane and undistorted. The image formed at *P* is viewed through the eye-piece at *E*, which may be of the Huygenian or Ramsden type. The practical difficulty of constructing Gregorian telescopes of good defining quality is very considerable, because if spherical mirrors are employed their aberrations tend to increase each other, and it is extremely difficult to give a true elliptic figure to the necessarily deep concavity of the small speculum. Short appears to have systematically conquered this difficulty, and his Gregorian telescopes attained great celebrity. The use of the Gregorian form is, however, practically abandoned.

The Cassegrain telescope differs from the Gregorian only in the substitution of a convex hyperboloidal mirror for a concave ellipsoidal mirror as the small speculum. This form has two distinct advantages: (1) if spherical mirrors are employed their aberrations have a tendency to correct each other; (2) the instrument is shorter than the Gregorian, *caeteris paribus*, by twice the focal length of the small mirror. For spectroscopic purposes the Cassegrain form has peculiar advantages, because in consequence of the less rapid convergence of the rays after reflection from the convex hyperboloidal mirror, the equivalent focus can be made very great in comparison with the length of the tube. This permits the employment of a spectroscope furnished with a collimator of long focus.

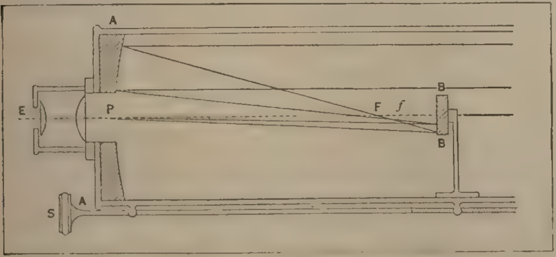


FIG. 3.—DIAGRAM OF THE GREGORIAN TELESCOPE

The Newtonian telescope is represented in fig. 4. *A A* is a concave mirror whose axis is *aa*. Parallel rays falling on *AA* converge on the plane mirror *BB*, and are thence reflected at right angles to the axis, forming an image in the focus of the eye-piece *E*. The surface of the large mirror should be a paraboloid of revolution, that of the small mirror a true optical plane. When used for photography the inclined mirror is removed; and the photographic plate is supported in a carrier mounted at the principal focus of the large mirror.

Most modern reflectors are made so that they can be used alternatively in the Cassegrain or Newtonian form by inserting alternative small mirrors. In the earlier reflectors the mirrors were made of metal. The art of making specula was notably developed by Sir William Herschel, who may be said to have created the fame of the reflector. His greatest telescope, made in 1789, was of 4 ft. aperture and 40 ft. focal length. In 1845 Lord Rosse erected the Parsonstown reflector of 6 ft. aperture. These suffered from the great drawback that whenever the mirror became tarnished, the re-polishing was likely to spoil the figure of the mirror. To preserve the quality the figuring must be done all over again, and the telescope became virtually a new instrument with different optical behaviour. In modern practice the reflecting surface is a film of silver deposited on a glass disc ground to the proper curvature. When the surface loses its brilliance the silver film is washed off (once or twice a year) and a new film deposited.

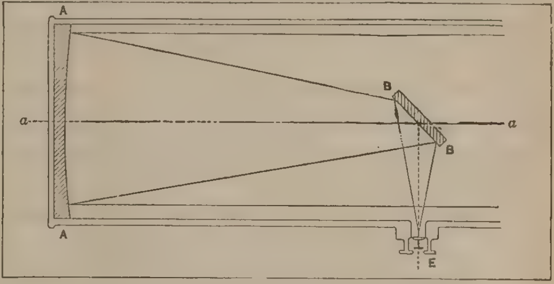


FIG. 4.—DIAGRAM OF THE NEWTONIAN TELESCOPE

Photography.—When a photograph is to be taken the eyepiece is removed and the photographic plate is placed in the focal plane of the object-glass or mirror. It is not a question of adding a camera to a telescope, but of turning the telescope into a camera, the main lens or mirror of the telescope acting as the lens of the camera. In visual observation it is no great drawback if the definition falls off in quality towards the outside of the field of view, because the observer cannot pay minute attention to more than one object at a time; but in astronomical photography it may be a great advantage to have objectives giving good definition over a wide field many degrees in diameter. This makes severe demands on the skill of the designer in correcting the various aberrations of the lens system, which usually increase rapidly with the distance from the centre of the field of view. In general, a *doublet*, consisting of two similar pairs of lenses separated by a wide interval, is employed. The problem of constructing these wide-angle lenses is essentially the same as that of constructing a good camera lens for terrestrial photography (where a wide field is also necessary); and indeed a good portrait lens can be usefully employed in celestial photography. The fact that the whole instrument is of insignificant size is irrelevant when *speed* and not *magnification* is the main essential. As is well-known in terrestrial photography the speed depends on the ratio of the aperture to focal length, and not on the absolute dimensions of either; and this ratio can be made greater in a doublet than in an ordinary refractor or reflector. For detecting faint diffuse light (*e.g.*, the limits of the tail of a comet, or the extended nebulosity in Orion or in the Pleiades) an instrument the size of a hand camera is more effective than a 100 in. telescope.

Mounting.—If a telescope is kept fixed, the stars in their apparent diurnal rotation pass rapidly across the field of view. Hence for most purposes a telescope should be mounted in such a way that it can automatically "follow" a star. This is contrived by an "equatorial" mounting. Fig. 5 shows the so-called English form. *AA* is the "polar axis," which is parallel to the axis of the earth's rotation, and therefore elevated at an angle equal to the latitude of the observatory. By rotating the whole instrument about this axis the effect of the earth's rotation is precisely counteracted, and the telescope remains pointing in the same absolute direction in space, *i.e.,* to the same star. The necessary rotation about *AA* is given by a driving-clock. The telescope tube is also free to turn about a "declination axis" at right-angles to *AA,* so that it can be pointed to objects of higher or lower declination; the declination is read off on the graduated circle *BB*. *DD* is a similar circle for reading the right ascension or hour-angle.

The English mounting had generally been considered rather antiquated, and all modern instruments were made on a plan which (although the same in principle) avoided the necessity of supporting the polar axis at its upper end; but its reputation is perhaps rehabilitated by the fact that it was found necessary to revert to it for the 100 in. reflector at Mt. Wilson.

An important adjunct to an equatorial mounting is the driving-clock. For visual work no great perfection is required, but for photography it is essential that the image should remain fixed at one point on the plate throughout the exposure. For this purpose the rate of the driving-clock is first controlled by a mechanical governor, which keeps it approximately steady. Then there is an electrical control, which puts in an accelerating or retarding mechanism, according as the clock is ahead of or behind current signals coming once a second from a freely swinging pendulum. Finally, since no automatic control can compensate for the changing displacements by refraction as the object rises or descends in the sky, the ultimate correction is made by hand. The observer watches a star seen in a parallel guiding telescope (or by some equivalent device); and whenever he detects a tendency to drift away from the original position marked by cross-wires he brings it back by a hand-control.

TWO LARGE TELESCOPES

The following are some details of the two largest telescopes at present existing. (*See* photographs in article OBSERVATORY.)

The Mount Wilson Telescope.—The diameter of the mirror is 100·4 in. (255 cm.), the focal length 42·3 ft. (12·89 metres). The tube of the telescope is swung in a split polar axis, the cross pivots on which the tube rotates serving as the declination axis. The great weight of the telescope (100 tons) is carried by large drums situated at the upper and lower ends of the polar axis, which float in troughs of mercury, while the actual direction of the axis is determined by self-aligning spherical bearings near its two extremities. The telescope can be used either in the Newtonian or Cassegrain form, separate terminal sections of the tube being provided as carriers for the auxiliary mirrors of each. These carriers, or "cages" as they are called, are very massive, and are removed and exchanged with the aid of an electric crane. When it is necessary to remove the mirror for silvering, which is about twice a year, it is lowered by means of a large hydraulic jack into a laboratory just beneath the floor. Two large tubes lying parallel to the telescope contain weights that can be moved longitudinally to perfect the balance. The instrument is provided with quick and slow motion devices operated electrically, and essentially all movements of it and of the dome are accomplished by motors under independent control by the observer at the eye end and the assistant at the desk. Forty motors are used in the dome. The mirror is supported by a counterpoise system. In order to minimize the effect on the mirror of changes in the temperature of the air, it is surrounded by an insulating sheath of cork-board. Means were originally provided for keeping the mirror cell jacketed with brine, which was automatically held at a constant temperature, but they were eventually discarded and reliance was placed on the cork insulation as well as on the protective covering of the dome.

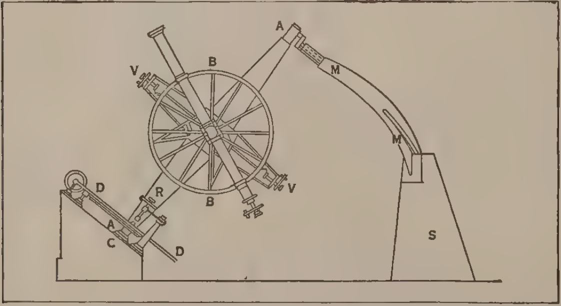


FIG. 5.—DIAGRAM OF THE EQUATORIAL TELESCOPE (ENGLISH FORM)

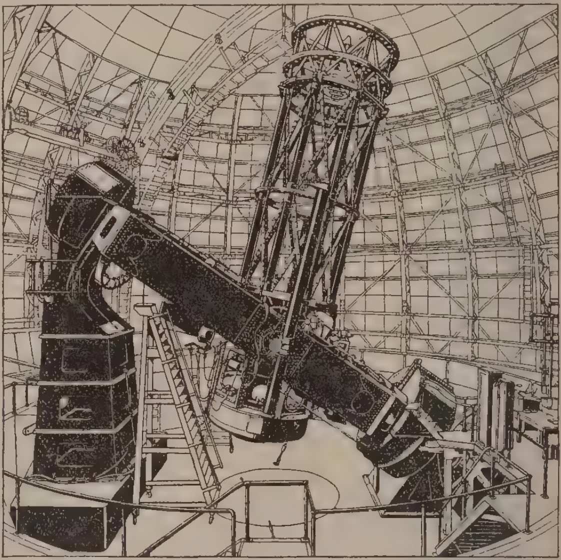


FIG. 6.—ONE-HUNDRED INCH REFLECTING TELESCOPE WITH CASSEGRAIN SPECTROGRAPH OF MOUNT WILSON OBSERVATORY, CALIFORNIA, AT THE TIME OF ITS CONSTRUCTION THE LARGEST IN THE WORLD

The Victoria Telescope (British Columbia).—The diameter of the mirror is 72·5 in. (184·15 cm.) the focal length 30·1 ft. (9·180 metres). Critical features of this telescope are the polar axis bearings and the construction of the tube. The polar axis rotates in ball bearings of large size, unrelieved by supporting or flotation devices. This departure from usual practice in the construction of large telescopes has proved very successful. The lattice-work part of the tube is built as a unit, without removable end pieces such as those of the Mt. Wilson telescope, provision being made for the direct interchange of the Cassegrain mirror, the Newtonian mirror and the focal plane apparatus without the removal of a terminal section of the tube. The telescope is electrically operated.

A new telescope, 200 inches in diameter, will soon be under construction, which will be double the size and have four times the light-gathering power of the reflector on Mount Wilson, California, at present (1929) the largest in the world. A half billion stars that cannot now be seen by any telescope will be revealed. Funds for the cost of this telescope will be provided by the International Education Board, which administers Rockefeller benefactions, and the instrument will be under the control of the California Institute of Technology. When completed it will be used to extend present researches in spectrum photography of the stars, direct photography of faint celestial objects, investigation of the nature of spiral nebulae and in radiometry.

REFERENCES.—Special forms of telescope (other than equatorials) are treated under TRANSIT CIRCLE and ZENITH TELESCOPE. *See* also OBSERVATORY, where illustrations are given. For a survey of the technical details of construction of telescopes and general instrumental equipment of a large observatory, *see* Gell, *History and Description of the Cape Observatory* (1913). (D. GI.; A. S. E.)

TELESILLA, Greek poetess, a native of Argos, one of the so-called nine lyric muses. According to the traditional story, when Cleomenes, king of Sparta, invaded the land of the Argives in 510 B.C., and slew all the males capable of bearing arms, Telesilla, dressed in men's clothes, put herself at the head of the women and repelled an attack upon the city of Argos. Of Telesilla's poems only two lines remain, quoted by Hephaestion, apparently from a Parthenion, or song for a chorus of maidens.

See Pausanias ii. 20, 8; Plutarch, *De Virtut. Mulierum*, 8; Clement of Alexandria, *Stromata*, iv. 19, p. 522; Bergk, *Poetae Lyrici Graeci*, iii.; and especially Macan, *Herodotus iv.–vi.*, i. 336 *seq.* and notes.

TELESIO, BERNARDINO (1509–1588), Italian philosopher and natural scientist, was born of noble parentage at Cosenza near Naples in 1509. He was educated at Milan by his uncle, Antonio, himself a scholar and a poet of eminence, and afterwards at Rome and Padua. He began his attack upon the mediaeval Aristotelianism which then flourished in Padua and Bologna. Resigning to his brother the archbishopric of Cosenza, offered to him by Pope Pius IV., he began to lecture at Naples and finally founded the academy of Cosenza. In 1565 appeared his great work *De natura rerum iuxta propria principia*, which was followed by a large number of scientific and philosophical works of subsidiary importance. A short time after his death, at Cosenza in 1588, his books were placed on the Index.

Telesio was the head of the great South Italian movement which protested against the accepted authority of abstract reason, and sowed the seeds from which sprang the scientific methods of Campanella and Bruno, of Bacon and Descartes, with their widely divergent results. He proposed an inquiry into the data given by the senses, from which he held that all true knowledge really comes. Instead of postulating matter and form, he bases existence on matter and force. This force has two opposing elements: heat, which expands, and cold, which contracts. These two processes account for all the diverse forms and types of existence, while the mass on which the force operates remains the same. The harmony of the whole consists in this, that each separate thing develops in and for itself in accordance with its own nature while at the same time its motion benefits the rest. The obvious defects of this theory, (1) that the senses alone cannot apprehend matter itself, (2) that it is not clear how the multiplicity of phenomena could result from these two forces, and (3) that he adduced no evidence to substantiate the existence of these two forces, were pointed out at the time by his pupil, Patrizzi. (*See* article on PATRIZZI, FRANCESCO.) His system is a forerunner of all subsequent empiricism, scientific and philosophical, and marks clearly the period of transition from authority and reason to experiment and individual responsibility. Beside the *De Rerum Natura*, he wrote *De Somno*, *De his quae in aere fiunt*, *De Mari*, *De Cometis et Circulo Lacteo*, *De usu respirationis*, etc.

See G. Gentile, *Bernardino Telesio, con appendice bibliographico* (Bari, 1911); E. Troilo, *Bernardino Telesio* (Modena, 1911).

TELESPHORUS, bishop of Rome from about 126 till about 137. St. Irenaeus says that he suffered martyrdom.

TELETYPESETTER, a new invention to set type by telegraph. It operates automatically either a linotype or intertype typesetting machine and will considerably increase production. It is estimated that one man can easily operate four or five of them when controlled by teletypesetters. From one transmitting distributor, type will be set on any number of typesetting machines situated in any place that can be reached by telegraph. It will be valuable also in newspaper offices and in printing plants for purely local work where the tape can be perforated and sent to the composing room to operate the typesetting machines. On the receiving end in newspaper offices a mechanical printer can be operated simultaneously for typewriting the message. In the printing of books, the rolls made by the teletypesetter can be used as a permanent record, making unnecessary storing of metal plate.

The teletypesetter is made of three units: sending, receiving and typesetting. At the sending station the apparatus consists of a perforator, a counter and a transmitting distributor. The perforator, resembling a portable typewriter, produces a tape with coded perforations which the distributor changes into electrical impulses. The receiving apparatus is made up of a reperforator and a printer, the purpose of the latter being to enable the receiver to read the matter transmitted. Beyond the reperforator are the transmitting distributor, through which the tape runs to be changed into electrical impulses, the selecting units, with magnets to operate the typesetting machine, and a panel box, containing relays to control the machine and furnish power to operate the automatic elevator.

Experiments are under way to make the teletypesetter typewrite the message on the tape at the same time that it perforates it. Also, it is being attempted to operate by radio a teletype which automatically records typewritten matter. The development of the teletypesetter is credited to Frank E. Gannett, Walter W. Morey and the Morkrum-Kleinschmidt Corporation. (J. C. Os.)

TELEVISION, by virtue of usage, has come to mean the transmission, to a distant point, usually by electrical means, of moving scenes, to be viewed at the distant point practically simultaneously with their original occurrence. Television is thus differentiated from the viewing of distant events by a telescope, from the electrical transmission of still pictures, and from the projection of motion pictures from films transported to a distance.

Analysis of the Problem.—The problem of electrical television consists essentially in the transformation of light into electrical signals, the transmission of these signals to a distant point and the recreation of light from them. If these three processes can be carried out with adequate speed and accuracy, the transmission of complete moving images may be attained. The process of creating electrical signals from light, transmitting these signals and producing light at the receiving end is a comparatively simple matter if a single light signal is all that is required. In the case of image transmission, however, it is necessary to transmit not one but a vast number of signals in a very brief time. Any image or picture may be considered as made up of a very large number of small areas or elements each of uniform brightness. When an image is viewed by the eye, the rods and cones of the retina perform this analysis of the image into small elements and the many fibrils of the optic nerve simultaneously transmit to the brain the impulses set up by light in each of the rods and cones. It would be theoretically possible to build a television system in which a large number of photosensitive cells were simultaneously exposed to an image and a separate electrical circuit connected with each one carried the electrical signals to a distant point where again a bank of lamps was controlled by the signals. Such a multi-channel scheme is not, however, practical, and all successful methods of television have resorted to a process of *scanning*, by means of which the whole of an image is traversed point by point and the signals corresponding to the various degrees of light and shade are transmitted *in sequence* instead of simultaneously. This is the same device which is used in the electrical transmission of still pictures, and the essential difference between still picture transmission which may take several minutes and television, is that in the latter the entire image must be traversed in a small fraction of a second (about $\frac{1}{20}$) in order that, through persistence of vision, the image when reconstructed may appear complete and may change its character with sufficient rapidity so that motion

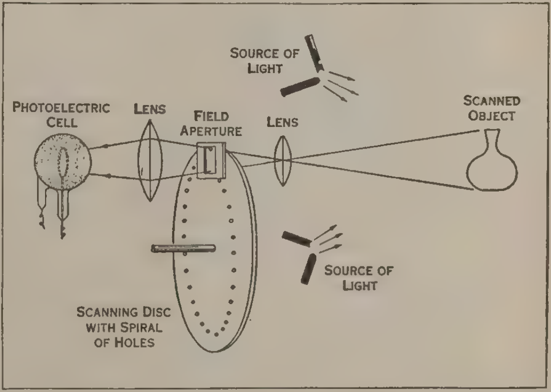


FIG. 1.—DIAGRAM ILLUSTRATING DIRECT SCANNING OF AN IMAGE FOR TELEVISION

of the object viewed may be reproduced without flicker or jerkiness.

Scanning Apparatus.—Various devices such as vibrating mirrors and rotating discs have been proposed for the rapid scanning of an image for television purposes. The means which thus far has been found most practical is a flat circular disc provided with a spiral of small holes. By the rotation of this disc each hole of the spiral passes in turn across the field of view, so that at each complete rotation of the spiral, the whole image has been covered. The most straightforward way of utilizing such a disc is shown in fig. 1, where an image of the scene to be transmitted is projected by means of a lens upon an aperture in front of the disc of such size and shape that only one hole of the disc is at any time exposed to the image. If such a disc is rotated 15 to 20 revolutions per second, the image transmitted through the holes appears virtually complete and steady, although the image is actually built up of a sequence of light signals.

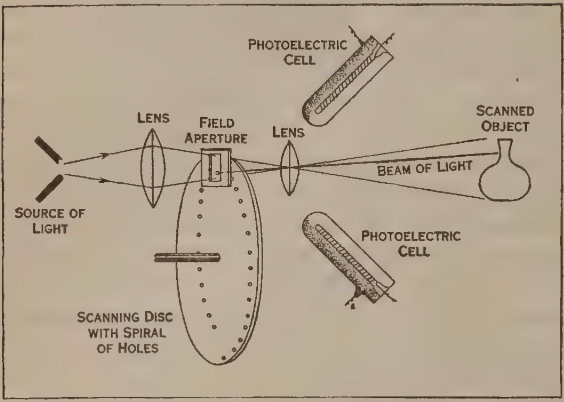


FIG. 2.—DIAGRAM ILLUSTRATING TELEVISION SCANNING BY THE "BEAM" METHOD. THE OPTICAL PATH IS REVERSED, AS COMPARED WITH THE DIRECT SCANNING METHOD SHOWN IN FIG. 1

Transformation of Light into Electrical Signals.—In order to produce electrical currents for transmission purposes, from the light passing through the scanning disc, use is made of some light sensitive device. This light sensitive device must be extremely rapid in its action and should if possible give currents of a magnitude acceptable for transmission over ordinary transmission channels such as a telephone line. For this purpose earlier experimenters used selenium which, however, is relatively sluggish in its response. More recently in the most successful experiments on television, a photo-electric cell has been used. This consists of a glass tube on whose inner wall is a layer of alkali metal such as potassium. The tube may be evacuated or may be filled with an inert gas such as argon at low pressure. The incidence of light on the sensitive surface causes the emission of electrons, thus producing an electrical current which in the case of properly designed photo-electric cells is not only practically instantaneous but is directly proportional to the intensity of the light.

Photo-electric currents suffer from the disadvantage that they are excessively minute when excited by the illumination available from an ordinarily illuminated object. It is necessary to amplify the photo-electric current by means of vacuum tube amplifiers before such currents are available for transmission purposes. It is in fact largely owing to the development of vacuum tube amplifiers, that it has been possible to bring television to a successful stage. Even, however, when using image-forming lenses of the largest light gathering power, it is necessary for the original object to be very brilliantly illuminated if the method of image formation and scanning shown in fig. 1 is to be utilized. It has only recently been possible, by constructing the television apparatus of large dimensions, whereby more light can be utilized, and by the development of very sensitive photo-electric cells, to utilize this "direct" method of scanning, with objects in the relatively intense illumination of outdoor daylight. An alternative method of scanning which utilizes the available light much more efficiently is the method of "beam" scanning. In this (fig. 2) the relative positions of the photo-electric cell and the light sources as shown in fig. 1 are reversed, and a narrow beam of light is projected through the hole in the scanning disc and traverses the object rapidly from side to side. The light reflected from the object is then picked up by photo-electric cells, which may be made of very large area so as to collect the maximum amount of light. The beam method of scanning is applicable to indoor scenes where the objects may be close to the scanning apparatus. The method of direct scanning is suitable for outdoor scenes in sunlight.

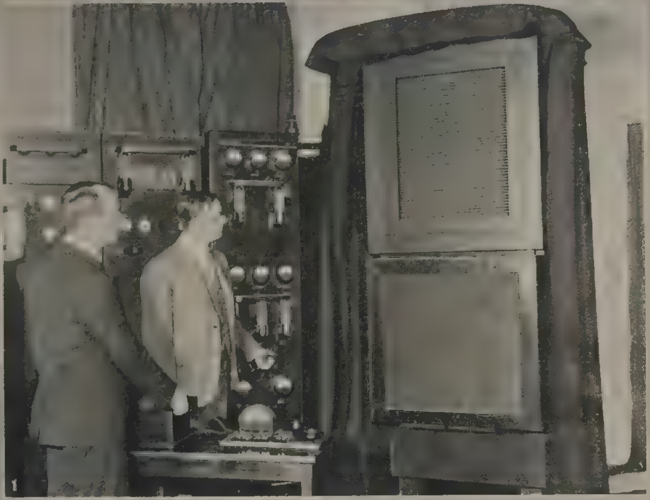
A practical exemplification of the direct method of scanning is shown in Plate fig. 4 where a scanning disc of 3 ft. diameter containing a spiral of 50 scanning holes is utilized to produce television signals from a full length human figure. Plate fig. 6 shows in skeletonized form a practical exemplification of apparatus for the beam method of scanning. Here the light from an arc lamp is condensed upon the back of a scanning disc which carries a spiral of 50 holes, and a narrow beam of light is projected by means of a lens to the face of the sitter. Three large photo-electric cells collect the reflected light and the photo-electric currents thus produced are amplified by means of vacuum tube amplifiers close to the cells. Subsequent amplification to the order of several thousand million-fold raises these currents to sufficient size for transmission over an ordinary electrical communication channel.

Transmission.—The problem of transmitting television signals presents considerable difficulty for the reason that an exceedingly wide band of frequencies must be transmitted without distortion. The nature of the problem may be comprehended by considering a typical case. If the image to be transmitted is scanned by a disc apparatus having 50 holes, the analysis of the entire image corresponds to dividing it into 50 by 50 or 2,500 elements. In order to create the illusion of continuity the image must be completely scanned about 20 times a second. This means that signals corresponding to 50,000 elements per second must be transmitted. In terms of alternating current frequencies, this means approximately 25,000 cycles per second. Now speech transmission by the telephone is successfully accomplished by a frequency band of approximately 2,000 cycles and the best radio broadcasting stations occupy bands not over 5,000 cycles in width. It is, therefore, obvious that the transmission of a relatively crude image corresponding in quality to considerably less than a square inch of newspaper halftone requires transmission facilities of extraordinary quality. In addition to extreme width of transmission frequency band, this band must extend to frequencies much below those necessary for speech, and all parts of the transmission band must be in proper phase relation with each other.

The transmission of television signals may be accomplished either over wire or wireless channels. In the case of wire transmission, it has been found most practical to transmit the television signals directly, utilizing a channel which transmits from below 20 cycles per second up to the highest frequency called for by the degree of resolution of the image. In radio transmission, the television signals are placed upon an appropriate high frequency carrier in the usual manner. In either case, the lowest frequencies—below the repetition frequency of the images—to which are due the general brightness of the picture, are not transmitted, this element of picture quality being arbitrarily inserted as a direct current component at the receiving end. This expedient is resorted to because of the serious technical difficulty of amplifying and transmitting very low frequencies.

In the case of wire transmission, the system must be reasonably free from interference such as produces what in voice transmission is called "noise," which in the case of television causes specks or streaks obscuring the image. In the case of wireless transmission, there are additional sources of trouble, particularly those associated with fading and multiple reflection of wireless signals in the Heaviside layer. These latter produce multiple images whose prominence varies with the distance and time of day, and for which as yet no remedy has been found.

Reception of the Image.—The simplest method of recon-



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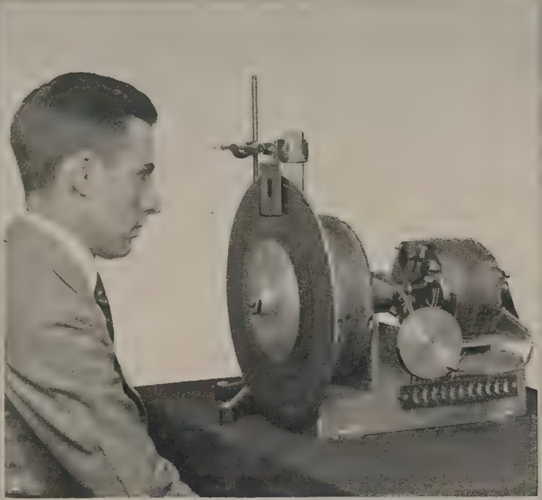

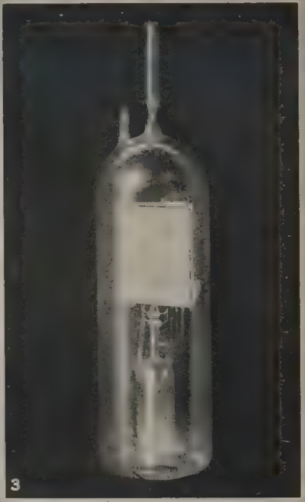

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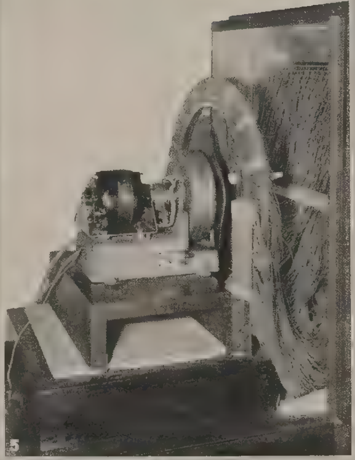

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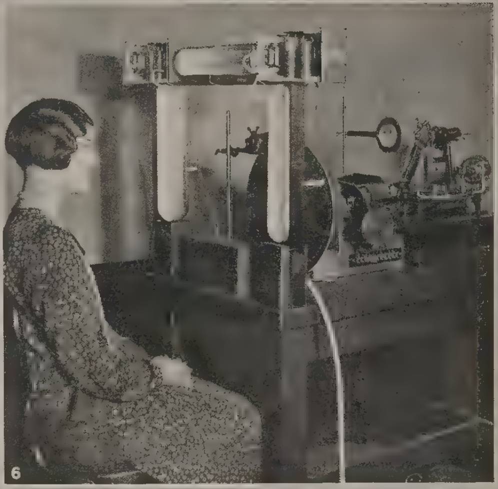

6

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EXPERIMENTAL RECEIVING AND SENDING EQUIPMENT OF TELEVISION

1. Receiving apparatus. Scenes are reproduced on upper screen formed by a continuous neon tube. Lower screen conceals a loud-speaker for reproducing the sounds accompanying the scene
2. Watching a television image. The perforated disc revolving 18 times per second, has 50 holes passing the aperture in the square plate, so that the viewer sees the cathode plate of a neon lamp
3. Neon glow lamp whose brightness varies to produce the illusion of a picture
4. Apparatus for transmission of outdoor scenes. It has larger scanning disc than indoor apparatus and one photoelectric cell which serves as the eye in television
5. Rear view of grid receiver of fig. 1, showing motor which rotates in exact synchronism with sending disc, the distributor and wires leading to the 2,500 external electrodes of the neon tube
6. Apparatus for television—scanning by the "beam" method

structing the image from the television signals consists in the use of a disc with a spiral of holes at the receiving end similar to that at the sending end. Combined with this is a light source, which can be viewed through the disc, which will follow faithfully the variations in strength of the incoming signals. The most successful light source for this purpose is a neon glow lamp furnished with a large flat electrode which when placed behind the disc fills the whole field of view. In the Plate, fig. 2 is shown this arrangement of disc and neon lamp and in the Plate, fig. 3 a neon lamp of a type commonly used. As the observer watches the rapidly rotating disc, he sees at any instant a bright point of light which is of the intensity corresponding to the incoming signal. This in turn corresponds to the photo-electric current generated at the sending end, that is, to the brightness of the image on the sending disc. Due to persistence of vision, the observer is conscious only of a completely illuminated field differing in brightness in its different elements. If the receiving disc is rotating at exactly the speed of the sending disc and exactly in phase with it, the image seen at the receiving end is similar to that at the sending end.

Apparatus of the sort just described is suitable for viewing only by a single individual. Apparatus by which the received image may be observed by a large audience is shown in the Plate, fig. 1. In place of the small neon lamp with a single electrode, a lamp composed of 50 straight parallel glass tubes is utilized. Each tube is furnished with 50 electrodes and the incoming electrical signals are transmitted to each of these electrodes in turn by the distributing device shown in the Plate, fig. 5. Here again, by persistence of vision, the whole area of the grid of neon tubes appears to be continuously illuminated and the image is developed by the varying intensity of the glow at each electrode.

Synchronization.—In order that the scanning and receiving means which have been described shall faithfully reproduce the scene, it is essential that the speed of operation of the two ends shall be identical to a high degree of accuracy. Thus with the two 50 hole discs, which have been taken as typical, if a hole at the receiving end is not to shift from its proper position by more than half its diameter, which is a reasonable restriction, the disc must not move from its proper position during rotation by the distance it travels in about a hundred thousandth part of a second. Deviations from the proper speed produce motion and distortion of the received image. The necessary accuracy of synchronization has been achieved by the use of synchronous motors with a large number of poles operated by relatively high frequency signals. These high frequency signals (2,000 cycles per second) may be generated by a vacuum tube oscillator, or by light received by an auxiliary photo-electric cell from holes or reflecting spots in the disc. The synchronizing signals may be transmitted either over a separate communication channel or, as has been proved practical, may be produced by piezo electric crystal oscillators separately operated at the two ends.

Applications and Problems.—A number of applications of television are suggested by considering parallel cases of sound transmission. In sound we have the use of the telephone for conversation between individuals, the use of loud speaking equipment for carrying speeches to large audiences (*see* Plate, fig. 1) and finally, broadcasting equipment for transmitting voice or music to receiving equipment in homes. We can similarly imagine television equipment to be used in connection with the telephone, in connection with displaying public speakers or athletic events to audiences at a distant point or for the broadcasting of scenes into homes.

At the present time (1928), while all of these possibilities have been experimentally demonstrated, the practical difficulties of transmitting really satisfactory images are so great as to impose a very serious obstacle to the rapid general use of television. The number of image elements which is necessary for the transmission of a complicated scene is excessively large. While a single face may be recognizably rendered with 2,500 elements, the amount of detail shown in the very coarsest newspaper halftones of new events demands 100,000 or more elements. While with sound the same apparatus and transmission channel will handle a chorus as well as a solo, in television the complexity of apparatus and width of transmission channel both increase with the number of performers. The transmission of the human face requires the equivalent of something like ten telephone channels for each direction of transmission, while the transmission of an extended scene in any detail would require transmission facilities equivalent to that of a very large number of radio broadcasting stations. Transmission channels of whatever sort have a money value, compared to which the value of the addition of sight to sound in communication must be soberly estimated. The technical problems encountered in the sending and receiving apparatus also increase greatly with the complexity of the images, so that unless totally new methods of image analysis and synthesis are developed, the apparatus to handle extended scenes must be exceedingly costly. In view of these considerations the likelihood of early wide-spread use of television appears problematic.

Historical.—The general principles by which television might be accomplished have been recognized for a long time. Nipkow in 1884 patented the now generally used disc with its spiral of holes, which he proposed to use in front of a selenium cell. All suggestions of this sort were, however, abortive until the advent of the current amplifying devices which have been developed in the last decade for telephone and radio. Apparatus utilizing spirals of lenses or holes, capable of developing electrical currents from images and reconstructing luminous images from the electrical current was exhibited by several experimentors as early as 1925, notably by C. F. Jenkins in America and J. L. Baird in England. The first complete public demonstration of television involving not only the terminal apparatus for the analysis and synthesis of images, but the actual transmission of the signals to great distances (Washington to New York city) was made by the American Telephone and Telegraph Company in April 1927. Transmissions of images across the Atlantic, and in colour were announced by Baird in 1928. In the same year several radio stations in the United States initiated the broadcasting of crude images of faces and other simple objects. Many technical problems have yet to be solved before television can claim to be more than an interesting novelty and it remains for the future to disclose what its field of utility will be. (H. E. I.)

TELFORD, THOMAS (1757–1834), British civil engineer, was the son of a shepherd, and was born at Westerkirk in Eskdale, Dumfriesshire, on Aug. 9, 1757. From early childhood he was employed as a herd, occasionally attending the parish school of Westerkirk. At 15 he was apprenticed to a stone-mason. He studied in his spare time, and published verses from time to time in the local press. In 1780 Telford went to Edinburgh, where he was employed in the erection of houses in the "new" town, and in 1782 was employed in the erection of Somerset House, London. In 1793 he was appointed engineer of the Ellesmere canal, for which he built the Chirk and Pont-y-Cysyllte aqueducts, and this work established his reputation as a canal engineer.

Telford was commissioned by the British Government to report on the improvement of communications in the Highlands of Scotland. He was appointed engineer for the Caledonian canal begun in 1804, and for the construction of 920 m. of roads, a great part through very difficult country. He was also employed on the improvement of the road between Carlisle and Glasgow, on plans for a system of roads through the more inaccessible parts of Wales, which included the magnificent suspension bridge across the Menai Straits, begun in 1820, and the Conway bridge, begun in 1822. The fisheries and industries of Scotland benefited by the improvements he effected at many of the harbours on the east coast; he constructed the St. Katherine's Docks, London (finished in 1828); and his last piece of professional work was a plan for the improvement of Dover harbour. Other achievements of his later years were the drainage of the north level of the eastern Fen district, an area of 48,000 ac., and erection of the Dean bridge, Edinburgh, and of the Broomielaw bridge, Glasgow. He died on Sept. 2, 1834, in London, and was buried in Westminster Abbey.

See Telford's *Memoirs*, written by himself and edited by John Rickman (1838); also Smiles's *Lives of the Engineers*.

TELL, WILLIAM. The story of William Tell's skill in shooting at and striking the apple which had been placed on the head of his little son by order of Gessler, the tyrannical Austrian bailiff of Uri, is so closely bound up with the legendary history of the origin of the Swiss Confederation that they must be considered together. Both appear first in the 15th century, probably as results of the war for the Toggenburg inheritance (1436–50); for the intense hatred of Austria, increased by her support of the claims of Zürich, favoured the circulation of stories which assumed that Swiss freedom was of immemorial antiquity, while, as the war was largely a struggle between the civic and rural elements in the Confederation, the notion that the (rural) Schwyzers were of Scandinavian descent at once separated them from and raised them above the German inhabitants of the towns.

The Tell story is first found in a ballad the first nine stanzas of which (containing the story) were certainly written before 1474. It is probably to this ballad that Melchior Russ of Lucerne (who began his *Chronicle* in 1482) refers when he excuses himself from giving the story. He narrates how Tell then stirred up his friends against the governor, who seized him and took him by boat to his castle on lake Lugano. A storm arose, and Tell, on account of his great strength, was given the rudder, on his promise to bring the boat to land. He steers it towards a shelf of rock, called in Russ's time Tell's Platte, springs on shore, shoots the bailiff dead with his cross bow, and returning to Uri, stirs up the strife which ended in the battle of Morgarten. In these two accounts, which form the basis of the Uri version of the origin of the Confederation, it is Tell who is the leader. We first hear of the cruelties of the Austrian bailiffs in the Forest districts in the *Bernese Chronicle* of Conrad Justinger (1420), who makes no allusion to Tell. The Tell story and the "atrocities" story are first found combined in a ms. known as the *White Book of Sarnen*. They are contained in a short chronicle written between 1467 and 1476, probably about 1470, and based on oral tradition.

The task of smoothing away inconsistencies and rounding off the tale, was accomplished by Giles Tschudi (*q.v.*), whose recension was closely followed by Johannes von Müller in his *History of the Confederation* (1780). The final recension of Tschudi's *Chronicle* (1734–36), which differs in many particulars from the original draft preserved at Zürich, tells how Albert of Austria, in order to deprive the Forest lands of their ancient freedom, sent bailiffs (among them Gessler) to Uri and Schwyz. Their tyranny resulted in a rising, planned at the Rütli, on Nov. 8, 1307, and led by Werner von Stauffacher of Schwyz, Walter Fürst of Uri, Arnold von Melchthal in Unterwalden, each with ten companions, among whom was William Tell, to expel the oppressors. On Nov. 18 the Tell incident takes place (described according to the *White Book* version), and on Jan. 1, 1308 the general rising. Tschudi thus finally settled the date, which had before varied from 1260 to 1334. He distorts the historical circumstances. In his first draft he speaks of the bailiff as Gryssler—the usual name up to his time, except in the *White Book* and in Stumpff's *Chronicle* of 1548—but in his final recension he calls him Gessler, knowing that this was a real name. Later writers added a few more particulars. Johannes von Müller (1780) described the oath at the Rütli by the three (Tell not being counted in), and threw Tschudi's version into a literary form. Schiller's play (1804) gave the tale a world-wide renown.

The general result of the researches of various students, J. E. Kopp, Vischer, Rochholz and others, has been to show that a mythological marksman and an impossible bailiff bearing the name of a real family have been joined with confused and distorted reminiscences of the events of 1245–47, in which the names of many real persons have been inserted and many unauthenticated acts attributed to them. Th. von Liebenau has, however, shown (in an article reprinted from the *Katholische Schweizerblätter* in the *Bollettino Storico della Svizzera Italiana* for 1899) that in 1283 the Emperor Rudolf of Habsburg gave the right of receiving the tolls for escort over the St. Gotthard Pass to his sons, the dukes of Austria. The levying of these tolls gave rise to various disputes between the men of Uri and the bailiffs of the dukes of Austria, and by 1319 (if not already in 1309) the claim to levy them was silently given up. These facts show (what could not hitherto be proved) that at the time when legend places the rising of Uri, Tell exploit, etc., the dukes of Austria really had disputes with Uri.

The alleged proofs of the existence of a real William Tell in Uri in the 14th century break down hopelessly. (1) The entries in the parish registers are forged. (2) As to the Tell chapels—(*a*) that in the "hollow way" near Küssnacht was not known to Melchior Russ and is first mentioned by Tschudi (1572). (*b*) That on Tell's Platte is first mentioned in 1504. The document which alleges that this chapel was built by order of a "landsgemeinde" held in 1388, at which 114 men were present who had been personally acquainted with Tell, was never heard of till 1759. The procession in boats to the place where the chapel stands may be very old, but is not connected with Tell till about 1582. (*c*) The chapel at Bürglen is known to have been founded in 1582.

In general *see* two excellent works by Franz Heinemann, *Tell Iconographie,* Lucerne, 1902 (reproductions, with text, of the chief representations of Tell in art from 1507 onwards), and *Tell Bibliographie* (including that of Schiller's play), published in 1908 at Bern. *See* also W. Vischer, *Die Sage von der Befreiung der Waldstätte* (Leipzig, 1867); E. L. Rochholz, *Tell und Gessler,* with a volume of documents 1250–1513 (Heilbronn, 1877); and P. Lang, *Die Schweiz. Tellspiele* (1924). (W. A. B. C.; X.)

TELLICHERRY, a seaport of British India, in the Malabar district of Madras, on the Madras railway, between Cannanore and the French settlement of Mahe. Pop. (1921) 27,576. It is a healthy and picturesque town, built upon a group of wooded hills running down to the sea, and is protected by a natural breakwater of rock. Ships are able to anchor 2 miles from the shore. A pier and sea-wall have recently been built and the port can be used during the monsoon season. Tellicherry was at one time defended by a strong mud wall and the old fort still stands to the north of the town. The East India Company established a factory here in 1683 for the pepper and cardamom trade. For two years (1780–82) the town withstood a siege by Hyder's general, and in the subsequent wars with Mysore Tellicherry was the base of operations for the ascent of the Ghats.

TELLURIUM, a chemical element and the third member of the sulphur and selenium family (symbol Te, atomic number 52, atomic weight 127·5). It is a complex element having three isotopes (*q.v.*) with atomic weights 126, 128 and 130. Tellurium is a brittle, silvery white, metallic substance of specific gravity 6·27; it melts at 452° C and boils at 1,390° C; its hardness is 2·3 (Mohs). It crystallises in hexagonal-rhombohedral prisms and is isomorphous with the stable grey modification of selenium (*q.v.*). Tellurium was first recognised as a distinct element in 1798 by M. H. Klaproth, although it had already attracted the notice of mineralogists and metallurgists who on account of its peculiar properties termed it "aurum paradoxum" or "metallum problematum." It is widely distributed although in small amounts. Rarely found native as metallic tellurium, it more generally occurs in combination with metals in such minerals as sylvanite, $(Au,Ag)Te_4$, petzite, $(Au,Ag)_2Te$, tetradymite, $Bi_2(Te,S)_3$, and telluric ochre, TeO_2. The red tellurium sulphur of Japan contains 99·76% S, 0·17% Te, 0·06% Se and 0·01% As. Tellurium minerals are found in Germany, Colorado, California, Ontario, Mexico, South America and West Australia, often accompanying gold deposits. The chief sources of tellurium are the slimes from copper and lead refineries and the flue dusts from telluride gold ores. The slimes contain both tellurium and selenium, and similar processes are used in the extraction of both elements. The slimes from copper refining contain more selenium, those from lead yield more tellurium. The dusts or slimes are fused with sodium carbonate and nitrate, the melt being lixiviated with water. The alkaline liquors containing sodium tellurite and selenite are cautiously acidified with sulphuric acid when tellurium dioxide is precipitated. The dioxide may be reduced in the dry way with powdered charcoal or dissolved in hydrochloric acid and reduced with sulphur dioxide, when tellurium is precipitated. Further purification is effected by dissolving tellurium in dilute nitric acid (sp.gr. 1·255) and crystallising the basic nitrate, $2TeO_2,HNO_3$.

Applications.—Despite the labours of the chemical research school at Wisconsin University, no extensive use has been found for tellurium, although comparatively large supplies are available, it being estimated that in the U.S.A. alone 125,000 lb. of the metal could be produced without material alterations in existing plants. Most of the output is sold to makers of wireless equipment, since metallic tellurium has some merit as a rectifier or crystal detector. A noteworthy application was the addition of diethyl telluride to motor spirit as an anti-knock material, but although effective this substance has been superseded by lead tetraethyl (*see* LEAD, COMPOUNDS OF; ORGANO-METALLIC COMPOUNDS: *Fourth Series*). Colloidal tellurium has been suggested as an insecticide and fungicide in wood preservation. To a limited extent tellurium has been employed in colouring glass or porcelain, developing brown, blue or red shades. Acid solutions of the dioxide have been used as a dip for silver ornaments, giving a "platinum finish" to the metal. Soluble tellurium compounds are utilised in toning baths in photography. Tellurium and compounds have been tested therapeutically without marked success.

Physical Properties.—Tellurium is a poor conductor of heat and electricity and the latter property varies only slightly with change of illumination. Its electrical resistance of 200,000 microhms per cubic centimetre is the highest of any metal. Its yellow vapour has a density corresponding with the molecular formula Te_2. Allotropy (*q.v.*) is far less definite than with selenium and sulphur. There is an amorphous modification of tellurium, a crystalline variety, and colloidal preparations of tellurium are made by reducing dilute solutions of telluric acid with hydrazine or sulphurous acid with or without protective colloids.

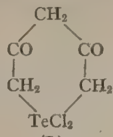
Compounds.—Hydrogen telluride or telluretted hydrogen, H_2Te, is a very unstable gas with a repulsive odour; its boiling point is 0° C and it melts at $-48°$ C. It is best prepared by decomposing aluminium telluride, Al_2Te_3, with water or dilute hydrochloric acid. Tellurium furnishes two chlorides, both prepared by direct combination of the metal with chlorine. The dichloride, $TeCl_2$, is a brown amorphous mass which melts indefinitely to a black liquid boiling at 327° C. The tetrachloride, obtained with excess of chlorine, is a snow-white, crystalline mass melting at about 220° and boiling at 380° C. It is hydrolysed by water. Similar compounds are formed with bromine.

Tellurium dioxide is a white crystalline mass produced by igniting telluric acid or by oxidising tellurium with nitric acid; it becomes yellow on heating, melts at dull red heat and distils in a vacuum at bright red heat. It is only slightly soluble in water but is amphoteric, dissolving in either aqueous acids or alkalis. Tellurium trioxide, an orange-yellow, crystalline substance, is left on igniting telluric acid at a red heat. Telluric acid, $H_2TeO_4,2H_2O$, a snow-white crystalline powder, is made by oxidising tellurium or its dioxide with either chromic acid or chlorates.

ORGANIC DERIVATIVES OF TELLURIUM

The dialkyl tellurides are prepared by distilling potassium telluride with the salts of alkyl sulphuric acids. Dimethyl telluride, a liquid of repulsive odour, boils at 82° C. It is probably the origin of the unpleasant garlic odour noticed in the breath and perspiration of patients or animals treated with tellurium or tellurium compounds. Diethyl telluride, the proposed anti-knock compound, boils at 137·5° C. When heated together at 80° tellurium and methyl iodide combine to form red dimethyltelluronium di-iodide, $(CH_3)_2TeI_2$, converted by silver oxide into dimethyltelluronium dihydroxide, $(CH_3)_2Te(OH)_2$, a base which on heating yields the complex oxide $(CH_3)_3Te{\cdot}O{\cdot}Te(CH_3){:}O$. This oxide forms two iodides, $(CH_3)_3TeI$ and CH_3TeI_3, which unite together yielding greenish-black spangles of the complex iodide $[(CH_3)_3Te][TeCH_3I_4]$ (H. D. K. Drew, 1929).

By the action of tellurium tetrachloride on acetylacetone and certain of its homologues, a series of cyclic organotellurium compounds have been obtained containing the *cyclo*telluropentane ring. The initial product, *cyclo*telluropentane-3:5-dione dichloride, m.p. 115° C (formula I.), is reduced by alkali bisulphites to *cyclo*telluropentane-3:5-dione (II.) crystallising in golden yellow needles and melting at 182° C (G. T. Morgan and H. D. K. Drew, 1920–1922). The substance and its homologues have outstanding bactericidal properties, even in extremely dilute solutions.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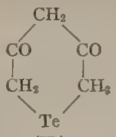
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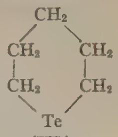
(III.)

The condensation of aluminium telluride with pentamethylene $\alpha\epsilon$-dibromide gives rise to three cyclic tellurium compounds from which *cyclo*telluropentane (formula III.) can be prepared. This compound, the parent substance of the ketonic series (II.) is a very oxidisable yellow oil (b.p. 82–83°/12 mm.) with disagreeable odour, and gives rise to crystalline dihalides, $C_5H_{10}{:}TeX_2$ (G. T. Morgan and H. Burgess, 1928). When tellurium tetrachloride reacts with acetic anhydride, the product furnishes tellurodiacetic and ditellurodiacetic acids, together with a compound, $CH_2(TeCl_3)_2$, containing no oxygen. This hexachloride on reduction with bisulphite loses all its chlorine and yields ditelluromethane $(CH_2{:}Te_2)_x$, a solid existing in red and black modifications (Morgan and Drew, 1925).

Detection and Estimation.—Tellurium is precipitated by hydrogen sulphide and is separated from selenium owing to the greater facility with which the latter is liberated from its compounds by reducing agents. In strongly acid solutions sulphur dioxide eliminates red selenium but not tellurium. The excess of acid and sulphur dioxide are boiled off; potassium iodide is added, and black TeI_4 is precipitated, redissolving in excess of reagent to K_2TeI_6, from which dark red solution sulphur dioxide now readily precipitates tellurium. Tellurium may be weighed either as such or as the oxide.

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TELPHERAGE. During the World War the Italian Army made extensive use of the telpher (*see* MONO-RAILS AND TELPHERS) system of transport for fighting in the Alps. It had previously been thought impossible to conduct military operations on the high peaks, but the early days of the war saw whole companies of men clinging hand and foot to the rocky summits. The building of roads could not always meet the requirements of troops operating in Alpine districts. Wire railways or "telphers" were provided, thus economising time, labour and oil, and avoiding congestion of roads. These telphers are a kind of suspension railway. A double metal cable called "bearer" is extended on trestles placed in a straight line at different distances on the sides of the mountain. There are two stations, one at the starting point and the other at the end of the line. In one of these stations there is a motor which works an endless cable (the "drawer") to which are fixed two or more small wagons. The cable turns and draws the wagons supported by the "bearer" cable by means of small wheels which run on it.

1. **Telefori.**—These were provisional lines moved by man power and used in the most advanced zones to supply isolated posts or trenches. Their average length was 500 metres and each could carry about 50 quintals a day.

2. **Dismountable Teleferiche.**—These were run by motors and were put up in advanced zones. Their average length was from 1,000 to 2,000 metres, and each could carry from 10 to 20 quintals an hour. They could be dismounted and were portable.

3. **Permanent Teleferiche.**—These were run by motors and were fixed. They were employed at some distance from the lines, and reached a maximum length of 8,000 metres. They could carry about 150 quintals per hour. The telphers covered on an average a rise of 650 metres from the starting-point to that of arrival; but in some cases even 1,500. The trestles were often at very great distances from one another and placed on peaks, while the wagons ran over fearful abysses. In the highest regions the lines often

ran at a height of 2,000 to 3,000 metres; a few were installed even at 3,500 metres above sea-level. The telpherage lines laid on the Italian front transported in all 33,000,000 quintals, the load of 330,000 railway trucks.

TELPHERS: *see* MONORAILS AND TELPHERS.

TELUGU, one of the five great Dravidian languages. The Telugu-speaking peoples are partly subjects of the nizam of Hyderabad and partly under British rule, beginning north of Madras city and extending north-west to Bellary, where Telugu meets Kanarese, and north-east to near Orissa. In many respects it occupies an independent position and can be characterized as the only descendant of the Āndhra dialect of Old Dravidian.

See Bishop Caldwell, *Comparative Grammar of the Dravidian Languages,* and *Linguistic Survey of India,* vol. iv. (1906).

TEM, a people in north-west Dahomey speaking a language related to Kokomba. They live in extended family groups in compounds in villages surrounded by a defensive wall.

TEMBU (Ama-Tembu), a powerful Kaffir tribe, who have given their name to Tembuland, a division of Cape Colony south-west of Griqualand East. They are traditionally descended from Tembu, elder brother of Xosa, from whom most "Kaffirs" claim descent.

TEMENOS, the Greek term in archaeology given to the enclosed sacred area around a temple or sanctuary.

TEMPE, VALE OF, the ancient name of the gorge, through which the river Peneus (mod. Salambria) reaches the sea from the plain of Lower Thessaly. Greek legend attributed this chasm to Poseidon; before it was riven, between Olympus and Ossa, Thessaly was a lake. It is about four and a half miles long, and towards the middle of the pass, where the rocks are highest, the precipices in the direction of Olympus fall steeply to the stream; but those which descend from Ossa are the loftiest, for they rise in many places not less than 1,500 ft. from the valley. It was a position easily defended, but has often offered a practicable entrance to Thessaly from the north; a number of castles (of which the ruins still exist) were built at different times at the strongest points. The mediaeval road follows sometimes one bank, sometimes the other; the railway is wholly north of the stream. Being still forested, with numerous lateral valleys, the scenery is unusually picturesque for Greece: its beauty was famous in antiquity. Tempe was sacred to Apollo, to whom a temple was erected on the right bank. Every ninth year a sacred mission visited the valley to pluck laurel for the chaplets for the Pythian games.

TEMPELHOF FIELD, the airport of Berlin, Germany, was constructed on the site of Tempelhof Military Field soon after the World War. The airport consists of 1,500,000 sq. metres and is admirably situated, being within the city limits. During 1928, 31,547 passengers and 615 tons of freight, baggage and mail were handled through Tempelhof. The airport is provided with numerous hangars, two of which cover an area of about 26,000 sq.ft. each. The wireless station supplies weather reports from all parts of Europe. Close to this office is the headquarters of the air police, above which is placed the field-control tower, from which all departing and arriving aeroplanes are regulated. There is also a powerful beacon which is visible at a distance of 60 miles. A modern system of lighting has been provided to facilitate night-flying. Every aeroplane landing at or leaving Tempelhof undergoes strict inspection by the air police. (*See* AIRPORTS.)

TEMPERA, the name given to the painting processes in which the medium employed is an albuminous, gelatinous or colloidal material. Practically, this is equivalent to saying that any painting process in which a vehicle, or binding material, other than oil is employed is tempera.

History.—The earliest known painting was undoubtedly of this nature. The wall paintings of ancient Egypt and Babylon and those of Mycenean Greece, as well as the mummy cases and papyrus rolls in the first named country, were executed in some form of tempera. The same is probably true of the wall paintings in Italian tombs.

Yolk of egg, either alone or with the addition of a little vinegar, was the vehicle most generally used, but many other substances were also employed. Among them were the liquid obtained by boiling parchment or the skins of animals in water, which is practically the same thing as using glue. Pliny mentions the use of milk as a medium.

In more modern times it was the medium of the Italian Primitives. Cimabue learnt it from the Greeks, or so says Vasari, and Giotto, Fillipo, Lippi, Ghirlandajo, Botticelli and many others used it for their inspired works. Raphael, Titian and Tintoretto probably used it, at least for under-painting. In northern Europe tempera was earlier supplanted by oil than in Italy, but many of the Flemish and German Primitives employed it.

Process.—The ground used by Cimabue, Giotto and their compatriots was usually gesso (plaster of Paris). Cennini gives very full instructions for the making of gesso panels. This was a complicated process involving, first, the preparation of the panel of poplar, lime tree or willow wood, of which all the interstices were to be filled with a mixture of size and sawdust. The panel was then covered with old linen cloth held in position by more size. On this surface the *gesso grasso,* or heavy plaster of Paris, ground in size, was spread with a spatula. The *gesso sottile* or final ground, composed of thoroughly slaked plaster of Paris mixed with size was then applied with a brush.

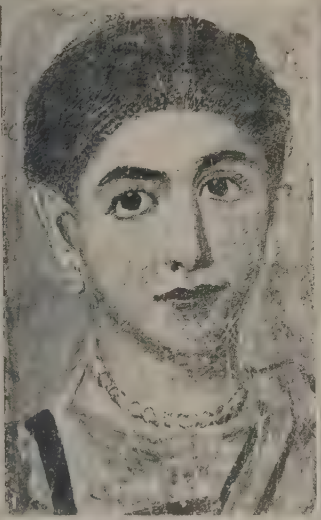
Devotees of tempera painting as practised by the Italians are convinced, not only of its great permanency, but of its peculiar charm. To quote Miss Herringham, the translator of Cennini: "There is no doubt that while fresco and tempera produce a decorated space in itself pleasant and figures and other objects can be suggested in slight chiaroscuro (*q.v.*) without appearing unfinished or crude, this is not the case in oil painting, which seems incapable of giving that pleasantness to the surface of a wall and requires a completeness in values, tones and tactile qualities which makes the spectator look into the picture and forget the surface. Therefore the one art is monumental, where the surface must not be forgotton or obliterated and the other on the whole appears opposed to monumental painting."

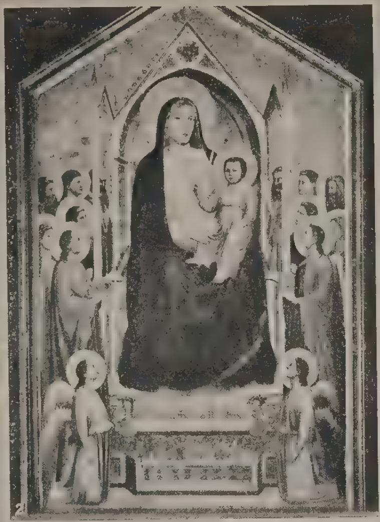
Roger E. Fry, writing in the *Burlington Magazine* of the charm of classic tempera says: "One may sum up the whole question of tempera as a medium by saying that, while it is more difficult than in oil painting to produce any effect at all, it is yet more difficult, almost impossible indeed, to produce with tempera those thoroughly ugly and uninviting surfaces which it requires profound science to avoid in the clayey mixtures of oil paint. Nothing would be likely to have a more restraining and sobering influence on our art than the substitution of tempera for oils as the ordinary medium of artistic expression."

Modern Uses.—Egg tempera, the medium to which both of these laudatory comments apply, is doubtless a most charming medium and an exceedingly permanent one, as demonstrated by the apparently magnificent preservation of many specimens of very great antiquity. It does, however, as Fry points out, present many technical difficulties, principally because of its exceedingly rapid drying. "Transitions of colour" says Fry, "must be made by hatched strokes or else by continual laying one thin coat over another until the transition is produced." This was the practice of the early Italians. In these days of "ready mixed" colours, procurable anywhere, there is not much occasion for the keeping alive of the ancient practices. Occasionally, however, an artist uses them successfully for current work.

In different fields, certain workers do find it desirable to-day to combine dry colours with a tempera medium. For example, commercial illustrators have discovered that it is possible, by the admixture of dry pigment with a gum arabic-glycerine compound, to obtain colour of much stronger intensity—saturation—than can be had in commercial water-colour. This method of working has the advantage that the strength of the prepared colour is within the artist's control. It is also claimed that it is possible to obtain a very even and flat tone and one that, because of the absence of reflections, is particularly adapted to photographic reproduction.

Doubtless there are many other forms of artistic endeavour in which use is made of tempera mediums with dry colour, as in some forms of modern fresco, for example, but tempera, in

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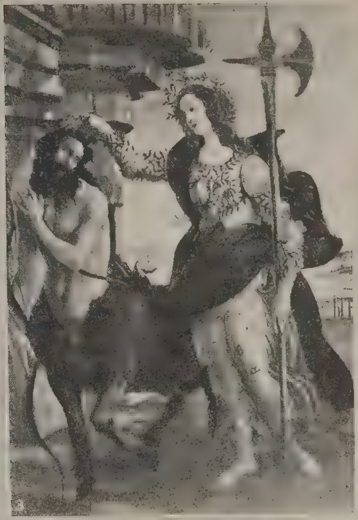

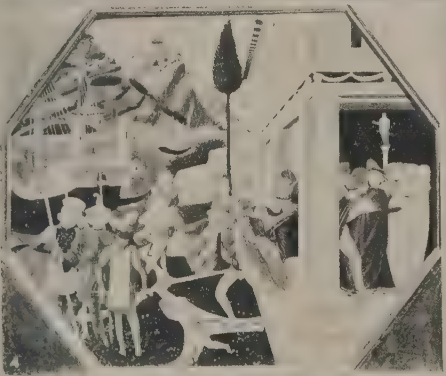

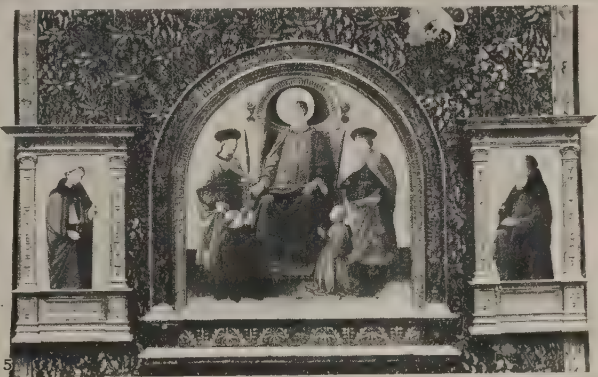
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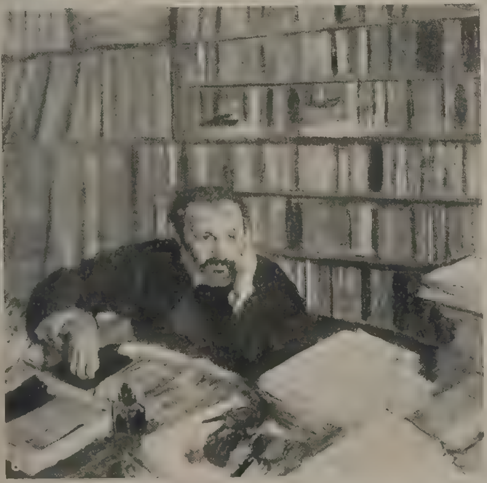

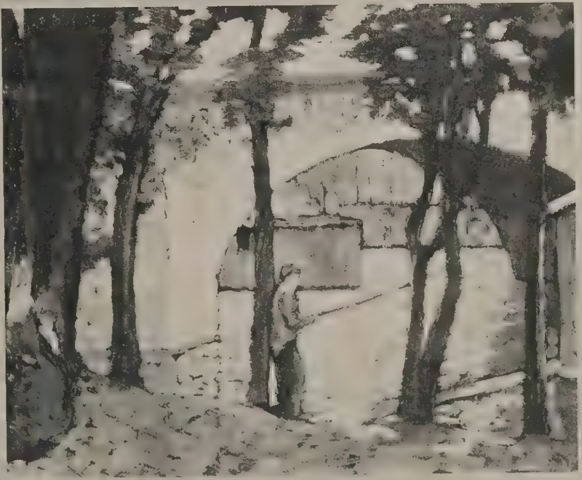

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TEMPERA PAINTINGS OF EARLY, MEDIAEVAL AND MODERN TIMES

1. Head of woman painted on wood with coloured powder mixed with white wax. Graeco Egyptian. In the Louvre. 2. "Madonna and Child Enthroned" by Giotto (*c.* 1267–1337). Uffizi Gallery, Florence. 3. "Pallas Taming a Centaur" by Botticelli (1444–1510). Uffizi Gallery. 4. "Rape of Helen" by Benozzo Gozzoli (*c.* 1424– ?). 5. "St. Lawrence Enthroned between Saints Cosmos and Damian" by Fra Fillipo Lippi (1406–69). 6. Portrait of Duranty by Hillaire G. E. Degas (1834–1917). Probably is partly done in thin oils with distemper in the dry—*i.e.*, pastel—used for the face. 7. "The Bridge—Right Bank" by Yarnall Abbott. American contemporary

its modern application is, like oil painting, almost entirely a matter of the use of prepared colours. These are ground by the manufacturers in various colloidal, gelatinous or albuminous vehicles and sold put up in tubes, pans or pots, but, unlike oil, the products of different manufacturers differ so greatly in character as to necessitate completely different techniques. The product of some colourmen is to be used with the addition only of water, while in other varieties the use of prepared "tempera mediums" is necessary. These are, naturally, compounds similar to the vehicles in which the particular colours are ground. It may be noted that ordinary water-colour, show-card colour and the like, are of course, strictly tempera, being ground in gum arabic and glycerine, although water-colour is only characteristic of the tempera medium when used as *gouache* or body colour.

As noted above, the products of different colourmen vary so radically that it is difficult to give any idea of present day tempera technique. In common they all present the quality of opacity; they may be used upon a great variety of surfaces and, in most cases, the permanency of the results depends only upon that of the ground. Due to their opacity, they may be used to very great advantage on dark grounds—a method of painting which has much to commend it. Most of the temperas in the market, however, are subject to the rather serious objection that the colours become lighter in drying.

Except as used for under-painting, tempera painting of to-day is a direct process. Unlike oil the colour usually dries very quickly upon the ground and any alteration of a tone by "painting into" it is difficult to achieve successfully. This directness, this *premier coup* quality, is one of the charms of the medium and also makes it desirable for quick sketching.

Most users of tempera to-day are in the habit of employing it very flatly, frequently in the form of spots or "lozenges," so to speak, of clean colour applied to grounds which vary from grey or brown to black. This technique is highly characteristic of tempera painting as it is found in the water-colour shows of the United States. But some forms of commercial tempera may be used in a manner which approaches oil in appearance and in which the broken quality of a partially mixed tone may be preserved. For this type of painting very little or no medium is used; heavy water-colour paper is employed as a ground and this may be obtained in a variety of tints from white to black.

A number of prominent artists still use tempera as the medium with which to commence paintings which are completed in oil.

Emil Carlsen, one of the most noted of those who employ this technique, uses an absorbent canvas, certain commercial colours and a commercial egg medium. For the first painting he recommends the using of the colour thinly, with water as a medium. This completed, the canvas is allowed to dry for a day or two, is then given one or two coats of tempera varnish A, and again let dry for a few hours. The picture is now given a light wash of the egg tempera medium and the painting is continued, using egg tempera as the medium instead of water. The colours can now be used solidly but it is necessary to lay layer over layer and let them dry between times or the colour will crack. "The result," says Mr. Carlsen, "is an extremely hard and light underpainting, that, if varnished with a good coat of tempera varnish, well dried, will hold up a piece of painting wonderfully and give it more luminosity in the picture's future than any other process."

It will be evident that the art of tempera painting is even more difficult to limit and define than is painting in oil. It is an art the technique of which varied greatly, as did the vehicles employed, even in its classic period, and this is equally true as to the more or less sporadic revivals of the old processes which are employed to-day, while, as to the commercial tempera of the shops, the colours supplied by one manufacturer may possess radically different qualities and call for a totally different technique from those of another manufacturer, and still be equally desirable. But in this very lack of uniformity is an incentive to the artist who is seeking for an individual, a personal technique. Whether he seeks for this in the use of prepared products or in the study and application of the ancient methods he will find in tempera a number of subtle and illusive charms which will well repay him for the search. (*See* also PAINTINGS; OIL PAINTINGS; PAINTS, CHEMISTRY OF.)

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(Y. A.)

TEMPERAMENT, in psychology, means a kind of lasting emotional mood or temper. Some people are habitually cheerful, others are as habitually melancholy, and so on. The oldest known classification of temperaments is considerably over two thousand years old, and the names associated with that classification are still in daily use. It originated with a Greek medical school known as the Hippocratic school (*see* HIPPOCRATES), and was based upon a theory about the varying proportions of four juices (or "humours") in bodies (Latin *temperare* means "to measure"). The four liquids in the body were alleged to be blood, phlegm, black bile and yellow bile. And according as one or other of these four preponderates in the body of a person, there results the *sanguine* temperament (Latin *sanguis*, blood), the *phlegmatic* temperament, the *melancholic* temperament (Gr. *μελαγχολικός*, with black bile), or the *choleric* temperament. The sanguine temperament is quick, predisposed to pleasant emotions, but weak, and inclined to change quickly from one interest to another. The phlegmatic temperament is slow, lacking in vivacity, but calm and strong. The melancholic temperament is predisposed to sad emotions, slow and weak. The choleric temperament is predisposed to anger, and emotionally quick and strong.

In Music.—Temperament is the manner in which the limited number of notes of a keyed instrument are tuned or "tempered," various methods being possible, *e.g.*, unequal temperament, mean-tone intonation and equal temperament. In the case of an instrument tuned in unequal temperament a few keys will be as near as possible to the mathematical ideal of just intonation, but all the other keys will be more or less seriously out of tune.

Thus supposing the key of C to be tuned in just intonation, with G tuned in consequence as a really exact fifth, this same G will not be in tune when it is required to serve, not as the fifth to C, but as, say, the third to E flat or the fourth to D. Hence therefore the adoption as a compromise of the system known as equal temperament, whereby these inaccuracies of intonation are equally distributed over all the keys, with the result that no one key is better than another but all are sufficiently in tune for practical purposes and can be used with equal freedom.

The mean tone system was an unequal temperament that split the difference between the major tone (8: 9) and the minor tone (9: 10). It long had its warm advocates, but finally had to yield to the superior practical advantages of equal temperament.

(*See* HARMONY; KEY; MUSICAL NOTATION.)

TEMPERANCE. The word "temperance," which strictly means moderation, has acquired a particular meaning in connection with intoxicating liquor, and it is here used in that sense.

Historical.—Ever since man in some distant age first discovered that process of fermentation by which sugar is converted into alcohol and carbonic acid, and experienced the intoxicating effects of the liquor so produced, there has been, in a sense, a temperance question. The records of the ancient oriental civilizations contain many references to it, and from very remote times efforts were made by priests, sages or law-givers in India, Persia, China, Palestine, Egypt, Greece and Carthage to combat the vice of drunkenness. But the evil appears never to have been so great or the object of so much attention in the ancient world as in Western countries and our own era. Two circumstances mainly differentiate the modern problem; one is the use of distilled waters or spirits as a beverage, and the other the climatic conditions prevailing in the more northern latitudes which are the home of Western civilization. The intoxicating drinks used by the ancients were wines obtained from grapes or other fruits, and beers from various kinds of grain. These products were not confined to the East, but were known to the ancient civilizations of Mexico and Peru and even to primitive peoples who used the sugar-containing juices and other substances indigenous in their country. In the time of the Romans the barbarians in the north of Europe used fermented liquors made from honey (mead), barley (beer) and apples (cider) in place of grape-wine. All such drinks produce intoxication if taken in sufficient quantity; but their action is much slower and less violent than that of distilled spirits.

Distillation of essences from various substances seems to have been known to the ancients and to have been carried on by the Arabians in the dark ages; but potable spirits were not known until the 13th century. The distilled essence of wine or *aqua vitae* (brandy) is mentioned then as a new discovery by Arnoldus de Villa Nova, a chemist and physician, who regarded it, from the chemical or medical point of view, as a Divine product. It probably came into use very gradually, but once the art of distillation had been mastered it was extended to other alcoholic substances in countries where wine was not grown. Malt, from which beer had been made from time immemorial, was naturally used for the purpose, and then gin or Geneva spirits and whisky or usquebagh (Irish for "water of life") were added to grape brandy; then came corn brandy in the north and east of Europe, rum from sugar canes in the Indies, potato spirit, and eventually, as the process was perfected, rectified ethyl alcohol from almost anything containing sugar or starch.

The concentrated form of alcohol, thus evolved, for a long time carried with it the prestige of a Divine essence given to it in the middle ages when chemistry was allied to all sorts of superstitions. It had potent properties and was held to possess great virtue. This view is embodied in the name "water of life," and was at one time universally held; traces of it still linger among the very ignorant. Ardent spirit seemed particularly desirable to the habitants of the cold and damp regions of northern Europe, where the people took to it with avidity and imbibed it without restraint when it became cheap and accessible. That happened in England in the early part of the 18th century (*see* Liquor Laws); and out of the frightful results which followed there eventually arose the modern temperance movement. The legislature had been busy with the liquor traffic for more than two centuries previously, but its task had been the repression of disorder; the thing was a nuisance and had to be checked in the interests of public order. It is significant that though drunkenness had been prevalent from the earliest times, the disorder which forced legislative control did not make its appearance until after the introduction of spirits.

Intemperance was one of many questions which we can now see were struggling into existence during the latter half of the 18th century, to become the subject matter of "social reform" in the 19th. Like the majority of them it was a question of bodily welfare, of health. A breach had been made in the unthinking traditional belief in the virtue of alcoholic liquor by the experiences referred to; and medical thought, as soon as it began to busy itself with health as distinguished from the treatment of disease, took the matter up. In 1804 Dr. Trotter, of Edinburgh, published a book on the subject, which was an expansion of his academic thesis written in 1788; Dr. Benjamin Rush, of Philadelphia, a distinguished American physician and politician, who had studied in Edinburgh and London, wrote a striking paper on the same subject in the same year; and very soon after this the organized temperance movement was set on foot in the United States.

Temperance Organization.—In 1808 a temperance society was founded at Saratoga in the State of New York, and in 1813 the Massachusetts Society for the Suppression of Intemperance made its appearance. These seem to have been the earliest organizations, though the device of a pledge of abstinence had been introduced in 1800. The movement made rapid progress mainly under the influence of the Churches. In 1826 the American Society for the Promotion of Temperance was founded in Boston, and by 1833 there were 6,000 local societies in several States with more than a million members. The campaign was, for the most part, directed against the use of spirits only, and the proposal to include all alcoholic drinks in the pledge of abstinence, though adopted by a few societies, was rejected in 1833 by the American society, but accepted in 1836 and retained ever since.

In Europe the earliest organizations were formed in Ireland. A temperance club is said to have been started at Skibbereen in 1818, and others followed; but it was in 1829 that the organized movement began to make effectual progress with the formation of the Ulster Temperance Society. By the end of that year there were 25 societies in Ireland and two or three in Scotland. In 1830 the movement spread to Yorkshire and Lancashire, and supported a newspaper called the *Temperance Societies' Record*, according to which there were then 127 societies with 23,000 paying members and 60,000 associated abstainers. In 1831 the British and Foreign Temperance Society was founded in London with the bishop of London (Blomfield) for president and Archbishop Sumner for one of the vice-presidents. This important society, of which Queen Victoria became patron on her accession in 1837, came to an end in 1850, when the whole cause was under an eclipse. The most remarkable episode in the temperance campaign at this period was the mission of the Rev. Theobald Mathew, of Cork, commonly known as Father Mathew, the greatest of all temperance missionaries. He travelled through Ireland in the years 1838–42 and everywhere excited intense enthusiasm. People flocked to hear him and took the pledge in crowds. In 1841 the number of abstainers in Ireland was estimated to be 4,647,000, which is more than the entire population to-day. In three years the consumption of spirits fell from 10,815,000 to 5,290,000 gallons. This was not all due to Father Mathew, because great depression and distress prevailed at the same time, but he unquestionably exercised an extraordinary influence. In 1843 he went to England, where he had less, though still great, success, and in 1850 to America. He died in 1856, by which time the cause had fallen into a depressed state in both countries. In the United States a flash of enthusiasm of a similar character, but on a smaller scale, known as the Washingtonian movement, had appeared. In 1845 a law prohibiting the public sale of liquor was passed in New York State but repealed in 1847; in 1851 State prohibition was adopted in Maine (*see* Liquor Laws).

Since that time the organized movement has embraced both elements, the voluntary and the compulsory, and has combined the inculcation of individual abstinence with the promotion of legislation for the reduction or suppression of the traffic. On the whole the latter has predominated, particularly in the United States, where organized agitation has for more than half a century made temperance a political question and has produced the various experiments in legislation of which an account is given in the article on Liquor Laws. In addition to combining the moral and the political elements the modern movement is characterized by the following features: (1) international organization, (2) organized co-operation of women, (3) juvenile temperance, (4) teaching of temperance in schools and elsewhere, (5) scientific study of alcohol and inebriety.

(1) International organization appears to have been started by the Order of Good Templars, a society of abstainers formed, in 1851, at Utica, in New York State. It spread over the United States and Canada, and in 1868 was introduced into Great Britain. Some years later it was extended to Scandinavia, where it is very strong. Temperance societies had previously existed in Norway from 1836, and in Sweden from 1837; these seem to be the earliest examples on the continent of Europe. The Good Templars organization has spread to several other European countries, to Australasia, India, South and West Africa and South America. There are several other international societies, and international congresses have been held, the first in 1885 at Antwerp. A World's Prohibition Conference was held in London in 1909. It was attended by about 300 delegates from temperance societies in nearly all parts of the world, and resulted in the foundation of an International Prohibition Federation, which embraces every country in Europe with three or four minor exceptions, the United States, Mexico, Argentina, the British self-governing dominions,

India, China, Japan, Palestine, Tunisia and Hawaii.

(2) The organization of women, which has also become international, dates from 1874, when the National Women's Christian Temperance Union was founded at Cleveland in the United States. In 1907 it had branches in every State in the Union and in about 10,000 towns and villages, with an aggregate membership of 350,000. It employs all means, educational and social as well as political, and has exercised great influence in promoting that drastic legislation which characterizes the United States. It has also taken up many other questions relating to women, and has adopted the white ribbon as badge. About 1883 Miss Frances Willard, who had been the moving spirit of the Union, carried the organization of women into other lands and formed the World's Women's Christian Temperance Union, which now possesses branches in some 50 countries.

(3) The inclusion of children in temperance organization goes back to 1847, when a society of juvenile abstainers who had taken the pledge was formed at Leeds; it took the name of Band of Hope. The practice spread, and in 1851 a Band of Hope Union was formed. There are now a number of such unions, for Scotland, Ireland and separate counties in England; the Bands of Hope are said to number 15,000 in all.

(4) The teaching of temperance in schools, which has become a great feature of the moral propaganda, was begun by private effort in 1852, when the late John Hope inaugurated a regular weekly visitation of day schools in Edinburgh. In 1875, at the invitation of the National Temperance League, Sir Benjamin Richardson wrote his *Temperance Lesson Book,* which was adopted by many schools as a primer. In 1889 school-teaching by travelling lecturers was taken up by the U.K. Band of Hope Union, and the example was followed by many other societies, which have spent large sums on itinerant lecturers; and object-lessons on the nature and effects of alcoholic drinks are given to children in the schools. The Church of England Temperance Society carries on similar work and examines children in the subject of temperance, the annual Report for 1926 stating that 20,000 people of all grades and ages came under instruction in the year. Voluntary temperance teaching having grown continuously and become very extensive, the central education authorities took action; in 1906 the Board of Education in Ireland made "Hygiene and Temperance" a compulsory subject in the public schools; in 1909 the English board issued a syllabus of temperance teaching, the adoption of which in elementary schools is optional (a revised edition, which includes the physiology of food also, was issued in 1922); in Scotland also courses of teaching in hygiene and temperance are permissive and have been adopted by many local educational authorities. In the United States compulsory teaching is of much longer standing and more advanced. The question was first taken up by the Women's Christian Temperance Union (*see above*) in 1879; it was believed that by teaching the physiological effects of alcohol to all children the problem of intemperance would be effectually solved, and a systematic political campaign was planned and carried out for the purpose of obtaining compulsory legislation to give effect to this idea. The campaign was successful in New York in 1884, in Pennsylvania in 1885 and subsequently in other States. Laws have now been passed in every State and territory, making anti-alcohol teaching part of the curriculum in the public schools, and tobacco is usually included. School-teaching is compulsory in Canada, except in Quebec and Prince Edward Island, where it is permissive; in France since 1902; in Sweden since 1892, and in Iceland. It is recognized by authority but optional in Australia, South Africa, some provinces of India, Belgium, Finland, Denmark, Norway, Germany, Austria-Hungary and Switzerland. The movement in favour of school-teaching is, which has become widespread, continuously and generally advancing.

(5) The scientific study of the physiology and pathology of alcohol is a very large subject in itself. As has been shown above, the pioneers of the temperance movement were medical men; and though the Churches soon became the chief moving force, doctors have always exercised an influence, and in more recent times since people learnt to bow down to the name of science there has been a marked tendency to have recourse to scientific authority for arguments and support, of which the teaching of temperance as a branch of physiology or hygiene is an illustration. Medical abstinence societies have been formed in England, Germany, Belgium, Holland, Norway, Sweden and Denmark.

Present State of the Movement.—In recent years the temperance movement has grown and spread, but there are no comprehensive figures of its numerical strength. The *Alliance Year Book,* however, contains a directory of societies, which give some idea of its wide distribution. It contains the names of over 600 organizations including local branches in Great Britain alone, embracing religious (54), women's (48) and juvenile societies (47). It further mentions four international organizations, eight in Australia, 12 in Canada, eight in South Africa and nine in the United States; there are, no doubt, central offices. The periodicals enumerated number 37 in Great Britain, mostly monthly, 14 in Australia, nine in Canada, five in India, two in South Africa and eight in the United States.

The Church of England Temperance Society is much the largest. It was founded in 1862, and re-constituted in 1873 on a dual basis of (1) total abstinence, and (2) general promotion of the society's objects, which are (*a*) promotion of habits of temperance; (*b*) reformation of the intemperate; (*c*) removal of the causes which lead to intemperance. It was incorporated in 1907, re-constituted in 1911 and 1921, and recognized by the Church Assembly in 1923. Its activity is many-sided; it carries on an extensive publication department and educational courses, police court and prison gate missions to seamen, travelling vans, and inebriate homes. The King and Queen are its patrons, the archbishops of Canterbury and York its presidents, and the bishop of London its chairman.

The United Kingdom Alliance, founded in 1853, is the chief political fighting organization. Its object is prohibition of the drink trade, but it has adopted the policy of local prohibition by means of the option. It has for many years furnished the "national drink bill," a calculation of the national expenditure on alcoholic liquors. No details of the membership are given, but the expenditure in 1927 was £9,420. Other legislative organizations are the National Temperance League, the British Temperance League, the National United Temperance Council, the National Temperance Federation, the Temperance Legislation League, and others in Scotland, Ireland and Wales. There is also a Royal Army Temperance Association, of which the King is the patron, and a Royal Naval Temperance Society. The National British Women's Total Abstinence Union has 44 county branches. The international societies enumerated are the World League against Alcoholism, the World Prohibitive Federation, the International Orders of Good Templars and the World's Women's Christian Temperance Union.

Effects of the Temperance Movement.—The organized agitation against the abuse and, in most cases, also the use, of alcoholic liquor is a very interesting feature of social life in those countries where it is mainly carried on. These are the United States of America, the British Islands and Dominions, and the northern countries of Europe, particularly Scandinavia and Finland. It is largely a matter of climate. In the wine-producing countries it is either weak or non-existent. In France alcohol means spirits, and that is generally the case on the Continent. In Spain, Portugal and along the Mediterranean there is no need to check drunkenness, because the people are naturally sober. But in the countries first mentioned that is not the case. It is here that the temperance movement is carried on with great energy, and when we come to ask what effect it has had, the enquiry is found to be full of difficulty. Of the societies some rely on moral influence, others aim at legislation, but too often at unattainable legislation. Nevertheless they must be credited with a large part in procuring the very varied and constantly changing mass of legislation dealing with drink; and, so far, the laws must be considered as results.

Consumption.—The following table gives the amount consumed in the United Kingdom per head of population in gallons from 1870 onwards:

Year	Beer	Spirits	Wine	Year	Beer	Spirits	Wine
1870	30.24	0.99	0.49	1916	20.84	0.61	0.22
1875	33.48	1.28	0.53	1917	12.60	0.41	0.15
1880	27.00	1.07	0.46	1918	9.99	0.33	0.25
1885	27.00	0.96	0.38	1919	16.99	0.47	0.41
1890	29.88	1.02	0.40	1920	20.61	0.47	0.32
1895	29.52	1.00	0.37	1921	18.56	0.39	0.24
1900	31.56	1.12	0.38	1922	15.80	0.36	0.26
1905	27.85	0.92	0.28	1923*	17.04	0.33	0.30
1910	26.31	0.65	0.28	1924*	17.96	0.33	0.35
1913	27.76	0.70	0.25	1925*	17.97	0.32	0.36
1914	26.66	0.69	0.23	1926*	17.17	0.29	0.37
1915	22.77	0.76	0.22	..	..	..	..

*Great Britain only.

The most notable feature in this table is the great change in 1914–26, the years of war and the subsequent period. The World War has, indeed, produced a greater change than any other event throughout the centuries of liquor control. Apart from this we notice a fluctuating tendency, with a general downward movement, which is most striking in the spirits column. The rise and fall correspond with the state of trade; consumption always rises with good trade and falls with bad. The year of the greatest consumption is 1875, which marked the close of the most prosperous trading period ever known. The years 1885–88 were years of extreme depression, followed by a short rise and later by a longer one, culminating in 1899. This slowly gave way to another depression, which lasted until 1909, when a rise began again. But throughout these fluctuations a general downward movement is discernible. The high-water mark is never so high as the previous one, while low-water mark is lower. The general decline is due to a change of social habits, to which many causes have contributed—the spread of education, the provision of alternatives to the public-house, the growth of sport and athletics, the example of the higher classes, and the temperance movement.

Coming to the World War we find the effects of a drastic and progressive interference with the drink trade. The interference operated in three ways: (1) Reduction of the amount available for drinking, (2) raised prices, (3) reduced hours of sale. Together with the withdrawal of men for service, these three conditions fully account for the fall of consumption shown in the table from 1914 to 1918, when the lowest point was reached. Their subsequent partial relaxation, with the return of men to civil life, accounts for the rise in 1919–20, when a period of temporary prosperity prevailed. That consumption remained still far below the level of 1913 was due to the fact that the war time restrictions were relaxed only in part; and to that has since been added a marked depression of trade, notably in 1922, when the consumption of beer, the most tell-tale commodity, fell heavily. In 1921 a new Licensing Act was passed, which embodied certain restrictions. The most important of these were the hours of sale, which had been reduced during the war from 16, 17 and, in London, 19½ to five and one-half; they were now extended to eight and in London to nine, but a break between the morning and evening is retained. At the same time the prices of drink remained unaltered, as affected by the high taxation of 100s. on a barrel of beer and 72s. a gallon on spirits. In the budget of 1923 a remission of 20s. a barrel on beer enabled brewers to lower the price by 1d. a pint. The continued state of comparative sobriety in subsequent years must be attributed to these three conditions: (1) Hours of sale, (2) high prices, (3) the depression of trade.

Prevalence of Drunkenness.—The table of convictions for drunkenness corresponds broadly with that of consumption. The following figures are taken from the licensing statistics of the Home Office:

England and Wales Convictions for Drunkenness

Year	Convictions	Year	Convictions
1905	207,171	1910	161,992
1906	199,014	1911	172,130
1907	197,064	1912	182,592
1908	187,803	1913	188,877
1909	169,518	1914	183,828
1915	135,811	1921	77,789
1916	84,191	1922	76,347
1917	46,410	1923	77,094
1918	29,075	1924	79,082
1919	57,948	1925	75,077
1920	95,763	1926	67,126

The table shows a fall corresponding with that of consumption down to 1910 and then a rise preceding the war; thereafter a rapid fall down to 1918, with a subsequent rise in 1919–20, followed by a pretty level rate, with a sharp fall for the year 1926, which was signalized by the general strike and the seven months' mining struggle. The general correspondence between the police figures and the statistics of consumption proves the trustworthiness of the former, which is further confirmed by the medical records:

England and Wales Drunkenness and Medical Results

Year	Convictions for drunkenness		Deaths from alcoholism		Deaths from cirrhosis of the liver	
	M.	F.	M.	F.	M.	F.
1913	153,112	35,765	1,288	865	2,088	1,586
1914	146,517	37,311	1,310	881	2,253	1,620
1915	102,600	33,211	1,027	745	1,994	1,421
1916	62,946	21,245	753	447	1,736	1,096
1917	34,103	12,307	446	292	1,423	775
1918	21,853	7,222	280	108	1,063	575
1919	46,765	11,183	354	112	900	510
1920	80,517	15,246	546	173	1,085	550
1921	64,897	12,892	454	193	1,188	585
1922	63,253	13,094	438	183	1,168	588
1923	63,850	13,244	376	186	1,071	551
1924	66,139	12,943	384	158	1,036	573
1925	62,843	12,224	331	177	1,114	597
1926	55,836	11,290	315	184	1,131	601

State Control.—Other points in war experiments remain to be considered in view of temperance activities. One of these is State control. It was adopted in South Carolina in 1893 and was inaugurated for Russia in 1895. It was brought to the front in Great Britain by the war experience. Among the powers conferred on the Liquor Control Board were those of purchasing and carrying on the trade, which meant State purchase. The Board made use of these powers to a very limited extent, directly connected with the war. In 1926 it took over the trade in four areas—Cromarty and Invergordon—at the instance of the Admiralty, Enfield at that of the Ministry of Munitions, Carlisle and the adjoining district of Gretna because of an enormous factory erected for munitions. The Carlisle and Gretna area is the only one of permanent importance. It was placed under the usual restrictions in Nov. 1915, but they failed to prevent an immense increase of drunkenness due to the presence of 22,000 navvies, engaged on construction work (the figures were given by the resident engineer). The board felt impelled to take drastic action and began the process, in Jan. 1916, by purchasing public-houses in the villages. Its operations were gradually extended until they embraced an area of about 500 sq.m. with a population of 140,000, in which Carlisle (52,000) was the only considerable town. The changes introduced into the liquor trade included: (1) Its concentration, (2) reduction in the number of licensed houses, (3) their re-arrangement and improvement, (4) the provision of meals, (5) salaried managers, (6) minor changes including the abolition of "grocers' licences." All these were very thoroughly carried out in the years following. In Carlisle itself only two establishments, a hotel and a restaurant, remain outside the State scheme, which has been carried on by the Home Office, after the dispersal of the Control Board in 1921.

The competition of clubs has been mentioned above. By the act of 1921 the hours of sale are the same as for the public-house, and registration has been compulsory since 1903, which involves power to strike a club off the roll for misconduct. But clubs are in a privileged position, and since the war they have increased steadily and rapidly from 7,972 in 1918 to 12,480 in

1927, while public-houses have become fewer, as already shown. A large number of the clubs are political, and there is a strong agitation for freeing them from all restrictions; while, on the other hand, the unfair competition with the public-house is insisted on.

The Temperance (Scotland) Act has no connection with the World War; it was passed in 1913, but did not come into operation until 1920. It is a local option act, which gives constituencies the power: (1) To remain as they are, (2) to vote for limitation of licences, (3) to vote for no licence.

The Drink Bill.—The following figures, which give an estimate of the national expenditure in Great Britain on drink, have been supplied by the courtesy of the United Kingdom Alliance:

Great Britain

Year	*Expenditure* £	*Per head of population* £	*Taxation* £
1900 . . .	168,500,000	4–10–4½	36,800,000
1913 . . .	153,500,000	3–12–5	34,800,000
1920 . . .	453,000,000	10– 0–0	181,000,000
1927 . . .	298,000,000	6–15–3	128,500,000

The great rise shown in 1920 and 1927 over the previous figures is due to the high prices of drink caused mainly by taxation, though it is to be noted that, in 1927, the nation spent on drink alone, quite apart from tax, nearly £40,000,000 more than in 1900.

World Changes.—In 1927 a Licensing Act was passed by the Irish Free State following a commission of enquiry. The principal measure was a reduction of the hours of sale; but the great change effected since the war is nation-wide Prohibition in the United States. It is separately dealt with (*see* PROHIBITION), and therefore little will be said about it here. It was not due to the war, as for many years past individual States have been adopting Prohibition; but the war gave a stimulus to the movement, which in 1919 reached the point required for an amendment to the Constitution. This step has given rise to an immense and interminable controversy, in which opinions of great weight can be quoted on both sides; but its effect outside the United States has been rather to check the movement for Prohibition, which was at first stimulated by the action of the United States. What follows is taken from the *International Record* and other sources.

Austria. A great campaign for reform of the liquor laws is being carried on. The proposals include: (1) Prohibition of sale from noon on Saturday to Monday morning; (2) prohibition of sale to persons under 18; (3) gradual extinction of licences; (4) debts for drink to be irrecoverable; (5) local option.

Belgium. By a law promoted by M. Vandervelde the retail sale of spirits for consumption on the premises is prohibited, but consumption has increased.

Bulgaria. The director of health has proposed a bill providing for (1) Local option; (2) the limitation of licences in proportion to population; (3) other restrictions of locality; (4) hours of sale to be from 8 A.M. to mid-day and from 2 to 6 P.M. with closing on Sundays and holidays; (5) prohibition of sale to persons under 20, sick people, students and police.

Czechoslovakia. An active campaign is being carried on under the presidency of Prof. Fourtka. Temperance teaching in schools is encouraged by the Government.

Denmark. The Temperance Commission appointed in 1914 has issued a final report. The majority of nine members think that education will suffice; the minority of six propose that the people shall have power locally to veto the granting of new licences and nationally to suppress liquor containing more than 2¼% of alcohol.

Finland. Finland is the one Prohibition country on the Continent. It was adopted there in 1916. Drunkenness is said to be excessive and a recent unofficial plebiscite declared against Prohibition, but its repeal is unlikely.

France. The temperance movement is directed mainly against spirits; the minister of commerce recently prohibited publicity concerning wines and spirits in post offices and on all administrative documents.

Germany. A strong movement in favour of local option is in progress.

Holland. The minister of labour has introduced a licensing bill, providing for local option.

Hungary. The licensing laws have been amended by a provision prohibiting the sale of drink to persons under 18.

Iceland. Iceland has Prohibition, and has experienced the difficulty of enforcement. Recently the Government has appointed supervisors with a view to enforcing the law more effectually.

Italy. The most interesting movement in Italy is one favoured by the Government for manufacturing non-alcoholic drinks from grapes and other fruits. The Ministry of Labour has forbidden the use of all kinds of alcoholic drinks in factories.

Norway. In 1927 Norway, by popular vote, gave up Prohibition of spirits in favour of local option.

Poland. The temperance organizations are active and made their first entrance into the electoral field at the last general election by urging electors to vote only for candidates in favour of reform legislation.

Rumania. The Government has in hand a bill for "progressive prohibition," whereby licenced houses will be reduced and gradually closed until in 12 years' time there will be none.

Russia. In Russia, where the Government monopoly of the manufacture and sale of vodka, which ceased in the war, has been restored, complaints of drunkenness and illicit distillation are rife; but the Government is too dependent on the revenue from vodka to give it up.

Sweden. During the war spirits were severely rationed, with the result of encouraging illicit distillation. After the war the country returned to the system of disinterested management, known as the Gothenburg system, as modified by Dr. Bratt.

Switzerland. There appears to be a conflict between the Federal Council and the temperance organizations. The former has introduced a bill in the national parliament, giving peasants the right to distil their own fruit, but providing that any excess, not required for domestic use, should be handed over to the liquor monopoly. This is opposed by the temperance societies.

Turkey. Prohibition was abandoned by Turkey in 1924, in favour of a Government monopoly.

Australia. The Prohibition movement is strong, but the wine business, which has become extensive and lucrative, is against it. The States have their own liquor systems, decided by popular vote; but no State has yet voted for Prohibition. Queensland voted in 1922 for continuance of licences. New South Wales has had no poll. Victoria will poll in 1930, West Australia voted against Prohibition in 1925.

New Zealand. New Zealand adopted local option in 1893 and 12 electorates secured no licence.

Canada. The greatest reaction against Prohibition is shown by Canada, which has repealed it in one province after another, except Nova Scotia, mostly in favour of Government control, though in some provision is made for local option. Newfoundland, after trying Prohibition for five years, has given it up for Government sale.

Science and Alcohol.—In 1916 the Liquor Control Board appointed a scientific advisory committee, which reported in 1918 and furnished a "review of the existing state of scientific knowledge regarding the action of alcohol on the human organism" as a "provisional basis for further research." This review was valuable, because it put together in a systematic way a large number of observations occurring only in various scientific journals. The committee continued the further research, with the addition of two members, and in 1920 prepared a revised version, which was not, however, published. In 1921 on the dissolution of the Control Board the Medical Research Council were invited by the home secretary to re-appoint the committee as one of their own investigation committee, and so to preserve the continuity of the work. They did so, and in 1924 published a revised version of their report, together with the two prefaces written in 1917 and 1920 by Lord D'Abernon, chairman of the Control Board and of the advisory committee.

See also PROHIBITION, LOCAL OPTION, LICENSED VICTUALLER, Gothenburg Licensing System, Disinterested Management, Drink Bill.

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TEMPERATURE OF BODY: *see* Animal Heat.

TEMPERING is the imparting of a certain degree of hardness to a tool or spring. The older practice was that of first hardening a tool to the limit, and then "letting it down," *e.g.,* allowing access of heat until a certain colour was shown on a part polished bright for observation, and then quenching in water or oil. This method is still practised on a large scale, but with the use of furnaces and pyrometers the tempering heat can be raised accurately without going through the hardening process first. Tempering colours range from the bright yellow down to grey, covering such tints as pure yellow, dark yellow, brown yellow, red brown, purple red, violet, cornflower blue, pale blue. The bright yellow gives the hardest temper suitable for steel engraving tools and certain metal cutting tools, while at the other end of the range lie saws for wood and most springs. *See* also Annealing and Hardening.

TEMPLARS. The Knights Templars, or Poor Knights of Christ and of the Temple of Solomon (*pauperes commilitones Christi templique Salomonici*), formed one of the three great military orders, founded in the 12th century. Unlike the Hospitallers and the Teutonic Knights it was a military order from its very origin. Its founders were a Burgundian knight named Hugues de Payns and Godeffroi de St. Omer, a knight from northern France, who in 1119 undertook the pious task of protecting the pilgrims who, after the first crusade, flocked to Jerusalem and the other sacred spots in the Holy Land. They were quickly joined by six other knights and soon afterwards organized themselves as a religious community, taking an oath to the patriarch of Jerusalem to guard the public roads, to forsake worldly chivalry, "of which human favour and not Jesus Christ was the cause," and, living in chastity, obedience and poverty, according to the rule of St. Benedict, "to fight with a pure mind for the supreme and true King."

To this nascent order of warrior monks Baldwin I., king of Jerusalem, handed over a part of his royal palace lying next to the former mosque of al-Aksa, the so-called "Temple of Solomon," whence they took their name. They had at first no distinctive habit, wearing any old clothes that might be given to them. Nor was their community exclusive. Their primitive rule seems to have enjoined them especially to seek out excommunicated knights, and to admit them, after absolution by the bishop, to their order, and they thus served a useful purpose in at once disciplining and converting the unruly rabble of "rogues and impious men, robbers and committers of sacrilege, murderers, perjurers and adulterers"[1] who streamed to the Holy Land in hope of plunder and salvation. It was this rule which led later to the most important privilege of the order, the immunity from sentences of excommunication pronounced by bishops and parish priests.

This practice might have brought them at once under the suspicion of the Church, and it soon became expedient to obtain the highest sanction for the new order and its rules. In the autumn of 1127 accordingly Hugues de Payns, with certain companions, appeared in Europe, where he was fortunate enough to secure the enthusiastic support of the all-powerful abbot of Clairvaux. Grateful pilgrims had already begun to enrich the order; the *De laude novae militiae,* a glowing panegyric of this new and holy conception of knighthood, addressed by Bernard to Hugues de Payns by name, insured the success of his mission. In 1128 the council of Troyes discussed and sanctioned the rule of the order.

Rule of the Temple.—No ms. of the original French Rule of the Temple (*Règle du Temple*) exists; but in essentials the later copies preserve the matter and spirit of the primitive Rule, and they prove that to the end the order was, in principle at least, submitted to the same strict discipline as at the beginning. Of a secret Rule, in spite of the most diligent research, no trace has ever been found. It is now generally held that none ever existed. The legend of its existence, so fatal to the order, is probably traceable to the fact that the complete Rule was jealously guarded by the chief office-bearers of the order.

The *Règle du Temple* in its final form as we now possess it contains the rules for the constitution and administration of the order; the duties and privileges of the various classes of its personnel; the monastic rules, regulations as to costume and as to religious services; rules for the holding of chapters, and a summary of offences and their punishment; the procedure at the election of a grand master and at receptions into the order; a definition of the relations of the order to the pope, and to other religious orders.

At the head of the order was the master of the Temple at Jerusalem (in Cyprus after the fall of the Latin Kingdom), known as the grand master. His authority was very great—except in certain reserved cases his word was law—but he was not absolute. Thus in matters of special importance—alienation of the estates of the order, attack on a fortress, declaration of war, conclusion of an armistice, reception of a new brother—he had to consult the chapter, and was bound by the vote of the majority; nor could he modify or abrogate a decree of the council of the order without their consent. He had to obtain the consent of the chapter also to the nomination of the grand commanders of the provinces of the order; the lesser offices were absolutely in his gift. He was elected by a complicated process, a chapter summoned *ad hoc* electing a "commander of the election" and one other brother who, after vigil and prayer, co-opted two more, these four choosing another two, and so on till the number of the twelve apostles had been reached. A chaplain, representing Jesus Christ, was then added to complete the electoral college. (*See* Curzon, *Règle du Temple,* p. xxxv.).

Of peculiar importance were the *chaplains* (*fratres capellani*). These did not originally form part of the order, which was served by priests from outside. The bull *Omne datum optimum* of 1163 imposed on clerics attaching themselves to the order an oath of life-long obedience to the grand master; by the middle of the 13th century the chaplains took the same oath as the other brothers and were distinguished from them only by their orders and the privileges these implied (*e.g.,* they were spared the more humiliating punishments, shaved the face, and had a separate cup to drink out of). The order thus had its own clergy, exempt from the jurisdiction of diocesan bishops and parish priests, owing obedience to the grand master and the pope alone.

It remains to be said that the brethren were admitted either for life or for a term of years. Married men were also received, but on condition of bequeathing one half of their property to the order.

History.—Long before St. Bernard's death (1153) the new order was established in almost every kingdom of Latin Christendom, and every establishment was the recipient of rich endowments. Henry I., for example, granted them lands in Normandy; and Louis VII. in the latter years of his reign gave them a

[1] Bernard of Clairvaux, *De laude novae militiae,* cap. v. (in Migne, *Patrol. lat.* 182, p. 928).

piece of land outside Paris, which in later times became known as the Temple, and was the headquarters of the order in Europe, and Stephen of England granted them the manors of Cressing and Witham in Essex, and his wife Matilda that of Cowley, near Oxford. Spiritual privileges were granted to them by the popes as lavishly as temporal possessions by the princes and people. Pope Adrian IV. allowed them to have their own churches; Eugenius III. added to these the right to have churchyards. They were, moreover, as defenders of the Church exempted from the payment of tithes. Finally, they were exempted from the action even of general censures and decrees of the popes, unless mentioned in them by name. Very soon the order refused to submit in any way to the ordinary jurisdiction of the diocesan bishops and formed in effect a separate ecclesiastical organization under the pope as supreme bishop. The result was that, scarce twenty-five years after its foundation, the order was at open feud with bishops and parish priests, and the popes found it necessary to issue decree after decree to protect it from violence and spoliation.

So long, however, as the attention of the papacy and of Christendom was fixed on the problem of recovering and safeguarding the Holy Land, the position of the Templars was unassailable and all efforts to curb the growth of their power vain. The later history of the Templars is therefore the history of the CRUSADES (*q.v.*).

Fall of Latin Kingdom.—There is something Homeric in the story of the fall of the Latin kingdom as related by the historians of the next century. A French knight, Gerard de Riderfort, coming to the East in quest of fortune, attached himself to the service of the ambitious Raymond, count of Tripoli; looking for the hand of some wealthy widow in reward. Failing ignominiously in this, Gerard enrolled himself among the Templars, biding his time for revenge, and was elected grand master in 1184. Baldwin IV., king of Jerusalem, died in 1185, leaving the throne to his young nephew Baldwin V., the son of his sister Sibylla, under the guardianship of Raymond, whose term of office was brief, as the little king died in September 1186. This was Gerard's opportunity. The Templars carried the body of their dead sovereign to Jerusalem for burial; and then, unknown to the barons of the realm, Gerard and the patriarch crowned Sibylla and her husband Guy de Lusignan, Raymond's rival. This was the overthrow of Raymond's ambition; and both Latin and Arabic writers are agreed that the Christian count and the Mohammedan sultan now entered into an alliance. To break this friendship and so save the kingdom, Gerard and the grand master of the Hospitallers were sent north to make terms with Raymond. But the rash valour of the Templars provoked a hopeless contest with 7,000 Saracens. The grand master of the Hospitallers was slain; but Gerard made his escape with three knights to Nazareth (1st May 1187). In this emergency Raymond became reconciled with Guy; and Gerard placed the Temple treasures of Henry II. at his king's disposal. Once more it was the Templars' rashness that led to the disastrous battle of Hittin (4th July). Gerard and the king fell into the hands of Saladin, but were released about a year later; Raymond of Tripoli made his escape through treachery or fortune; and 230 Templars fell in or after the battle, for the fight was scarcely over before Saladin ordered all the Templars and Hospitallers to be murdered in cold blood. One after another the Christian fortresses of Palestine fell into the hands of Saladin. Jerusalem surrendered on 2nd–3rd October 1187, and the treasures of the Temple coffers were used to purchase the redemption of the poorer Christians, part of whom the Templar warriors guarded on their sad march from the Holy City to Tripoli. Part of their wealth was expended by Conrad of Montferrat in the defence of Tyre; but, when this prince refused to admit Guy to his city, both the Templars and the Hospitallers from the neighbouring parts flocked to the banner of their released king and accompanied him to the siege of Acre (22nd August 1189). In his company they bore their part in the two years' siege and the terrible famine of 1190–91; and their grand master died in the great battle of 4th October 1189, refusing to survive the slaughter of his brethren.

On the capture of Acre Philip Augustus established himself in the palace of the Templars, who are, however, stated to have sympathized with Richard. The English king sold them the island of Cyprus for 100,000 besants; but, unable to pay the purchase money, they transferred the debt and the principality to Guy of Lusignan. Richard consulted them before deciding on any great military movement; and in June 1192 they advocated the bold plan of an advance on Egypt rather than on Jerusalem. It was in the disguise of a Templar and in a Templar galley that Richard left the Holy Land, after the failure of his own military schemes. When Acre was recovered, the Templars, like the Hospitallers, received their own quarters in the town, which from this time became the centre of the order. On the death of Henry of Champagne (1197) they vetoed the election of Raoul de Tabarie; after the death of his successor Amalric they refused to renew the truce with Saladin's brother, Saif al-Dīn, and led an expedition against the Saracens before the arrival of the new king, John de Brienne, at whose coronation in 1210 William de Chartres, the grand master, was present. Seven years later, with the aid of Walter de Avennis and of the Teutonic Knights, they commenced the building of their fortress of Castle Pilgrim, near Acre, on a rocky promontory washed by the Mediterranean on every side except the east.

It was from this castle that in May 1218 the fifth crusade started for the expedition against Egypt. The Templars were the heroes of the siege of Damietta, at which William de Chartres was slain. "First to attack and last to retreat," they saved the Christian army from annihilation on 29th August 1219; and when the city surrendered (5th November) the only one of its twenty-eight towers that had begun to give way had been shaken by their engines. On the other hand, it was largely owing to their objections that John de Brienne refused the sultan's offer to restore Jerusalem and Palestine.

From the very first the Templars seem to have been opposed to Frederick II., and when he landed at Acre (7th September 1228) they refused to march under the banners of an excommunicated man, and would only accompany his host from Acre to Joppa in a separate body. They were accused of notifying Frederick's intended pilgrimage to the Jordan to the sultan, and they were certainly opposed to Frederick's ten years' peace with Al-Kāmil, the sultan of Egypt, and refused to be present at his coronation in Jerusalem. On neither side was the treaty fully observed; and preparations were made in Europe for a fresh crusade. In the meantime open dissension broke out between the Templars and the Hospitallers, the former advocating negotiations with the sultans of Damascus and Kerak, the latter with the sultan of Egypt; and when Richard of Cornwall arrived (11th October) he had to decide between the two rival orders and their opposing policies. After some hesitation he concluded a treaty with the sultan of Egypt, much to the annoyance of the Templars, who openly mocked his efforts. On his departure the three orders came to open discord: the Templars laid siege to the Hospitallers in Acre and drove out the Teutonic Knights "in contumeliam imperatoris." They were successful on all sides. The negotiations with Damascus and Kerak were reopened, and in 1244 Hermann of Perigord wrote to the princes of Europe that after a "silence of fifty-six years the divine mysteries would once more be celebrated in the Holy City."

It was in this moment of danger that the sultan of Babylon called in the barbarous Kharizmians, whom the Mongol invasions had driven from their native lands. These savages, entering from the north, flowed like a tide past the newly built and impregnable Templar fortress of Safed, swept down on Jerusalem, and annihilated the Christian army near Gaza on October 18th, 1244. From this blow the Latin kingdom of the East never recovered; 600 knights took part in the battle; the whole force of the Templars, 300 in number, was present, but only 18 survived, and of 200 Hospitallers only 16. The masters of both orders were slain or taken prisoners, and Jerusalem was lost to Christendom once more. The havoc caused by the Kharizmians was alleged by pope Innocent IV. as the reason for again summoning Christendom to the rescue of the Holy Land. Recognizing the fact that the true way to Jerusalem lay through Egypt, Louis IX. led his host to the banks of the Nile, being accompanied by the Templars. Their master, William de Sonnac, attempted in vain to restrain the rash advance of the count of Artois at the battle of Mansura (8th February 1250), which only three Templars survived. St. Louis, when captured a few weeks later, owed his speedy release to the generosity with which the order advanced his ransom-money.

A new enemy was now threatening Mohammedan and Christian alike. For a time the Mongol advance may have been welcomed by the Christian cities, as one after another the Mohammedan principalities of the north fell before the new invaders. But this new danger stimulated the energies of Egypt, which under the Mameluke Bibars encroached year after year on the scanty remains of the Latin kingdom. The great Frankish lords, fearing that all was lost, made haste to sell their lands to the Templars and Hospitallers before quitting Palestine for ever. But they lost their power of resistance, and became so enfeebled as to welcome the treaty which secured them the plain of Acre and a free road to Nazareth as the result of the English crusade of 1272. While thus weak against external foes, the Templars were strong enough for internal warfare. In 1277 they espoused the quarrel of the bishop of Tripoli, formerly a member of the order, against his nephew Bohemond, prince of Antioch and Tripoli, and began a war which lasted three years. In 1276 their conduct drove Hugh III., king of Cyprus and Jerusalem, from Acre to Tyre. In the ensuing year, when Mary of Antioch had sold her claim to the crown to Charles of Anjou, they welcomed this prince's lieutenant to Acre and succeeded for the moment in forcing the knights of that city to do homage to the new king. Thirteen years later (26th April 1290) Tripoli fell, and next year Acre, after a siege of six weeks, at the close of which (16th May) William de Beaujeu, the grand master, was slain. The few surviving Templars elected a new master, and sailed for Cyprus, which now became the headquarters of the order.

Power and Influence of the Order.—For more than a hundred years the Templars had been one of the wealthiest and most influential factors in European politics. If we confine our attention to the East, we realize but a small part of their enormous power. Two Templars were appointed guardians of the disputed castles on the betrothal of Prince Henry of England and the French princess in 1161. Other Templars were almoners of Henry III. of England and of Philip IV. of France. One grand master was godfather to a daughter of Louis IX.; another, despite the prohibition of the order, is said to have been godfather to a child of Philip IV. They were summoned to the great councils of the Church, such as the Lateran of 1215 and the Lyons council of 1274. Frederick II.'s persecution of their order was one of the main causes of his excommunication in 1239; and his last will enjoined the restoration of their estates. Their property was scattered over every country of Christendom, from Denmark to Spain, from Ireland to Cyprus. But the wealth of the Templars was due not so much to their territorial possessions as to the fact that they were the great international financiers and bankers of the age. The Paris Temple was the centre of the world's money market. In it popes and kings deposited their revenues, and these vast sums were not hoarded but issued as loans on adequate security. Above all, it was the Templars who made the exchange of money with the East possible. It is easy, indeed, to see how they were the ideal bankers of the age; their strongholds were scattered from Armenia to Ireland, their military power and strict discipline ensured the safe transmission of treasure, while their reputation as monks guaranteed their integrity. Thus they became the predecessors, and later the rivals, of the great Italian banking companies. To take interest (usury) was of course unlawful. The method of circumventing this seems to have been that the mortgagees paid to the mortgagors a *nominal* rent which was used towards the reduction of the debt. The difference between this and the *real* rent represented the interest. A document throwing a vivid light on the banking methods of the Templars and Hospitallers is a charter of Margaret, queen of the English, A.D. 1186, from the abbey of Fontevrault, printed in *Calendar of Documents,* France (1899), vol. i., ed. J. H. Round, No. 1084.

Suppression of the Order.—Never had the order of the Temple been to all appearance more powerful than immediately before its ruin. Sovereign power, in the sense of that of the Teutonic Knights in Prussia or the Knights of St. John in Rhodes and later in Malta, it had never possessed; but its privileges and immunities constituted it a church within the church and—in France at least—a state within the state. Philip IV., indeed, in pursuance of his policy of centralizing power in the crown, had from 1287 onwards made tentative efforts to curtail the power and wealth of the order; but soon his necessities forced him to a temporary change of policy. In January 1293 the privileges of the order in and about Paris were confirmed and extended, and in 1297 Philip borrowed 5,200 *livres tournoises* from the Paris Temple. Then came the great quarrel with Pope Boniface VIII., and on the 10th of August 1303 the king signed with Hugues de Peraud, the general visitor of the French Templars, a formal treaty of alliance against the pope. On the 6th of February 1304 Boniface's successor, Benedict XI., once more confirmed all the Templars' privileges; while Philip, for his part, appointed Hugues de Peraud receiver of the royal revenues and, under pressure of the disastrous campaign in Flanders, in June granted a charter exempting the order from all hindrances to the acquisition of property. Two years later the king took refuge in the Temple from the violence of the Paris mob, and so late as the spring of 1307 was present at the reception of a new Templar.

Yet for some two years past the king had been plotting a treacherous attack on the order. His motives are clear; he had used every expedient to raise money, had robbed and expelled the Jews and the Lombard bankers, had debased the coinage; the suppression of the Templars would at once rescue him from their unwelcome tutelage and replenish his coffers. He cherished also another ambition. The question of an amalgamation of the great military orders had often been mooted; the project had been approved by successive popes in the interests of the Holy Land; it had been formally proposed at the Lyons council of 1274, only to be rejected by the opposition of the Templars and Hospitallers themselves. To Philip this scheme commended itself as an opportunity for bringing the orders under the control of the French crown; there was to be but one order, that of the "Knights of Jerusalem," of which the grand master was always to be a prince of the royal house of France. Clearly, it only needed an excuse and a favourable opportunity to make him attack the Templars; and, once having attacked them, nothing short of their entire destruction would have been consistent with his safety. The excuse was found in the denunciation of the order for heresy and unspeakable immoralities by a venal informer; the opportunity was the election of a pope, Clement V., wholly devoted to the interests of the king of France.

For perhaps half a century there had been strange stories circulating as to the secret rites practised by the order at its midnight meetings, stories which probably had their origin in the extreme precautions taken by the Templars, originally perhaps for military reasons, to secure the secrecy of their proceedings, which excited popular curiosity and suspicion.

In the spring of 1304 or 1305 a certain Esquiu de Floyran of Béziers pretended to betray the "secret of the Templars" to James II. of Aragon. The pious king, who had every reason to think well of the order, did not affect to be convinced; but the prospect of spoils was alluring, and he seems to have promised the informer a share of the booty if he could make good his charges. Esquiu now turned to Philip of France, with more immediate success. For the purpose of collecting additional evidence the king caused twelve spies to find admission to the order, and in the meantime sought to win over the pope to his views. Clement V. owed the tiara to the diplomacy of Philip's agents, perhaps to their gold; but though a weak man, and moreover a martyr to ill health, he was not so immediately accommodating as the king might have wished, expressing his disbelief in the charges against the order, and, though promising an inquiry, doing his best to procrastinate. Philip determined to force his hand. All France was at this time under the jurisdiction of the Inquisition, and the Inquisition could act without consulting the pope. The grand inquisitor of France, William of Paris, was Philip's confessor and creature. The way was thus open for the king to carry out his plan by a perfectly legal method. His informers denounced the Templars to the Inquisition, and the grand inquisitor—as was the customary procedure in the case of persons accused of heresy—demanded their arrest by the civil power. On the 14th of September 1307, accordingly, Philip issued writs to his *baillis* and seneschals throughout the kingdom, directing them to make preparations to arrest the members of the order.

The Templars had for some time past been aware of the charges against them. On the 6th of June 1306 Pope Clement had summoned Jacques de Molay, the grand master, from Cyprus to France, in order to consult him on the projected crusade. He had obeyed the call, and, in an interview with the pope, had taken the opportunity to demand a full inquiry. They had, however, taken no measures to defend themselves; the sudden action of the king took them wholly by surprise; and on the night of Friday, the 13th of October 1307, their arrest was effected without difficulty, Jacques de Molay himself with sixty of his brethren being seized in Paris.

The Templars were caught in toils from which there was no escape. To force them to confess, they were first tortured by the royal officials, before being handed over to the inquisitors to be, if need were, tortured again. In Paris alone thirty-six died under the process. The result was, at the outset, all that the king could desire. Of 138 Templars examined in Paris between the 19th of October and 24th of November, some of them old men who had been in the order the greater part of their lives, 123 confessed to spitting on (or "near") the crucifix at their reception. Many of the prisoners confessed to all the charges, however grotesque. But the most damning confession was that of the grand master himself, publicly made with tears and protestations of contrition and embodied in a letter (October 25) sent to all the Templars in France. He had been guilty, he said, of denying Christ and spitting on the cross.

To the pope, meanwhile, the proceedings in France were to the highest degree unwelcome. He had, indeed, become convinced, if not of the general guilt of the order, at least of the guilt of some of its members. But the affair was one which he desired to reserve for his own judgment; Philip's action he interpreted, rightly, as an encroachment of the civil power on the privileges and property of the Church, and his fears were increased when the French king, without consulting him, sent letters to King James of Aragon, Edward II. of England, the German king Albert and other princes, calling upon them to imitate his example. On the 27th of October Clement issued letters suspending the powers of the Inquisition in France. What followed is not clear, for the documentary evidence for these months is very defective; but on the 22nd of November the pope issued a bull calling on all kings and princes to arrest the Templars everywhere, his motive probably being to forestall the probable action of the secular powers and keep the affair in his own hands. All scruples and hesitations now vanished. In England the Templars were arrested on the 10th of January 1308, in Sicily on the 24th of the same month, in Cyprus on the 27th of May; in Aragon and Castile the process was less easy, for the knights, forewarned, had put their fortresses into a state of defence, notably their strong castle of Monzon, which was only taken after a long siege on the 17th of May, while the last of the Templars' strongholds, Castellat, did not fall until Nov. 2nd.

Meanwhile, on the 26th of May, Philip had made his solemn entry into Poitiers, where the pope and cardinals had already assembled for the purpose of conferring with the king on the matter. After stormy debate, an arrangement was made. The king agreed to hand over to the papal commissioners the property and persons of the Templars; Clement, for his part, withdrew the sentence of suspension against the grand inquisitor of France and ordered an inquisition into the charges against individual Templars by the diocesan bishops with assessors nominated by himself. The examination of the grand master, of the grand visitor of France, and of the grand preceptors of Cyprus, Normandy and Aquitaine he reserved to himself. Inquisition was to be made into the conduct of the order in each country by special papal commissions; and the fate of the order as a whole was to be decided by a general council, summoned at Vienne for the 1st of October 1311, when the question of the guilt of the order might be considered. Meanwhile the pope and cardinals had elaborated the organization of the new inquisition. There was much confusion and delay, however, and the actual public trial did not begin till the 11th of April, 1310. Many Templars, trusting in the assurance implied in their citation, had volunteered to defend the order and withdrew their previous confessions. They were soon undeceived; the commission was packed with creatures of the crown. The evidence given in Paris for or against the order was, it was soon found, used against the individual Templars on their return to the provinces; the retractation of a confession, under the rules set up for the diocesan inquisition, was punished with death by fire. Sixty-seven Templars perished in this way during May 1310. Meanwhile Clement and Philip had come to terms. The pope condemned the Templars. The council of Vienne met in October 1311. A discussion arose as to whether the Templars should be heard in their own defence. Clement, it is said, broke up the session to avoid compliance; and when seven Templars offered themselves as deputies for the defence he had them cast into prison. Towards the beginning of March Philip came to Vienne, and he was seated at the pope's right hand when that pontiff delivered his sermon against the Templars (3rd April 1312), whose order had just been abolished, not at the general council, but in private consistory (22nd March). On 2nd May 1312 he published the bull *Ad Providam,* transferring the goods of the society, except for the kingdoms of Castile, Aragon, Portugal and Majorca, to the Knights of St. John.

The final act of the stupendous tragedy came early in 1314. Jacques de Molay, the grand master, had not hitherto risen to the height of his great position; the fear of torture alone had been enough to make him confess, and this confession had been used to extract avowals from his brethren, subject as they were to unspeakable sufferings and accustomed to yield to the military chief. Humiliation on humiliation had been heaped on the wretched man, public recantations, reiterated confessions. Before the papal commission he had flamed into anger, protested, equivocated—only in the end to repeat his confession once more. The same had happened before the commission of cardinals at Chinon; the audience with the pope, which he demanded, he had never obtained. On the 6th of May 1312 Pope Clement issued his final decision as to the fate of the Templars in general; that of the five great offices of the order he reserved in his own hand. With this a silence falls over the history of the Templars; the fate of the order had been decided, that of the individuals still under trial was of little interest to contemporary chroniclers. Then the veil is suddenly lifted. Jacques de Molay has found his wonted courage at last, and with him Gaufrid de Charney, the preceptor of Normandy; on the 14th of March 1314 they were brought out on to a scaffold erected in front of Notre Dame, there in the presence of the papal legates and of the people to repeat their confessions and to receive their sentence of perpetual imprisonment. Instead, they seized the opportunity to withdraw their confessions and to protest to the assembled thousands the innocence of the order. King Philip the Fair did not wait to consult the Church as to what he should do; he had them burnt.

A word must be added as to the significance of the work of the Templars and of the manner of their fall in the history of the world. Two great things the order had done for European civilization: in the East and in Spain it had successfully checked the advance of Islam; it had deepened and given a religious sanction to the idea of the chivalrous man, the *homo legalis,* and so opened up, to a class of people who for centuries to come were to exercise enormous influence, spheres of activity the beneficent effects of which are still recognizable in the world. On the other hand, the destruction of the Templars had three consequences fateful for Christian civilization. (1) It facilitated the conquests of the Turks by preventing the Templars from playing in Cyprus the part which the Knights of St. John played in Malta. (2) It partly set a precedent for, partly confirmed, the cruel criminal procedure of France, which lasted to the Revolution. (3) It set the seal of the highest authority on the popular belief in witchcraft and personal intercourse with the devil, sanctioned the expedient of wringing confessions of such intercourse from the accused by unspeakable tortures, and so made possible the hideous witch-persecutions which darkened the later middle ages and, even in Protestant countries, long survived the period of Reformation.

On the question of the guilt or innocence of the Templars in respect of the specific charges on which the order was condemned opinion has long been divided. Their innocence was maintained by the greatest of all their contemporaries, Dante (Purg. xx. 92), and by the historian Villani and others. In more recent times a certain heat was introduced into the discussion of the question owing to its having been for centuries brought into the arena of party controversy, between Protestants and Catholics, Gallicans and Ultramontanes, Freemasons and the Church. Thus in 1654 Pierre Du Puy, librarian of the Bibliothèque Royale, published his work on the Templars to confute those who sought to establish their innocence in order to discredit a king of France. On the other hand, Nicolas Gurtler published his *Historia Templariorum* (Amsterdam, 1691, 2nd ed. 1703) to show, as a good Protestant, that the Templars had the usual vices of Roman Catholics, while, according to Loiseleur, the later editors of Du Puy were Freemasons who, under false names, garbled the old material and inserted new in the interests of the supposed origin of their own order in that of the Templars. Several Roman Catholic champions of the order now entered the field, notably the Premonstratensian canon R. P. M. Jeune, prior of Etival, who in 1789 published at Paris his *Histoire critique et apologétique de l'ordre des chevaliers . . . dits Templiers,* a valuable work directed specifically against Gurtler and Du Puy. In the 19th century a fresh impetus was given to the discussion by the publication in 1813 of Raynouard's brilliant defence of the order. The challenge was taken up, among others, by the orientalist F. von Hammer-Purgstall who, in a paper entitled "Mysterium Baphometis" (*Fundgraben des Orients,* vol. vi., Vienna 1818), attempted to prove that the Templars followed the doctrines and rites of the Gnostic "Ophites" (*q.v.*), and gave reproductions of obscene representations of supposed Gnostic ceremonies and of mystic symbols said to have been found in Templars' buildings. W. F. Wilcke (*Geschichte des Tempelherrenordens,* 1826, 2nd. ed. 1860), while rejecting Hammer's main conclusions as unproved, argued for the existence of a secret doctrine based not on Gnosticism but on the monotheism of Islam, of which Baphomet (Mahomet) was a symbol. On the other hand, Wilhelm Havermann (*Geschichte des Ausganges des Tempelherrenordens,* 1846) decided in favour of the innocence of the order. This view was also taken by a succession of German scholars; in England, by C. G. Addison; and in France by a whole series of conspicuous writers: Mignet, Guizot, Renan, and others. On the other hand, Hans Prutz, in a series of brilliant contributions, of which the most well-considered is his *Entwicklung und Untergang des Tempelherrenordens* (1888), maintained that the custom of denying Christ and spitting on the cross was often, and in some provinces universally, practised at the reception of the brethren, "as a coarse test of obedience, of which the original sense had partly been forgotten, partly heretically interpreted under the influence of later heresies." Prutz points out that the failure of the Crusades had weakened men's absolute belief in Christianity, at least as represented by the mediaeval Church (*Kulturgeschichte der Kreuzzüge,* p. 268 ff.).

H. C. Lea, in his *History of the Inquisition* (1888, vol. iii.), had already come independently to the conclusion that the Templars were innocent. Lastly appeared the fascinatingly interesting and closely reasoned book of Professor H. Finke (1907) which, based partly on a mass of new material drawn from the Aragonese archives, had for its object to establish the innocence of the order on an incontrovertible basis (*Papsthum und Untergang des Templenordens,* 1907).

BIBLIOGRAPHY.—The original sources given by Du Puy, though often valuable, were selected and edited with a purpose; but Michelet's *Procès des Templiers* (2 vols., 1851, 1861), gives the original minutes of the trial preserved at the Bibliothèque Nationale. This is analysed by Gmelin (*op. cit.*). Of documents published elsewhere, the most important are in Finke (*op. cit.,* from the Aragonese archives) and K. Schottmüller (*Untergang des Templerordens,* 1887, from the Vatican archives). The Rule of the Temple has several times been published; the most convenient edition is that of H. de Curzon, *La Règle du Temple* (1886); *see* also Maillard du Chambure, *Règle et statutes secrets des Templiers* (1840). In addition to the works already mentioned, the following may be named: M. Lavocat, *Procès des frères et de l'ordre du Temple* (Paris, 1888); G. Schnürer, *Die ursprüngliche Templerregel* (1903); C. G. Addison, *The Knights Templars* (3rd ed. 1854), which contains a valuable account of the suppression of the order in England; Marquis d'Albon, *Cartulaire général de l'Ordre du Temple* (1922); G. Lizerand (ed.), *Le Dossier de l'affaire des Templiers* (1923). (W. A. P.; X.)

TEMPLE, FREDERICK (1821–1902), English divine, archbishop of Canterbury, was born in Santa Maura, one of the Ionian Islands, the son of Major Octavius Temple. He was educated at Blundell's School, Tiverton, and at Balliol College, Oxford. The "Tractarian Movement" had set in five years before he went up to Oxford, but the memorable tract, No. 90, had not yet been written. After much discussion and reflection he drew closer to the camp of "the Oxford Liberal Movement." In 1842 he took a "double-first" and was elected fellow of Balliol, and lecturer in mathematics and logic. Four years later he took orders, and with the aim of helping forward the education of the very poor, he accepted the headship of Kneller Hall, which served at that time for the training of masters of workhouse and penal schools. But the experiment was not altogether successful, and Temple himself advised its abandonment in 1855. He then accepted a school-inspectorship, which he held until he became headmaster of Rugby in 1858. In the meantime he had attracted the admiration of the prince consort, and in 1856 he was appointed chaplain-in-ordinary to the queen. In 1857 he was select preacher at his university.

At Rugby Temple showed great energy and bold initiative. Whilst making the school a strong one on the classical side, he instituted scholarships in natural science, built a laboratory, and gave importance to that side of the school work. He had the courage also to reform the games, in spite of all the traditions of the playing fields. His school sermons were deeply impressive: they rooted religion in the loyalties of the heart and the conscience, and taught that faith might dwell secure amid all the bewilderments of the intellect, if only the life remained rooted in pure affections and a loyalty to the sense of duty. Two years after he had taken up his work at Rugby *Essays and Reviews* appeared. The first essay in the book, "The Education of the World," was by Dr. Temple. Temple refused, so long as the storm lasted, to comply with the request that he would repudiate his associates, and it was only at a much later date (1870) that he saw fit quietly to withdraw his essay. In the meantime, however, he printed a volume of his Rugby sermons, to show definitely what his own religious positions were. His appointment by Gladstone as bishop of Exeter in 1869 raised a fresh storm.

G. A. Denison, archdeacon of Taunton, Lord Shaftesbury, and others formed a strong committee of protest, whilst Pusey declared that "the choice was the most frightful enormity ever perpetrated by a prime minister." At the confirmation of his election counsel was instructed to object to it, and in the voting the chapter was divided. But Gladstone stood firm, and Temple was duly consecrated on Dec. 21, 1869. On the death of Dr. John Jackson in 1885, he was translated to London, the appointment gave general satisfaction. In 1884 he was Bampton Lecturer, taking for his subject "The Relations between Religion and Science." In 1885 he was elected honorary fellow of Exeter College, Oxford.

Temple led a strenuous life as bishop of London. His normal working day at this time was one of fourteen or fifteen hours, and he was felt by many of his clergy and by candidates for ordination to enforce almost impossible standards of diligence and efficiency. The working classes instinctively recognized him as their friend. When, in view of his growing blindness, he offered to resign the bishopric, he was induced to reconsider his proposal, and on the sudden death of Archbishop Benson in 1896, though now seventy-six years of age, he accepted the see of Canterbury.

As archbishop he presided in 1897 over the decennial Lambeth Conference. In the same year Temple and his brother archbishop issued an able reply to an encyclical of the pope which denied the validity of Anglican orders. In 1900 the archbishops again acted together, when an appeal was addressed to them by the united episcopate, to decide the vexed questions of the use of incense in divine service and of the reservation of the elements. After full hearing of arguments they gave their decision against both the practices in question. During his archbishopric Dr. Temple was deeply distressed by the divisions which were weakening the Church of England, and many of his most memorable sermons were calls for unity. His first charge as primate on "Disputes in the Church" was felt to be a most powerful plea for a more catholic and a more charitable temper, and again and again during the closing years of his life he came back to this same theme. While speaking in the House of Lords on Dec. 2, 1902 on the Education Bill of that year, he was seized with sudden illness, and, though he revived sufficiently to finish his speech, he never fully recovered, and died on Dec. 23, 1902. He was interred in Canterbury cathedral four days later.

See Archdeacon E. G. Sandford, *Frederick Temple: an Appreciation* (1907), with biographical introduction by William Temple; *Memoirs of Archbishop Temple,* by "Seven Friends," ed. E. G. Sandford (1906).

TEMPLE, RICHARD GRENVILLE-TEMPLE, 1ST EARL (1711–1779), English statesman, eldest son of Richard Grenville (d. 1727) of Wootton, Buckinghamshire, was born on Sept. 26, 1711. His mother was Hester (*c.* 1690–1752), daughter, and ultimately heiress, of Sir Richard Temple, Bart. (1634–1697), of Stowe, Buckinghamshire, and sister of Richard Temple, Viscount Cobham, whose title she inherited under a special remainder in 1749; in the same year, her husband having been long dead, she was created Countess Temple. Her son, Richard Grenville, was educated at Eton, and in 1734 was returned to parliament as member for the borough of Buckingham. In 1752, on the death of his mother, he inherited her titles together with the estates of Stowe and Wootton; and took the name of Temple in addition to his own surname of Grenville. By the marriage of his sister Hester with William Pitt, afterwards earl of Chatham, Temple's career was linked with that of his brother-in-law.

In November 1756 Temple became first lord of the admiralty in the ministry of Devonshire and Pitt. He was disliked by George II., who dismissed both him and Pitt from office in April 1757. But when the coalition cabinet of Newcastle and Pitt was formed in June of the same year, Temple received the office of privy seal. He alone in the cabinet supported Pitt's proposal to declare war with Spain in 1761, and they resigned together on Oct. 5. From this time Temple became one of the most violent and factious of politicians, and it is difficult to account for the influence which he exerted over his brother-in-law. He was at variance with his younger brother, George Grenville, when the latter became first lord of the treasury in April 1763, and he had no place in that ministry; but the brothers were reconciled before 1765, when Temple refused to join the government, and persuaded Pitt to refuse likewise.

By 1765, however, the old friendship between the brothers-in-law was dissolving; and when at last in July 1766 Pitt consented to form a government, Temple refused to join, being bitterly offended because, although offered the head of the treasury, he was not to be allowed an equal share with Pitt in nominating to other offices. Temple forthwith began to inspire the most virulent libels against Pitt; and in conjunction with his brother George he concentrated the whole Grenville connection in hostility to the government. After George Grenville's death in 1770 Lord Temple retired almost completely from public life. He died on Sept. 12, 1779.

See *The Grenville Papers* (1852), a considerable portion of which consists of Earl Temple's correspondence; Horace Walpole, *Memoirs of the Reign of George II.,* 3 vols. (1847); *Memoirs of the Reign of George III.,* 4 vols. (1845 and 1894); Earl Waldegrave, *Memoirs 1754–58* (1821); Sir N. W. Wraxall, *Historical Memoirs,* ed. H. B. Wheatley, 5 vols. (London, 1884); *Correspondence of Chatham,* ed. W. S. Taylor and J. H. Pringle, 4 vols. (1838–40); W. E. H. Lecky, *History of England in the Eighteenth Century,* vols. ii. and iii. (7 vols., 1892).

TEMPLE, SIR WILLIAM, BART. (1628–1699), English statesman, diplomatist, and author, was born in London. He was the eldest son of Sir John Temple (1600–1677), Irish master of the rolls, whose father was Sir William Temple (1555–1627), provost of Trinity college, Dublin. Temple was educated at the grammar-school at Bishop Stortford, and at the Puritan college of Emmanuel at Cambridge, where he came under the influence of Cudworth. In 1647 he started to travel abroad. In the Isle of Wight he met Dorothy Osborne, the daughter of the Royalist governor of Guernsey, Sir Peter Osborne; and though her family were opposed to the match, he married her in 1655.

In 1660 Temple sat in the convention parliament, and in its successor, at Dublin as member for Carlow. He removed to England in 1663, attached himself to Arlington, secretary of state, and two years later was employed in various negotiations on the continent. In 1666 he became the English representative at the viceregal court at Brussels. While the Dutch war continued, Temple's duties consisted chiefly in cultivating good relations with neutral Spain, which was threatened by the claims of Louis XIV. on the Spanish Netherlands. Louis's designs became apparent in the spring of 1667, when he marched an army into Flanders. This event was one of those which led to the peace of Breda, and to the subsequent negotiations, which are Temple's chief title to fame. The French conquests were made at the expense of Spain, but were almost equally dangerous to the United Netherlands, whose independence would have been forfeited had Louis succeeded in annexing Flanders. While the French were taking town after town, Temple made a journey into Holland and visited De Witt.

Temple had for some time pressed on his government the necessity of stopping the French advance, and had pointed out the way to do so, but it was not till December 1667 that he received instructions to act as he had suggested. He at once set out for The Hague, and in January 1668 a treaty was made between England and the United Netherlands, which, being joined shortly afterwards by Sweden, became known as the Triple Alliance. It was a defensive treaty, made against the encroachments of France. The skill and celerity with which the negotiations were conducted and the results of the treaty, reflect great credit on Temple. The French king was checked in mid-career, and, without a blow being struck, was obliged to surrender almost all his conquests.

Unfortunately the policy thus indicated was undone by Charles's personal policy embodied in the secret treaty of Dover which reversed the policy of the Triple Alliance. (*See* CHARLES II.) Meanwhile Temple had developed the good understanding with the Dutch by contracting a commercial treaty with them (February 1668), and had acted as English plenipotentiary at Aix-la-Chapelle, where peace between France and Spain was made in May 1668. Shortly afterwards he was appointed ambassador at The Hague. Here he lived for two years on good terms both with De Witt and with the young prince of Orange, afterwards William III. The treaty of Dover led to Temple's recall, but Temple nominally held his post for another year. He perceived, however, that his day was over and retired to his house at Sheen. In June 1671 he received his formal dismissal. The war with the Netherlands broke out next year, and was almost as discreditable to England as that of 1665. Want of success and the growing strength of the opposition in parliament forced Charles to make peace, and Temple was commissioned to carry through the change of front. After a negotiation of three days, carried on through the medium of the Spanish ambassador, the treaty of Westminster was made (February 1674).

As a recognition of his services Temple was now offered the embassy to Spain. This he declined, as well as the offer of a far more important post, that of secretary of state, but accepted instead a renewal of his embassy to The Hague. In the March following he was nominated ambassador to the congress at Nijmwegen; but, owing to the tortuousness of Charles's dealings, it was not till July 1676 that he entered that town. The negotiations dragged on for two years longer, for Charles was still receiving money from France, and English mediation was no more than a ruse. In the summer of 1677 Temple was summoned to England and received a second offer of the secretaryship of state, which he again declined. In the autumn of the same year he had the satisfaction of bringing about the marriage of William and Mary, an event which seemed to complete the work of 1668 and 1674. Louis still remaining obstinate in his demands, Temple was commissioned in July 1678 to make an alliance with the states, with the object of compelling France to come to terms. This treaty was instrumental in bringing about the general pacification which was concluded in January 1679.

This was Temple's last appearance in the field of diplomacy. His plan for the reform of the privy council failed. His name was removed from the list of the council in 1681, and thenceforward he lived in retirement, first at Sheen, and then at Moor Park in Surrey. When William III. came to the throne Temple was pressed to take office, but refused. His son became secretary at war, but committed suicide immediately afterwards. Temple died at Moor Park on Jan. 27, 1699.

Temple's works include *An Essay on the Present State and Settlement of Ireland* (1668); *The Empire, Sweden*, etc., a survey of the different Governments of Europe and their relations to England (1671); *Observations upon the United Provinces* (1672); *Essay upon the Original and Nature of Government* (1672); *Essay upon the Advancement of Trade in Ireland* (1673). Some of these were published in the first part of his *Miscellanea* (1679). In the same year apparently his *Poems* were privately printed. In 1683 he began to write his *Memoirs*. The first part, extending from 1665 to 1671, he destroyed unpublished; the second, from 1672 to 1679, was published without his authority in 1691; the third, from 1679 to 1681, was published by Swift in 1709.

See *Life and Works of Sir William Temple* (2 vols., 1720; 2nd ed., with *Life* by Lady Giffard, 1731); a more complete edition, including the *Letters*, was published in 4 vols. in 1814; Burnet, *History of his own Time;* T. P. Courtenay, *Memoirs of the Life, etc., of Sir William Temple* (2 vols., 1836); Macaulay, *Essay on Sir William Temple;* A. F. Sieveking, *Sir W. Temple and other Carolean Essays* (1908); and E. S. Lyttel, *Sir William Temple* (Oxford, 1908).

TEMPLE, WILLIAM (1881–), English divine, second son of Frederick Temple, archbishop of Canterbury (*q.v.*), was born at Exeter on Oct. 15, 1881, and educated at Rugby and at Balliol College, Oxford, where he was president of the Oxford Union. From 1904–10 he was fellow and lecturer in philosophy at Queen's College, Oxford. In 1914 he resigned the headmastership of Repton School, which he had held from 1910, to take charge of St. James's, Piccadilly. During this period (1915–18) he was editor of *The Challenge*. He resigned from St. James's in 1917, and was then made a canon of Westminster (1919), and in 1921 bishop of Manchester. For 16 years (1908–24) he was president of the Workers' Educational Association, to which he rendered powerful assistance. In Nov. 1928 he was appointed archbishop of York to succeed Dr. Lang.

TEMPLE, a city of Bell county, Texas, U.S.A., 73 m. N. by E. of Austin, on Federal highway 81, and served by the Missouri-Kansas-Texas and the Santa Fe railway systems. Pop. (1920) 11,033 (19% negroes), estimated locally at 18,000 in 1928. It is the trade centre and shipping point for a rich agricultural region, raising chiefly cotton, grain and live stock. Its cotton gins and compresses handle 70,000 bales in a normal season. There are railway shops and other manufacturing industries, with a total output in 1925 valued at $2,674,301. Temple was founded in 1881 by the Gulf, Colorado and Santa Fe Railway company, and was chartered as a city in 1884. Since 1922 it has had a commission-manager form of government.

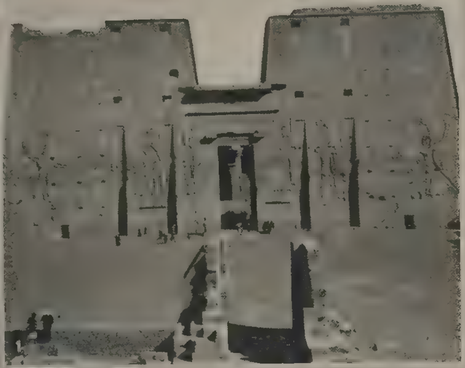
TEMPLE, a word signifying, loosely, any enclosed space or structure erected for purposes of worship, or to protect a cult image or cult objects. In a figurative sense the word is used for (1) any shrine; (2) any building built in a style similar to that of a classic temple; (3) for the meeting houses of certain nonconformist denominations; (4) for synagogues; (5) for the meeting places of certain fraternal orders.

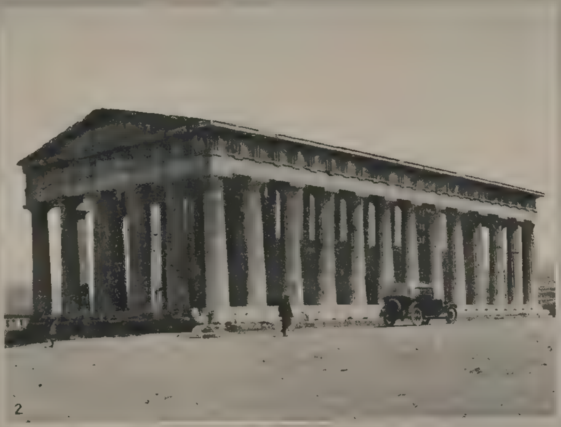
Cave Temples.—Although perhaps antedated by existing temple remains of the earliest Chaldean and Egyptian periods, a primitive type of cave temple culturally much earlier is that of certain cave temples of the Mediterranean basin, of which the most remarkable are those on the island of Malta, apparently dating originally to a neolithic culture, although undoubtedly in use for a thousand years afterwards. It is remarkable that in these temples, despite their early date (?5000 B.C.), great care is shown in the decoration and finish of altar stones, doors and other important features, and that many steatopygous female statues were found in the temples. This, together with the large size and important position of many phallic stones, would seem to indicate that the temple was dedicated to a god or goddess of fertility, or perhaps to a pair. The most important sites are Hagar Kim, Hal Tarxien and Mnaidra. There is also at Hal Saflieni a large, neolithic series of caves which seem to have been both for habitation and worship; the presence of enormous numbers of human bones also indicates that part of it was used as an ossuary. The much later Egyptian cave temples at Abu Simbel (time of Rameses the Great) are merely highly developed descendants of such primitive cave structures, and the great groups of temple caves in India, as well as certain early cave temples along the Yangtse river, China, show that this tendency was wide spread.

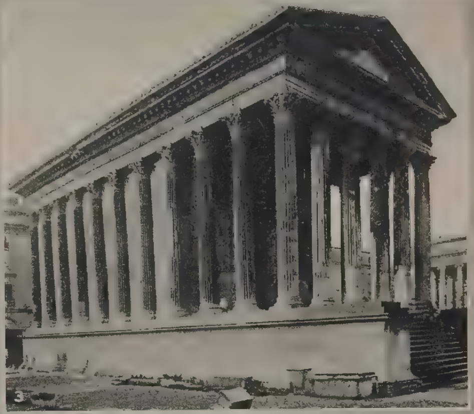
High Places.—Not only do such primitive hill-top altars, common to many parts of western Asia, indicate the love for such positions, but also megalithic remains like those of Stonehenge (*q.v.*) indicate a similar feeling. It is noteworthy that even in China the great Temple of Heaven in Peking takes the form of a series of circular terraces, obviously pointing to a primitive desire to imitate hill forms, and the Assyrian ziggurat (*q.v.*), as well as the Mexican and Central American pyramids are merely variant expressions of the same controlling emotion. This probably explains the situation of the temple at Jerusalem upon the hill top, and, combined with ease of military defence and love of architectural effect, the site of the temples of the Greek cities.

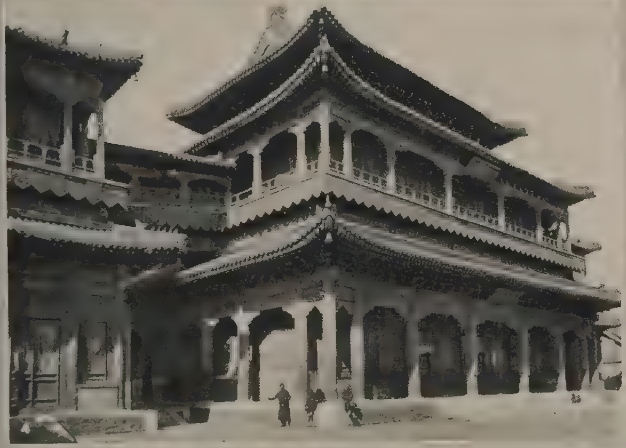
Egyptian Temples.—With the civilization of Egypt the structural temple assumes a controlling importance, for the cave temples of Egypt are exceptional and secondary. The developed Egyptian temple shows a complex type which is evidently the accretion of many stages. The earliest examples were probably simple, square or rectangular shrines of small size and with no openings but a door. Occasionally four columns supported the roof of flat stone. As worship grew more complex and wealth increased, additional halls were added in front of and around the original shrine, with a monumental, colonnaded hall open at the front, probably for the combined purposes of narthex (or vestibule) and prayer hall. Finally, a large court with entrance pylons of enormous size became part of the scheme, and by far the greater number of the Egyptian temples existing show all of these elements. The result was characteristic; both the widest and the highest elements in the building were toward the front (pylons, forecourt, hypostyle hall) and the narrowest and lowest at the rear (the shrine). The mystical effect of this gradual narrowing down and darkening of the interior scheme is impressive. In addition to these simple elements, the great temples of Thebes (Karnak and Luxor), representing the building of many generations and many dates, have the shrines surrounded with a maze of small rooms, courts and corridors, whose use is difficult to assign. The most perfect example of Egyptian temples, so well preserved that its ancient effect can be readily judged, is the late temple at Edfu (237–257 B.C.).

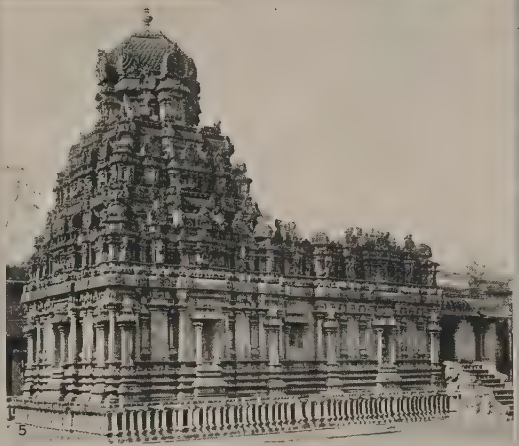
Western Asia.—The principal feature of Assyrian and Chaldean temples was the ziggurat (*q.v.*) or stepped pyramid, with stairs or an inclined plane leading up to the terraces of the steps and the summit. The walls were decorated with glazed brick or painted stucco, and in some cases, at least, each stage was dedicated to a separate divinity, as in the famous example at Babylon, in which each of the seven stages was dedicated to a separate planet. It is undoubtedly to a ziggurat that the biblical tradition of the Tower of Babel refers. Besides a ziggurat the temple group comprised a court or courts and various rooms for priests and for the storage of temple treasures and archives. Further west, on the Mediterranean coast, a different type occurs, in which a small, enclosed room is fronted with a monumental entrance, frequently flanked by columns. This type is not only known from various small Phoenician models, but is also clearly represented in the biblical descriptions of the various temples at Jerusalem. The earliest description of Solomon's temple is that of I Kings, vi. 7, which, despite its completeness, is open to many interpretations and an enormous number of different restorations have been based upon it and indications found on the site. The essential elements are, however, clear and consist of a courtyard, a great altar of burnt offerings, traditionally placed upon the sacred rock now known as the *sakhra*, and the temple building itself. This was entered through a lofty porch or gateway of obviously Egyptian pylon type, which was flanked or fronted by two enormous free-standing columns, which were purely decorative or traditional and may represent a lingering of the same neolithic tradition that set the phallic stones in the Malta temples. Through the pylon one entered the naos (the holy place or *hēkāl*), 40 cubits long, 20 wide and 30 high (the cubit being roughly one and a half

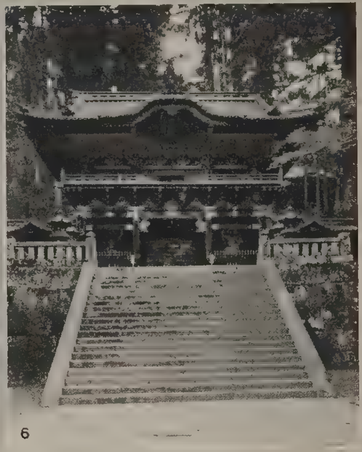












PHOTOGRAPHS, (1-5) EWING GALLOWAY, (6) DE COU FROM EWING GALLOWAY

TEMPLE ARCHITECTURE FROM THE 5TH CENTURY B.C. TO THE 17TH CENTURY A.D.

1. The great entrance pylons of the temple at Edfu (237–57 B.C.). These pylons embody, despite their late Ptolemaic date, all of the magnificent grandeur of scale and elaborate construction characteristic of Egyptian religious architecture
2. Greek temples, on the other hand, sought and achieved repose and classic dignity through careful relationship of every portion. The Theseum at Athens, completed before 421 B.C. and probably once dedicated to Hephaestus and Athena, is one of the best preserved
3. The Roman variation of the classic temple form is well shown in the Maison Carrée at Nîmes, France (*c.* A.D. 1). Its high podium or base, entrance steps and superb Corinthian order are typical of the governed lavishness of the Roman genius
4. The Lama temple at Peking, China, in its carefully spaced columns, richly bracketed cornices and subtly curved roofs is characteristic of Northern Chinese tradition. Roof tiles of imperial yellow, columns lacquered deep red and cornices of brilliant green, blue and gold give the much sought after Chinese colour richness
5. The Subrahmanya shrine in the temple of the great pagoda at Tanjore, India, is a much later addition to the earlier 11th century temple, typical of the Dravidian style, in its strongly contrasted horizontal and vertical lines
6. The Yashamon gate of the tomb shrine of Iyemitsu at Nikko, Japan, shows the graciousness, intricacy and occasional over elaboration typical of the Tokugawa style of the middle of the 17th century,

feet). It was lighted by a row of lattice windows, probably a clerestory set high in the wall, like the somewhat similar clerestory windows at Karnak. Behind the naos, and entered from it, was the Holy of Holies or *dĕbir,* 20 cubits in all three dimensions. Within this sanctuary was kept the Ark of the Covenant, flanked by two cherubim. Surrounding the naos and sanctuary were three storeys of small chambers. In the details described, this temple shows an interesting combination of forms with origins in all the surrounding countries. Thus the pylon porch and the diminution of height from front to back are purely Egyptian, while the greater number of the ornamental motives (cherubim, etc.) are of Mesopotamian origin. In construction, however, the combination indicated of stone, timber and metal is distinctively of the Mediterranean coast. The temple was destroyed (586 B.C.) and rebuilt 70 years later, largely in accordance with the older type, with certain differences, the most important of which was the use of a great curtain to separate the naos from the sanctuary and the existence of two courts instead of one. In *c.* 20 B.C. Herod built a third temple which was hardly completed in its entirety before the capture of the city and the razing of the temple by Titus (A.D. 70).

The Aegean World and Greece.—The Minoan civilization has left remains which indicate that both caves and high places were deemed sacred. Representations on seals and wall paintings also show that small shrines existed in great numbers, but up to the present time (1928) no large, monumental temples have been discovered. The most ordinary type of Aegean shrine of pre-Greek date is well represented on a fresco in the palace at Knossos (*c.* 1500 B.C.), showing a wall surrounding a temenos or sacred area, planted with trees, and filled with worshippers.

In the early Hellenic Greek world it would seem that the temenos with its altar was the most common form of temple; the constructed building not appearing until two or three centuries had elapsed after the Dorian migration. The earliest temples were of various forms, patterned on primitive dwellings, but the rectangular form was finally adopted and developed. The construction was apparently of sun-dried brick, with wall ends and openings cased in wood. A porch in front was early added, between solid end walls, which were the continuation of the side walls of the cella or enclosed portion. As building skill increased, and the need for larger and more splendid temples was felt, columns were added, first in one row down the centre, to decrease the unsupported span of the roof, and later in two rows, dividing the covered space into nave and aisles. On the outside columns on the porch matched those within. Later, another porch was added at the rear, and finally a colonnade would be continued entirely around the building, giving the developed type which has been famous as the characteristic classic type ever since. One of the earliest of large size, of which many remains exist, is the temple of Hera at Olympia (variously ascribed to many dates between the 10th and 7th centuries B.C.). Its stone foundations were obviously originally designed to carry sun-dried brick walls and its wood cased antae (*q.v.*), or pilaster-like wall ends, and door jambs are of the most primitive type. It is reported by Pausanius that the original wooden columns of the colonnade were replaced by stone columns of various shapes and sizes during the entire history of classic Greece, differences in contemporary styles accounting for the relative delicacy or crudity of the columns. Naturally, the greater number of the architectural fragments found are of late date. By the middle of the 7th century B.C. the Greek temple type was thoroughly established and the ruined temple at Corinth, of this date, had a stone colonnade in which all the elements of the later perfected Doric order are found. There is also a large group of archaic temples in south Italy and Sicily, where the Greek colonies of the time had reached a high level of wealth and established civilization. Thus at Syracuse, at Segesta, Selinus, Agrigentum (Acragas) and Paestum there are many examples of archaic Doric temples of the late 7th and 6th centuries B.C. In all of these the columns are heavy and low, closely spaced and with widely projecting, heavily convex capitals, and the entablature above is heavy in proportion. Sculpture of a crude type appears during this period, notably in the metopes and the pediments, or gable ends.

The type of temple building thus set remained constant throughout the history of Greek architecture, although the refinements of taste and growing structural skill of the period succeeding the Persian wars led to the use of slenderer columns and more delicate entablatures. The typical temple was surrounded by a colonnade, usually with six columns at each end, and with 12 or more on the sides. The walls of the enclosed cella were usually separated from the columns of the colonnade by a space wider than that between the columns and, following the old tradition, frequently projected in front of the doorway proper, forming, as it were, a little subsidiary porch inside the main colonnade. Within, the building was sometimes divided into two chambers, the larger in front, the smaller, rear chamber, being entered occasionally from the larger, but often, as in the Parthenon (447–438 B.C.), entered only from the rear porch. This rear chamber was frequently used as a treasury. The larger room was usually divided into a nave and aisles by two rows of columns, in most cases in two storeys, either with or without a gallery at the level of the lower entablature. At the end of the nave, opposite the entrance, stood the statue of the deity, which might be either an antique and shapeless tree trunk, going back to prehistoric times, or the most perfect colossal work of a sculptor like Pheidias, whose gold and ivory statues of Zeus in Olympia and of Athena in the Parthenon at Athens were perhaps the two most admired works of art of the ancient world. The interior was probably lighted only by light entering through the door; this illumination, upon the rich colours of the painted architectural detail and the mass of votive offerings, and reflected from the white and gold of the statue, undoubtedly produced an effect of sombre and impressive richness. The same richness of colour and sculpture decorated the exterior. The entablature glowed with deep blues and reds, against which the metope sculptures were sharply relieved. In the pediments above, great groups of free-standing sculpture, brilliantly composed, gave an adequate crown. In some cases the exterior walls were probably painted, as well.

The typical Greek temple, however, consisted usually of more than a single building, which was only the most important feature of the temenos. The sacred enclosure might contain, as well, smaller shrines of heroes or related deities; treasury buildings for gifts from special localities, like the treasuries at Olympia and Delphi; colonnades, as at Argos; and, in special cases, halls for mysteries and the like. Thus, such temples or sacred areas as those at Eleusis, Argos, Delos, Delphi and Olympia became vast congeries of all sorts of buildings devoted to the common purpose and use of aiding in some way the cult, and usually representing many periods of Greek history down to, and even later than, the Roman conquest.

In Asia Minor the Ionian influence, working on the same basis, produced effects of a different type. Not only was the Ionic order most commonly used in place of the Doric, but also the sense of scale was different, and when the Doric builders sought beauty through perfection of detail and every possible refinement, the Ionians sought it through enormous size and lavish richness. Thus even the archaic temple of Artemis at Ephesus (early 6th century B.C.) was of a scale scarcely ever attempted in Greece proper, prior to Roman times, and in the much later temples at Priene, Miletus and Sardis, great size and scale was the controlling force.

Etruria and Rome.—Etruscan temples are little known except from literary descriptions and certain remains of terra-cotta revetments, or covering decorations for wooden members. It is well established that the cella was much shorter than in Greek examples, approaching a square in plan, and that columns were limited to a porch in front, usually of great depth. The construction of the roof and entablature was apparently usually in wood, sometimes covered with terra-cotta plaques, and the spacing between columns was much greater than in Greek temples.

Roman temples, in plan, always retained the influence of their Etruscan prototypes, and the great temple of Jupiter on the Capitoline hill preserved to the end its primitive Etruscan lay out—a wide, shallow cella divided into three chambers, all opening out upon a deep, many-columned porch. The peripteral scheme, with columns on all four sides of the cella, appeared only in imperial times and was always rare, being reserved for the very largest and most monumental temples, such as the enormous double temple of Venus and Rome at Rome, designed for Hadrian, by Apollodorus of Damascus. The normal type, with a porch only in front, nevertheless, frequently had the cella walls decorated with pilasters or engaged columns. Thus the temple of Fortuna Virilis at Rome (variously attributed to the beginning of the 2nd and the beginning of the 1st century B.C.), has a range of engaged columns around three sides of the cella, matching exactly the columns of the porch. The same treatment, on a much larger scale, is found in the Maison Carrée at Nîmes (*c.* A.D. 1), which is the most perfect example of a Roman temple extant. Similarly based upon Etruscan tradition is the fact that all Roman temples were raised upon high podia (base or pedestal), whose side walls projected forward and received the ends of a great flight of entrance steps. Roman temple interiors were usually both larger and more lavish than the interiors of Greek temples, and the larger examples were frequently vaulted with richly coffered barrel vaults. This led also to a greater enrichment of wall design, and walls, beside being cased in rich marbles, were often enriched with pilasters or engaged columns, and further decorated with small niches pediment-crowned and flanked by columns. The most extraordinary examples of this type of development extant are the temples comprising the great group at Baalbek in Syria, the ancient Heliopolis (begun during the reign of Hadrian and completed early in the 3rd century). The cella of the temple of Bacchus, the smaller of the group, still remains, in large measure complete up to the cornice, and shows ranges of engaged Corinthian columns, and between them arched recesses below, and pedimented statue frames above. The great temple of Jupiter is chiefly remarkable for its enormous forecourt, colonnaded and with great niches, and in front of that an hexagonal court, and the colonnaded propylaea. Both of these temples have colonnades all around, in the Greek manner, and the same is true of the contemporary double temple of Venus and Rome at Rome, in which the surrounding colonnade was double. This temple is also remarkable for the two apses back to back in which the statues of the two divinities were placed. The side walls were treated with niches and columns in a way much resembling the Baalbek example. The surroundings of Roman temples never had the informal charm of the Greek temenos, but were usually surrounded by a rectangular courtyard with colonnades, like that of the temple of Venus and Rome, or the temple of Apollo in Pompeii (rebuilt *c.* A.D. 65). Other temples were placed merely at street corners, like the temple of Fortune at Pompeii, of early imperial date, or the temple of Fortuna Virilis at Rome. Many temples were also placed in or facing the forum, which served, itself, as the temenos or sacred area.

Many exceptional types of Roman temples are found. Thus the temple of Vespasian at Brescia (A.D. 72) had three chambers in the cella with the six-columned portico in front of the central one projecting far beyond the small porticos of the side chambers. That of Concord, at Rome (7 B.C. to A.D. 10) had the main entrance to the cella in the middle of one of the long sides, with a superb portico in front of it. Remarkable also is the great development of round temples, either of comparatively small size, like the temple of the Sybil at Tivoli (usually attributed to the beginning of the 1st century B.C.); the so-called temple of Hercules at Rome; or the so-called temple of Venus at Baalbek, in which the cella is surrounded with a portico of Corinthian columns, whose entablature is scalloped or star-shaped in plan. The most magnificent of the round temples is the Pantheon (*q.v.*) at Rome (A.D. 110–125), whose vast domed hall, over 140 ft. in diameter, is one of the most impressive interiors in the world.

Classic Temples: Technical Definitions.—In architectural descriptions of the classic temple a number of technical words have become common. Many of these owe their origin to the work of Vitruvius, author of a complete Roman treatise on architecture of the time of Augustus. The most common of these terms descriptive of the general arrangement and of the position of columns may be shortly defined as follows:

A. Those affecting general distribution of parts.
  Prostyle—with a porch or portico in front.
  Amphiprostyle—with a porch or portico both at front and rear.
  Peripteral—with a colonnade completely surrounding the cella, either rectangular in plan, as in the typical Greek temple, or circular, as in the temple of the Sybil at Tivoli.
  Pseudoperipteral—with a porch or portico only in front, but with the exterior walls of the cella decorated by engaged columns or pilasters, as in the Maison Carrée at Nîmes.

B. Terms describing detailed arrangement or position of temple columns.
  In antis—columns placed between the pilaster-like decorations at the ends of the side walls of a naos or cella when these walls are projected forward beyond the front of the building to form a porch between them.
  Dipteral—with a double colonnade along the sides.
  Pseudodipteral—with the columns of the side colonnade separated from the cella walls by a space wide enough to allow a double colonnade but without an inner row of columns.
  Distyle, tetrastyle, pentastyle, hexastyle, octostyle, decastyle, etc.—with two, four, five, six, eight or ten columns in front. Such words composed of "style," with a Greek numerical prefix, may be multiplied indefinitely, to describe buildings or porticos with any number of columns.

Indian Temples.—Indian temples show clearly the development from sacred cave to free-standing structure. The earliest existing monumental temples are all rock-cut and developed with caves. The earlier temples, such as those at Behar, and at Karli, near Bombay, show a great cave interior, divided by piers or columns into nave and aisles, with a small stupa, or solid masonry curve-topped structure enclosing a relic of Buddha, and a façade cut in the face of the rock, with doorway below and huge horseshoe-shaped window above, all in imitation of wooden construction. A second common type of rock-cut temple consists of those in which, in addition to the shrine proper, there are great courtyards surrounded by cells for monks. These are known as *viharas.* The most remarkable groups of cave temples are those at Ajanta and Ellora. In both there are temples of Buddhism and also Brahmanism, and the types of detail known as Dravidian and Jain are both found. The dates vary from the 2nd century B.C. to the 6th and 7th centuries A.D. The Dravidian and Jain constructed temples both show a power and heaviness of general mass with an amazing intricacy of carved detail that is more typical of rock-cut than free-standing structures, and the characteristic pyramidal towers, with their strongly marked horizontal mouldings and vertical projections have almost the character of artificial mountains and cliffs. The rôle played by figure sculpture in its lavishness, its multitude of figures and their bold relief, is unlike that played in any other structural style, and without doubt owes much, also, to rock-cut prototypes. The plan type shows usually a vast rectangular enclosure entered through several monumental gateways, crowned with enormous, solid towers. Within are smaller enclosures and subsidiary buildings, and sometimes an additional closed court, also with monumental gates. Near the centre is the shrine proper, containing the cult statue, sometimes approached by vast, colonnaded halls, and every exposed surface of the great towers and the interior columns and walls is covered with a rich network of sculpture and ornament.

East Indies.—Indian influence is marked in the temple ruins found in scattered places through Cambodia, Burma, Java and nearby islands. All of the great temples are elaborations of the stupa idea, and consist in essence of one or more stupas on raised terraces. Thus in the Shwe Dagon pagoda at Rangoon there are a multitude of small stupas crowned with high, spire-like finials, surrounding a central stupa which rises to a height of over 350 ft., and the whole surface is heavily gilded. At Boro-Budur, Java, the great Buddhist temple (? 7th or 8th century

A.D.) consists of a series of terraces around a hill 150 ft. high, at the top of which is a large stupa surrounded by 16 smaller ones. All of the stone lining of the terrace walls is covered with exquisite relief sculpture, not only illustrating the life of Buddha, but also containing many pictures of ordinary, every day events. The most remarkable of these eastern Buddhist temples is Angkor-Wat at Angkor in Cambodia (attributed to the 1st half of the 12th century, and apparently originally intended as a Brahmin temple, being converted to Buddhist uses later). This consists of three great symmetrical terraces with elaborate stairs, corner towers, porticos and colonnaded halls, with a great stupa-like tower as the climax in the centre. The sculpture and ornament, although typically Khmer, show distinct traces of Hindu influence. The extremely classic character of some of the pier and column capitals is noteworthy.

China and Japan.—Further east an entirely contradictory tradition governs temple design, that of the columned prayer halls of Japan and China. The expression of this in China differs from that in Japan. The typical Chinese temple, whether Taoist or Buddhist, is basically symmetrical and rectangular. Through a gate-house, frequently vaulted, an outer court is entered, in which on either side of the main axis is a small tower, one containing a drum and the other a bell. Directly opposite is the main prayer hall of the temple, with many columns, and a richly beamed and coffered ceiling. Against the back wall is a large pedestal, usually supporting three statues, and in front of it a table-like altar with its ritual utensils. In temples of Confucius, a simple, richly decorated shrine replaces the statues. There is often, in addition, a court at the rear, with another hall shrine on its axis. In large groups, the number of courts and shrines is increased and additional halls at the sides of the courts serve the purpose of chapels. In Taoist temples, the most important shrine is sometimes in the centre of the court, and bell and drum towers are absent. There is also, at times, a long gallery containing statues of the 500 Lohans, or holy men. The architectural character varies with the locality. Those in the north are full of the monumental grandeur of the Peking school, as in the temple of Confucius, or such monasteries in the western hills as that of Wo Fu Tsu (both of the Ming and subsequent dynasties). Those in the Yangtse valley are more picturesque, with exaggeratedly curved roofs, and slimmer supports, as in the 18th century Sheng Yan Sze monastery near Hangchow. In those in the south, granite supports replace the wooden columns found further north. Roof ridges are of extraordinary intricacy and the wood carvings of the interiors exquisitely rich and delicate, as in the 18th century temple of the Chen family in Canton.

In Japan the elaborate formality of the typical Chinese temple is absent. In fact, the native Shinto temples are based upon exceedingly primitive house ideas, and are simple, rectangular buildings with heavily thatched roofs. Architectural effect is gained, however, through the monumental *torii* or gateways which cross the main entrance paths. Many votive stone lanterns also decorate the grounds. In the Buddhist temples the halls themselves are based entirely on Chinese prototypes, but the detail is typically Japanese in its composition and its mannered realism, and roof and cornice details are endlessly varied. In disposition there is little attempt at absolute symmetry. Instead, there is a brilliant grasp of informal balance and composition, and a remarkable genius in adapting the exigencies of the plan to the picturesque hillside site so loved by the Japanese. Outstanding examples are the temples of the magnificent group at Nikko, largely of the 17th century, and the Hong Wanji temple at Kyoto. The genius for placing temples is well seen in the island temples that dot the Inland sea, especially those of the sacred island of Itaku Shima, near Hiroshima, where the chief temple was founded in 587.

(*See* also CHINESE ARCHITECTURE; EGYPTIAN ARCHITECTURE; GREEK ARCHITECTURE; INDIAN ARCHITECTURE; JAPANESE ARCHITECTURE; RELIGIOUS AND MEMORIAL ARCHITECTURE; ROMAN ARCHITECTURE; WESTERN ASIATIC ARCHITECTURE, FROM EGYPT TO ARCHAIC GREECE.) (T. F. H.)

TEMPLE BAR, an historic site in London, England. In more than one of the main roads converging upon the city of London a bar or chain marked the extra-mural jurisdiction of the Corporation. Temple Bar stood at the junction of the present Strand and Fleet street, over against the Law Courts. A bar is first mentioned here in 1301, but the name is most familiar in its application to the gateway designed by Sir Christopher Wren, which replaced an older structure on this spot in 1672. This was removed in 1878, and set up in 1888 at the entrance to Theobalds park near Cheshunt, Hertfordshire. A pedestal surmounted by a dragon or "griffin" marks the old site. When the sovereign is about to enter the city in state, whether by Temple Bar or elsewhere, the Lord Mayor, in accordance with ancient custom, presents the sword of the city to him, and he at once returns it. Formerly the bar or gate was closed until this ceremony was carried out.

TEMPO (It.), term used in music signifying literally time, though in practice it has come to mean more often the speed at which a composition is, or should be, performed. It is however still used in the other sense in such expressions as *tempo ordinario,* meaning "in common time"; likewise in *tempo rubato* (literally "robbed time"), meaning the slight deviations from strict time which the performer makes for expression. (*See* TIME.)

TENANT: *see* LANDLORD AND TENANT.

TENANT-RIGHT, in law, a term expressing the right which a tenant has, either by custom or by law, against his landlord for compensation for improvements at the determination of his tenancy. In England it is governed for the most part by statute; *e.g.,* the Agricultural Holdings Act, 1923, and the Small Holdings and Allotments Acts, 1908–26 (*see* ALLOTMENTS; LANDLORD AND TENANT; SMALL HOLDINGS). A right to compensation for improvements is created in favour of tenants of business premises by the Landlord and Tenant Act, 1927. In Ireland tenant-right was a custom, prevailing particularly in Ulster, by which the tenant acquired a right not to have his rent raised arbitrarily at the expiration of his term. Tenants of houses and shops in urban districts, towns or villages in Ireland enjoy a statutory tenant-right to compensation for improvements and disturbance (*see* the Town Tenants [Ireland] Act, 1906).

No custom giving rise to tenant-right seems ever to have existed in the United States, and no right of compensation in favour of tenants exists apart from agreement or local statutes.

TENASSERIM, a division of Lower Burma, bordering on Siam. Area, 35,788 sq. miles. Pop. (1921) 1,613,523, including 55,883 Christians, the great majority of whom are Karens. The headquarters of the commissioner are at Moulmein. It is divided into six districts: Toungoo, Salween, Thatôn, Amherst, Tavoy and Mergui. It formed the tract south of Pegu conquered from Burma in 1826, which was for many years known as the Tenasserim province. The southern extremity of the division approaches the insular region of Malaya, and it is fringed along its entire western coast by a number of islands, forming in the north the Moscos and in the south the Mergui Archipelago. The eastern frontier is formed by a mountain range 5,000 ft. high, the waterparting between Tenasserim and Siam. (*See* BURMA.)

TEN BRINK, BERNHARD EGIDIUS KONRAD (1841–92), German philologist, of Dutch origin, was born at Amsterdam on Jan. 12, 1841, and educated at Düsseldorf, Münster and Bonn. In 1870 he became professor of modern languages at Marburg, and in 1873 professor of English at Strasbourg university. In 1874 he began to edit, in conjunction with W. Scherer, E. Martin and E. Schmidt, *Quellen und Forschungen zur Sprache und Kulturgeschichte der germanischen Völker.* In 1877 he published *Chaucer: Studien zur Geschichte seiner Entwickelung und zur Chronologie seiner Schriften;* in 1884, *Chaucers Sprache und Verskunst.* He also published critical editions of the *Prologue* and the *Compleynte to Pité.* Ten Brink's work stimulated a revival of Chaucer study in the United Kingdom as well as in Germany, and to him was indirectly due the foundation of the English Chaucer society. His *Beowulf-Untersuchungen* (1888) proved a hardly less valuable contribution to the study of Early English literature. His best known work is his *Geschichte der englischen Literatur* (1889–93) (English by H. Kennedy in Bohn's *Standard Library*), which was never completed, and broke off just before the Elizabethan period. He died at Strasbourg Jan. 29, 1892.

TENBY, municipal borough and seaside resort, Pembrokeshire, Wales, on a promontory on the south coast of the county. Pop. (1921) 4,832. Its two sandy beaches and mild climate contribute to its success as a watering-place. The settlement is first definitely mentioned as a Danish fishing station, and the old Welsh name is Dynbych-y-Pyscod (the "precipice of fishes"). The name Tenby may be derived from "Dynbych"; but is usually said to come from the Scandinavian "Daneby." Flemish cloth-workers came here in the early 12th century. The earls-palatine of Pembroke often had to defend it from, and refortify it after, Welsh attacks. The town was associated with the Tudors during the Wars of the Roses and Jasper Tudor rebuilt its walls. The early charters were confirmed by that of Elizabeth in 1580 and the walls were repaired in 1588 when a Spanish invasion was feared.

During the 15th and 16th centuries Tenby traded by sea with Bristol and had wealthy mercantile families. It declined after the Restoration. During the 18th century it was a market centre.

The large parish church, St. Mary's, has a 13th century tower of local type, with spire, but is mostly 15th century. The ancient town walls are almost intact on the north and west. The ruins of the castle, part of the keep and outer walls, stand on Castle Hill, N.E. of the town.

TENCH (*Tinca tinca*). A cyprinid fish of Europe, Asia Minor and Siberia, greenish, with small scales and rounded fins. It thrives in weedy ponds. Specimens exceeding 8 lb. are rare. The flesh is more palatable than that of most cyprinids.

TENDA, the name given by the Fulani to the peoples known as Bassari, Koniagui and Badiar. They call themselves Ayan, Awonhen or Akus, and live between the Upper Gambia and the Rio Nunez, in confederated villages, each village forming a political and a religious unit. They have three degrees of initiation to corresponding age classes, with a chief for each class, and a higher dignitary over all who in turn is subject to the paramount chief. The women are organized into societies. Marriage is prohibited between relations of the direct paternal or maternal line and collaterally within three degrees, but marriage is common between second cousins; the woman's consent is necessary. Family property is administered by the head of the family, and there is personal property. Succession is based on maternal kinship, the eldest brother coming first, then younger brothers and finally nephews. The Tenda are excellent cultivators of millet, maize, earth-nut and tobacco, and breed oxen, sheep and goats.

See Delacour, "Les Tenda," *Revue d'Ethnographie et de Sociologie* (1912–13).

TENDER. (1) An adjective meaning soft, either physically or figuratively (Fr. *tendre*, Lat. *tener*, soft, allied to *tenuis*, thin). (2) A legal term meaning an offer for acceptance, particularly an offer in money for the satisfaction of a debt or liability or an offer to pay or deliver according to the terms of a contract; for "legal tender" *see* PAYMENT. The term is also applied to an offer to do a specified piece of work or to supply certain goods for a certain sum or at a certain rate or to purchase goods at a certain rate. Contracts for important works or for the supply of large amounts of goods are usually put out to tender in order to secure the lowest price. In this sense the word is from "to tender," to offer (Fr. *tendre*, Lat. *tendere*, to stretch out). (3) A "tender" is also one who "attends" (Lat. *attendere*, to stretch towards, to give heed to), and so is applied particularly to a small vessel which brings supplies, passengers, etc., to a larger vessel or which is used to take or bring messages, and similarly to a carriage attached to a locomotive engine on a railway, which carries fuel and water.

TENDON OF ACHILLES, the large tendon at the back of the ankle. It is the tendon of the calf muscles which extend and invert the foot, and is inserted into the heel bone (calcaneus). These muscles often become shortened, owing to overdevelopment, or sometimes to the continued use of high heels, or they may be congenitally short. This defect sometimes leads to fallen arches and foot pain so severe that the tendon has to be lengthened by surgical operation. This tendon is named after Achilles, a famous hero of the Trojan war. According to Greek legend when Achilles was born his mother plunged him into the river Styx. This made his whole body invulnerable except the part of the heel by which she had held him, and in this heel he later received a mortal wound.

TENEBRAE, an office sung in Roman Catholic churches on the afternoon or evening of Wednesday, Thursday, and Friday of Holy Week. Durandus (vi. 72, n. 2) derives the name from the fact that "the church on these days cultivates darkness (*tenebras colit*)" in sorrow for the Lord's Passion, celebrating his exequies on three days since for three days He was dead, and it symbolizes the darkness that fell on the earth while the Sun of justice was crucified.

TENERIFFE [Tenerife], the largest of the Canary islands; Pop. (1900) 138,008; area, 782 sq.m. It is of irregular shape, 60 m. long, with an extreme breadth of 30 m. The celebrated peak, locally known as the Pico de Teyde (or Teide) with its supports and spurs, occupies nearly two-thirds of the whole island. It has a double top; the highest point, El Piton, is 12,200 ft. above the sea; the other, Chahorra, connected with the first by a short narrow ridge, has a height of 9,880 ft. They are both orifices in the same grand dome of trachyte. Snow remains for about four months on the upper part of the peak.

For more than one-half of its circumference the base of the true peak rises from an elevated but comparatively level tract. On the south-east, south and south-west there is a high curved ridge overlooking the Pumice-Stone Plains, and presenting a very steep face to the peak. Between the ridge and the sea the slope is more gradual, and there are intervening tablelands. Peaks rise from the ridge, one of which (Guajara) attains the height of 8,900 ft. Both El Piton and Chahorra have craters on their summits, from which issue steam and a little sulphurous vapour. The crater on El Piton is partly surrounded by a wall of lava, which has been made white by the action of sulphurous vapours. The crater is about 300 ft. across, with a depth of 70 ft. The crater on Chahorra has a diameter of 4,000 ft.; its depth is scarcely 150 ft. The entrance to the Llano at a sort of natural gateway (called *Portillo*) between two basaltic hills, is about 7,000 ft. above the sea. Between two and three hours are consumed in crossing the Llano to the base of the cone, the lower part of which is ascended to a point 9,750 ft. above the sea.

To the north-west of the grand cone, some thousands of feet below Chahorra, there are many small cones of eruption, showing that the intensity of volcanic action was greatest on this side. Eastward from the ridge bounding the Pumice-Stone Plains extends a chain of mountains to the north-eastern extremity of the island. The highest peaks are Izana (7,374 ft.), Perejil (6,027), and Cuchillo (5,467).

There is no record of eruptions from either crater of the peak. In 1795 a great quantity of lava was poured out from three vents on the eastern side; and in the same year lava streams issued from a crater near Guimar, half-way between Santa Cruz and the peak. In the year 1706 a vent on the north-western side of the peak discharged a copious stream, which flowed down to the sea, and nearly filled up the harbour of Garachico. For three months in 1798 much lava and other volcanic matter were ejected.

Santa Cruz, the capital of Teneriffe and of the Canaries, and La Laguna, the former capital, are described in separate articles. A good road connects Santa Cruz and Orotava, a town on the north coast 25 m. W.N.W. Date-palms form a striking feature in the landscapes. The town of Orotava (pop. 9,192) is 1,040 ft. above the sea. The houses are solidly built, but it has a deserted aspect. A stream of water is conducted through every street. Port Orotava, 3 m. N. of the town, is a clean place, with about 4,500 inhabitants. The streets are broad and the houses well built. (*See* also CANARY ISLANDS.)

TENGYUEH (Burmese MOMEIN), a town in the province of Yunnan, south-west China, near the Burmese frontier, with an estimated Chinese population of 18,000. It is situated at an elevation of 5,400ft., in a region of heavy monsoonal rainfall, between the parallel north to south valleys of the Salwen and Irrawaddy. The town dates from the 14th century, when the Shan principality of Nankao was conquered by the Chinese, and Tengyueh was built as an outpost. The town lies on the old trade route from Yunnan-fu to Bhamo, a Burmese trade-centre in the upper Irrawaddy valley. Trade is conducted by mule-transport; the journey to Yunnan-fu, over difficult country, takes about 24 days, while Bhamo is a seven days' journey. The town was opened to foreign trade in 1897, but the actual customs opening did not take place until 1902. Foreign piece goods, cotton yarn, kerosene oil and matches are imported, while there is an export trade in carpets, musk, split bamboo hats and Szechuan raw silk. In times of difficulty, as in 1926, the Szechuan silk is exported via Szemao, a neighbouring frontier port. In 1925 (a normal year) the net foreign imports were valued at 3,701,194 Haikwan taels, and the exports at 1,755,263 taels.

TENIERS, the name of a family of Flemish artists who flourished at Antwerp and Brussels during the 17th century.

David Teniers, the elder (1582–1649), was born at Antwerp, the son of Julian Teniers, a mercer who settled at Antwerp in 1558. He received his first training in the painter's art from his brother Juliaen, then studied under Rubens in Antwerp, and subsequently under Elsheimer in Rome; he became a member of the Antwerp gild of painters in 1606. Though he tried his skill in large religious, historical and mythological compositions, his fame depends chiefly on his landscapes and paintings of peasants carousing, of kermesse scenes and the like, which are marked by a healthy sense of humour, and which are not infrequently confused with the early works of his son David. A large painting by the elder Teniers at St. Paul's church in Antwerp, represents the "Works of Charity." At the Vienna Gallery are four landscapes painted by Teniers under the influence of Elsheimer, and four small mythological subjects, among them "Vertumnus and Pomona," and "Juno, Jupiter and Io." The National Gallery has a characteristic scene of village life, "Playing at Bowls," a "Conversation," and a "Rocky Landscape." Other examples of his work are to be found at the galleries of Leningrad, Madrid, Munich, Dresden and Berlin ("The Temptation of St. Anthony"). He died at Antwerp on July 29, 1649.

David Teniers, the younger (1610–1690), his more celebrated son, was born in Antwerp and was baptized on Dec. 15, 1610. Through his father, he was indirectly influenced by Elsheimer and by Rubens. We can also trace the influence of Adrian Brouwer at the outset of his career. In 1637 Teniers married the ward of Rubens, Anne Breughel, the daughter of John (Velvet) Breughel. He became a "master" in the gild of St. Luke in 1633. The Berlin Museum possesses a group of ladies and gentlemen dated 1634. Some first-rate works—the "Prodigal Son" and a group of "Topers" in the Munich Gallery, and a party of gentlemen and ladies at dinner, termed the "Five Senses," in the Brussels Museum—are instances of the perfection attained by the artist when he was probably scarcely twenty. His touch is of the rarest delicacy, his colour at once gay and harmonious. He was little over thirty when the Antwerp gild of St. George enabled him to paint the marvellous picture now in the Hermitage Gallery in Leningrad —the "Meeting of the Civic Guards." Correct to the minutest detail, yet striking in effect, the scene, under the rays of glorious sunshine, displays acquired knowledge and natural good taste. Another work of the same year (1643), now in the National Gallery, London, is "The Village Fête."

Teniers was chosen by the common council of Antwerp to preside over the gild of painters in 1644. The archduke Leopold William, who had assumed the government of the Spanish Netherlands, employed Teniers not only as a painter but as keeper of the collection of pictures he was then forming. With the rank and title of "ayuda de camara," Teniers took up his abode in Brussels in 1651. Immense sums were spent in the acquisition of paintings for the archduke. A number of valuable works of the Italian masters, now in the Vienna Museum, came from Leopold's gallery after having belonged to Charles I. and the duke of Buckingham. De Bie (1661) states that Teniers was some time in London, collecting pictures for the duke of Fuensaldaña, then acting as Leopold's lieutenant in the Netherlands. Paintings in Madrid, Munich, Vienna and Brussels show what the imperial residence was at the time of Leopold, who is represented as conducted by Teniers and admiring some recent acquisition. No picture in the gallery is omitted, every one being inscribed with a number and the name of its author, so that the *ensemble* of these paintings might serve as an illustrated inventory of the collection. Still more interesting is a canvas, now in the Munich Gallery, showing Teniers at work in the palace, with an old peasant as a model and several onlookers. When Leopold returned to Vienna, the pictures travelled to Austria. Teniers remained in high favour with the new governor-general, Don Juan, a natural son of Philip IV.

Shortly after the death of his wife in 1656 Teniers married Isabella de Fren, daughter of the secretary of the council of Brabant, and strove to prove his right to armorial bearings. In 1663 Teniers founded the Academy at Brussels.

Teniers died in Brussels on April 25, 1690. David, his eldest son, a painter of talent and reputation, died in 1685. One of this third Teniers's pictures—"St. Dominic Kneeling before the Blessed Virgin," dated 1666—is in the church at Perck.

See T. Smith, *Catalogue Raisonné III.* (1831); John Vermoelen, *Notice historique sur David Teniers et sa famille* (Antwerp, 1871); Alph. Wauters, *Histoire des environs de Bruxelles* (1851); and *Les tapisseries bruxelloises* (1878); Max Rooses, *Geschichte der Malerschule Antwerpens* (Munich 1880); A. v. Wurzbach, *D. Teniers* (1877); J. van den Branden, *Gesch. d. Antw. Schilderschool* (1883); A. Rosenberg, *David Teniers* (Leipzig, 1901).

TENISON, THOMAS (1636–1715), English archbishop, was born at Cottenham, Cambs., on Sept. 29, 1636. He was educated at Corpus Christi college, Cambridge, of which he became a fellow in 1639. After holding cures at Cambridge, where he gave devoted care to sufferers from the plague, and at Norwich, he was presented in 1680 by Charles II. to the vicarage of St. Martin's-in-the-Fields, London, where he endowed schools, established a public library, and was a champion of Protestantism during the reign of James II. Monmouth sent for him before his execution. Under William III., Tenison was in 1689 named a member of the ecclesiastical commission appointed to prepare a reconciliation of the Dissenters, the revision of the liturgy being specially entrusted to him. He preached a funeral sermon on Nell Gwyn (d. 1687) in which he represented her as truly penitent—a charitable judgment which did not meet with universal approval. He was made bishop of Lincoln in 1691 and archbishop of Canterbury in Dec. 1694. He attended Queen Mary during her last illness and preached her funeral sermon in Westminster Abbey. During William's absence in 1695 Tenison was appointed one of the seven lords justices to whom his authority was delegated. With Burnet he attended the king on his death-bed. He enjoyed little favour with Queen Anne, but was a commissioner for the Union with Scotland in 1706. A strong supporter of the Hanoverian succession, he was one of the three officers of state to whom on the death of Anne was entrusted the duty of appointing a regent till the arrival of George I., whom he crowned on Oct. 31, 1714. Tenison died in London on Dec. 14, 1715.

Tenison's works include *The Creed of Mr. Hobbes Examined* (1670) and *Baconia, or Certain Genuine Remains of Lord Bacon* (1679). He was one of the founders of the Society for the Propagation of the Gospel.

TENNESSEE (tĕn″ę-sē′), popularly known as the "Volunteer State," is a S. central State of the American Union. It lies between lat. 35° and 36° 40′ N. and between long. 81° 37′ and 90° 28′ W. of Greenwich. Tennessee is bounded on the north by Kentucky and Virginia; on the east by North Carolina along the line of the crest of the Unaka mountains to within 26 m. of Georgia, where the boundary turns due south; on the south by Georgia, Alabama and Mississippi along the 35th parallel of N. lat.; on the west by the Mississippi river, which separates it from Arkansas and Missouri. The extreme length of the State from E. to W. is 432 m., and the extreme breadth is 109 m., its area being 42,022 sq.m., of which 335 are water surface. The popular name "Volunteer State" was given to Tennessee because of her remarkable record in furnishing volunteers in the Civil War.

Physical Features.—The State is popularly divided into three large divisions known as east, middle and west Tennessee. The first extends from the heights of the Unaka ridges along the North Carolina border, across the valley of the Tennessee river to the heights of the Cumberland plateau. The middle section includes a part of the Cumberland plateau, all the Highland Rim plateau and the Central basin, and extends westward to the Tennessee river. The western division includes the plateau region from the Tennessee river to the precipitous escarpment overlooking the Mississippi Flood plain; also a narrow strip of low land which extends to the Mississippi river. From a maximum elevation of 6,680 ft. at Mt. Le Conte near the North Carolina border, in Sevier county, the surface descends to 182 ft. on the Mississippi river in Shelby county. The mean elevation of the State is approximately 900 feet. The general slope, however, is west by north. The Unaka mountains, which occupy a belt 8 to 10 m. wide along the State's eastern border, are a series of somewhat irregular ridges developed on complexly folded and faulted crystalline rocks. Sixteen peaks exceed 6,000 ft. in height. That part of the Great Appalachian valley which traverses Tennessee is commonly known as the valley of East Tennessee. It consists of parallel ridges and valleys developed by erosion on folded sandstones, shales and limestones, the valley quality predominating because the weak limestones were of great thickness. The valley areas vary in height from 600 ft. in the south-west to 1,400 ft. in the north-east. In the north-east the ridges are more numerous and higher than in the south-west, where White Oak ridge and Taylor's mountain are among the highest, although Missionary and Chickamauga ridges are better known, because of their association with battles of the Civil War. Along the north-west border of the valley a steep escarpment, known as the Cumberland Scarp, rises to the Cumberland plateau. This plateau has a mean elevation of about 1,800 ft., is only slightly rolling, and the northern portion slopes gently toward the north-west. The western edge of the plateau is much broken by deep indentations of stream valleys, and drops suddenly downward about 1,000 ft. to the Highland Rim plateau, so named from the scarp formed by its western rim about the Central and (farther north) Louisville basins. It is fairly level generally except where it is cut by river valleys. The Central basin, with a more rolling surface, lies for the most part 400 to 600 ft. below the Rim; a few hills or ridges, however, rise to the level of the Rim. The Basin is elliptical in form, extending nearly across the State from north-east to south-west with an extreme width of about 60 m.; near its centre is the city of Murfreesboro, and Nashville lies in the north-west. Westward from the lower Tennessee river the surface of the East Gulf Coastal plain rises rapidly to the summit of a broken *cuesta* or ridge and then descends gently and terminates abruptly in a bluff overlooking the Mississippi Flood plain. The eastern slope, about a quarter of the length of the western slope, is steep and rocky, and the western slope is broken by the valleys of numerous streams. The bluff, 150 to 200 ft. in height, traverses the State in a rather straight course; between it and the meandering Mississippi, except at a few points where that river touches it, lie low bottom lands varying in width according to the bends of the river and containing numerous swamps and ponds. In the northern portion, principally in Lake county, is Reelfoot lake, which occupies a depression formed by an earthquake in 1811. It is 18 m. long, has a maximum width of 3 m., and is the only large lake in the State.

The whole of the Appalachian province of Tennessee and the southern portion of the Cumberland plateau, the Highland rim, and the Central basin are drained southward and westward by the Tennessee river and its tributaries. The valley of the lower Tennessee is drained northward by the same river. The northern portion of the Cumberland plateau, Highland rim and Central basin is drained northward and westward by the Cumberland river and its tributaries. The western slope of the East Gulf plains is drained directly into the Mississippi by several small streams.

The Central basin, the less elevated parts of the valley of East Tennessee and parts of the outer portion of the Highland rim have a fertile soil of limestone origin. There are narrow strips of rich alluvium along many other rivers. The soils on the mountains, on the ridges of the valley of East Tennessee, and on the eastern slope of the East Gulf plains vary greatly, according to the rocks from which they are derived. In the Cumberland plateau, in the inner portion of the Highland rim and in the western slope of the East Gulf plains, there is for the most part a light sandy soil, much of it too poor for cultivation.

Tennessee has a delightful climate. The mean summer temperature varies according to elevation from 62° F. on the Unaka mountains to 72° on the Cumberland plateau, or 75° in the valley of East Tennessee and on the Highland rim, 77° in the Central basin, and about 78° on the East Gulf plains. The mean winter temperature for each of these divisions varies little from 38°, and the mean annual temperature ranges only from 57° in East Tennessee to 58° in Middle Tennessee and to 60° in West Tennessee. Usually the highest temperatures of the year are in July and the lowest in January. Killing frosts are rare, especially in the southern and western parts of the State, between the third week in April and the middle of October. An average annual precipitation of about 50 in. is quite equally distributed over the State, and a little more than one-half of it is well distributed through the spring and summer months. The average annual snowfall is about 8 inches. The warm, moisture-bearing winds blow low from the south or south-west with a free sweep across the State in a direction nearly parallel with the trend of the mountains. The commingling of these winds with upper cold currents from the north gives rise frequently to westerly and occasionally to easterly winds.

Government.—With the exception of the administrative changes made in 1923, few alterations have been made in the Government of Tennessee since the present Constitution was adopted in 1870; and this was only a revision of the State's second Constitution, which was adopted in 1834. Every attempt to amend or revise the existing Constitution has been unsuccessful, because of the difficult procedure involved in such changes. Amendments may be proposed not oftener than once in six years by a majority of the members elected to each house of the legislature; but before an amendment can be adopted, it must be agreed to by two-thirds of the members elected to each house of the next succeeding legislature, and later by a majority of all the citizens of the State voting for representatives at the next regular election. The legislature may also submit to the people the question of calling a convention to amend or revise the Constitution, and such a convention must be called whenever, upon the submission of this proposition, a majority of the votes are cast in favour of it. The election of the governor, members of the general assembly and congressmen is held biennially, in even-numbered years, on the first Tuesday after the first Monday in November, but the election of judicial and county officers is held on the first Thursday in August.

The governor is the only State executive officer elected by the people. He is elected for a term of two years and is not eligible for more than three consecutive terms. There is no lieutenant-governor; in case of a vacancy in the office of governor, the speaker of the senate becomes acting governor. The secretary of State and comptroller of the treasury are elected by a joint ballot of the senate and the house of representatives, each for a term of two years; the attorney-general is appointed by the judges of the supreme court for a term of eight years. In 1923 the administrative system of the State was reorganized, 64 boards, commissions, agencies, etc., being combined into nine departments, each with a commissioner at its head. These are known as the departments of Insurance and Banking; Highways and Public Works; Labour; State Institutions; Agriculture; Finance and Taxation; Railroads and Public Utilities; Public Health; and Education.

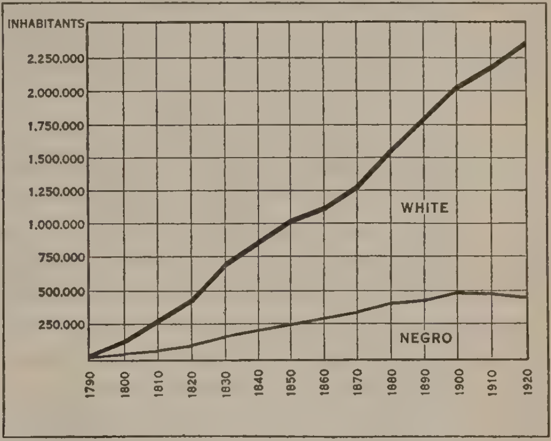
Both senators and representatives are elected for a term of two years by counties or by districts having approximately the same population. The number of representatives is limited by the Constitution to 99, and the number of senators to one-third the number of representatives. The legislature meets biennially, in odd-numbered years, on the first Monday in January, and the length of the session is limited by a provision that the members shall be paid four dollars a day, besides an allowance for travelling expenses, for a period not exceeding 75 days; when the governor calls an extra session, they are paid for not more than 20 days. Bills of whatever character may originate in either house, but no bill can become a law until it has passed both houses by a majority of all the members to which the house is entitled under the constitution, and if the governor vetoes a bill it cannot become a law until it has again passed both houses by such a majority. The Constitution provides that no minister or priest is eligible to a seat in either house of the legislature.

The administration of justice is vested in a supreme court, a court of civil appeals, chancery courts, circuit courts, criminal courts, county courts, justice of the peace courts, and, in certain cities and towns, a recorder's court. The supreme court consists of five judges elected by the State at large for a term of eight years, one for each of the three grand divisions (Eastern, Middle and Western) and two for the State at large. The judges designate one of their number to preside as chief justice. The court has appellate jurisdiction only. The court of civil appeals, which in 1907 was substituted for the court of chancery appeals, is composed of nine judges elected for a term of eight years. This court has jurisdiction of appeals from equity courts in which the amount in controversy does not exceed $1,000, except in cases involving the constitutionality of a Tennessee statute, a contested election, State revenue or an ejectment suit; it has jurisdiction also of civil cases tried in the circuit and common law courts in which writs of error or appeals in the nature of writs of error are applied for. It may transfer any case to the supreme court. The state is divided into 13 chancery districts, in each of which a chancellor is elected for a term of eight years, and at every county seat in each district a court of chancery is held; exceptions are the 10th district, which has three chancellors, and the 15th, which has four. There are also ten criminal judges, principally in the larger cities, and there is one probate judge in the city of Memphis. The State is also divided into 19 circuits, in each of which a circuit judge is elected for a term of eight years, and at every county seat in each circuit a circuit court is held. In several of the counties the county court is composed of a county judge, elected for a term of eight years, together with the justices of the peace in the county, and in the other counties it consists of the justices of the peace alone, who elect a chairman. Each county is divided into civil districts, varying in number according to population or other factors, and each district elects at least two justices of the peace for a term of six years; each county town or incorporated town also elects one justice of the peace. A recorder has concurrent jurisdiction with a justice of the peace.

The government of each county is vested principally in the county court. This body represents and acts for the county as a corporation; has charge of the erection and repair of county buildings; levies the county taxes; divides the county into highway districts, and chooses a highway commissioner for each district for a term of two years; and chooses a superintendent of schools (except where this is done by popular ballot), a surveyor, a public administrator and public guardian, a board for the equalization of taxes, a coroner, and a county physician or health officer, each for a term of two years, three commissioners of the poor for terms of three years (one chosen each year), and a keeper and sealer of weights and measures to serve during the pleasure of the court. A county trustee, whose duty it is to collect State and county taxes, and a sheriff are elected by the people of the county for a term of two years; a clerk of the county court and a registrar are also elected by the voters of the county for a term of four years. The capital city of Tennessee is Nashville.

Population.—The population in the census of selected years was as follows: 35,691 in 1790; 105,602 in 1800; 681,904 in 1830; 1,002,717 in 1850; 1,542,359 in 1880; 1,767,518 in 1890; 2,020,616 in 1900; 2,184,789 in 1910; 2,337,885 in 1920. The population on July 1, 1928, was 2,502,000, according to the United States census estimate. The increase of population in the decade 1910–20 was 153,096, or 7%, as compared with 8·1% in the preceding decade. The negro population during 1910–20 decreased numerically from 473,088 to 451,758, and decreased proportionally from 21·7% of the total to 19·3%. The average density of population in 1920 was 56·1 per sq.m.; in 1910 it was 52·4. The urban population (in places of 2,500 inhabitants or more) increased from 20·2% of the total in 1910 to 26·1% in 1920. The population of the chief cities in 1920 and 1927 was as follows: Memphis, 162,351 and 244,500 (estimate); Nashville, 118,342, and 147,000; Knoxville, 77,818, and 102,100; Chattanooga, 57,895, and 96,000; Jackson, 18,860, and 25,000; Johnson City, 12,442 and 28,128.

Finance.—In common with the other States of the Union, Tennessee has had a great increase in State expenditures. Also as in other States, highway expenditures rank first, and educational second in importance. The chief sources of revenue are: motor-car licences and other revenue of the highway department, a general property tax, a gas-privilege tax, a State tax on insurance companies, a sales tax on tobacco, an excise tax and an inheritance tax. Various privilege taxes, fines and forfeitures also help to augment the State's revenue. The property assessment for 1926 was $1,724,357,940, on which a rate of 25 cents per $100 gave the State a tax of $6,431,089. The gross receipts for the fiscal year July 1, 1926, to June 30, 1927, were $27,191,448; the disbursements for the same period were $26,185,582. Some of the chief disbursements for the fiscal year July 1, 1926, to June 30, 1927, were as follows: highways, $13,751,274; education, $5,616,156; charitable institutions, $2,850,206; pensions (soldiers and widows), $731,547; State debt and interest, $835,748. The funded indebtedness of the State, as on June 30, 1927, was $14,572,000.



GRAPH OF GROWTH OF POPULATION IN TENNESSEE, 1790–1920, SHOWING RELATIVE PROPORTIONS OF WHITES AND NEGROES AT EACH CENSUS

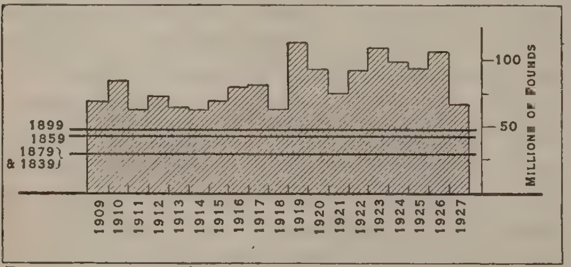
Education and Charities.—The first steps toward the creation of a common-school system for Tennessee were taken in 1823, when an act was passed setting aside for school purposes, the revenue and taxes accruing from public lands. From that beginning until the adoption of a uniform school code in 1925, more than 1,000 different acts were passed pertaining to the educational system. Under the new code the administration is vested in a State commissioner of education; a State board of education, consisting of the commissioner, the governor and nine other members; a county superintendent and a county board in each county; and in cities, city boards of education. The commissioner and the other members of the State board are appointed by the governor. The county superintendent is elected biennially by either the county court or by popular ballot. The county board consists of seven members (unless otherwise provided), elected by the county court for a term of seven years, one retiring annually.

The State board of education conducts examinations for county superintendents and issues certificates of qualification, classifies the high schools, maintains and controls the State teachers' colleges and establishes a salary schedule. No teacher may receive pay from the public school funds unless he or she has received a certificate from the State commissioner of education. The quarterly county court has power to issue bonds, levy taxes and provide funds for buildings for the county schools. The court is under obligation to maintain at least one four-year high school within the county.

Public schools are free to all persons above the age of six years; attendance is compulsory between the ages of seven and 16 unless high-school standing has been attained. Separate schools are maintained for the white and for the coloured. In 1927 the scholastic population between six and 17 years of age, inclusive, was 601,407. On the same date 649,007 were enrolled in the public elementary and secondary schools. Of these, 590,126 were in kindergarten and elementary schools and 58,881 were in secondary schools. In 1924 there were 22,900 pupils enrolled in private and parochial schools. The average length of school term for rural public schools increased from 110 days in 1915 to 154 days in 1927. From 1900 to 1925 the *per capita* expenditure for public schools based on population between five and 17 years of age, inclusive, increased from $6.32 to $23.61. Illiteracy among persons over ten years of age decreased from 13·6% in 1910 to 10·3% in 1920.

The State provides for higher education in the University of Tennessee, at Knoxville; the Polytechnic Institute, at Cookeville; East Tennessee Teachers college, at Johnson City; Middle Tennessee Teachers college, at Murfreesboro; and West Tennessee Teachers college, at Memphis. The Agricultural and Industrial Normal college for negroes is at Nashville. Other schools maintained by the State are: a school for the deaf, at Knoxville; a school for the blind, at Nashville; Tennessee Industrial school, at Nashville; Tennessee Girls' Vocational school, at Tullahoma; State Training and Agricultural school for boys at Nashville; and a vocational school for coloured girls at Nashville. Peabody college for teachers, at Nashville, founded and maintained chiefly with proceeds of the George Peabody fund for the improvement of education in the south, is State controlled. Other institutions of higher learning not under the control of the State are: Vanderbilt university (non-sectarian), at Nashville; University of the South (Episcopal), at Sewanee; Southwestern Presbyterian college, at Memphis; Cumberland university (Presbyterian), at Lebanon; Union university (Baptist), at Jackson; Christian Brothers' college (Catholic), at Memphis; Bethel college (Presbyterian), at McKenzie; University of Chattanooga (Methodist), at Chattanooga; Milligan college (Christian), at Milligan; Carson-Newman (Baptist), at Jefferson City; Lincoln Memorial university (non-sectarian), at Cumberland Gap; Tusculum college (non-sectarian), at Greenville; King college (Presbyterian), at Bristol; Maryville college (Presbyterian), at Maryville; Bryson college, at Fayetteville, and Tennessee college, at Murfreesboro. Education for the coloured is provided by Fisk university, at Nashville; Lane college, at Jackson; Le Moyne Institute, at Memphis; and Knoxville college, at Knoxville.

The State maintains a Confederate Veterans' Home near Nashville, on the "Hermitage," the estate formerly belonging to Andrew Jackson; the Eastern hospital for the Insane, at Knoxville; Central hospital for the Insane, at Nashville; Western hospital for the Insane, at Bolivar; and various schools, as mentioned above under "Education." The main penitentiary is located on a farm of 4,000 ac. near Nashville. Another penitentiary, known as Brusby Mountain prison, is located in the coal region in East Tennessee. The prisoners are kept at labour principally in the State coal-mines, on the farm, or at mechanical employment within the prison walls. Contract labour was not entirely abolished until 1917. All charitable and corrective institutions are under the supervision of the department of State institutions.

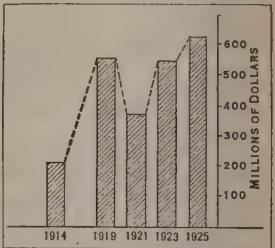


TOBACCO CROP EACH YEAR, 1909–1927; ALSO (HORIZONTAL LINES CROSSING THE FIGURE) IN 1839, 1859, 1879 AND 1899

Industry, Trade and Transport.—The interests of the State remain predominantly agricultural, though manufacturing is developing rapidly. The total land area in farms decreased from 20,041,657 ac. in 1910 to 17,901,139 ac. in 1925. The number of farms increased from 246,012 in 1910 to 252,669 in 1925; from 1910 to 1925 the average acreage per farm decreased from 81·5 to 70·4. The farm population decreased from 1,271,708 in 1920 to 1,173,316 in 1925. Of the 252,669 farmers in 1925, 218,022 were white and 34,647 were negroes. Of all farmers in 1925, 148,627 were owners; 103,718 were tenants; and 324 were managers. In 1920 there were 11,374 women farmers. The total value of farm crops in 1919 was $318,285,307; in 1926, it was $175,614,000. In 1926 Tennessee ranked 22nd among the States of the Union, in total value of farm products. The following table shows the comparative acreage, production and value of six important crops for 1919 and 1927:

Crop	Year	Acreage	Production	Value
				$
Indian corn	1919	3,301,075	70,639,252 bu.	127,150,649
	1927	2,944,000	70,656,000 „	58,644,480
Oats . .	1919	162,417	2,413,409 „	2,534,082
	1927	179,000	3,043,000 „	1,826,000
Wheat .	1919	684,497	6,362,357 „	14,506,174
	1927	528,000	3,696,000 „	5,137,000
Hay and forage .	1919	1,751,123	1,907,345 tons	49,649,657
	1927	1,402,000	1,822,000 „	27,114,000
Cotton .	1919	807,770	306,974 bales	48,808,866
	1927	943,000	345,000 „	32,775,000
Tobacco .	1919	138,561	112,367,567 lb.	24,720,869
	1927	81,500	71,435,000 „	12,858,000

The number and value of the principal domestic animals on Jan. 1, 1927 were: cattle, 912,000, valued at $27,816,000; swine, 968,000, valued at $12,584,000; sheep, 300,000, valued at $3,030,000; horses, 219,000, valued at $11,826,000; and mules, 352,000, valued at $24,288,000. The three national forests that lie in part in Tennessee had, in 1925, a total area of 267,939 ac. within the State. According to the United States Bureau of Mines, Tennessee ranked 25th among the 48 States in the value of minerals produced in 1925. In that year the production had a value of $38,869,198. The principal products in order of value were coal, cement, clay products and stone. The coal-producing area is a belt running from north-east to south-west, a little east of the centre of the State, production being reported in 16 counties. Valuable building marble is quarried in the eastern part of the State. Tennessee produces most of the copper mined in the Southern States. Its entire production of copper, gold and silver comes from mines worked primarily for copper in Polk county. Rock phosphate is mined in five counties in the central and south-central sections of the State. The most important products, in 1925, were: coal, 5,454,011 short tons, worth $10,077,000; clay products exclusive of pottery, worth $3,941,395; stone, 1,835,150 short tons, worth $4,334,891; copper, 19,788,234 lb., worth $2,809,929; rock phosphate, 464,240 long tons, worth $2,334,995; zinc, 16,256 short tons, worth $2,470,912. Other products of economic value are: sand and gravel, lime, iron ore, barite, lead, gold, silver and petroleum (*see* PETROLEUM).



AVERAGE VALUE OF MANUFACTURED PRODUCTS AT EACH CENSUS, 1914–1925

Manufacturing is growing rapidly in Tennessee. In 1925 there were 2,162 establishments, employing 107,645 wage-earners; the wages amounted to $95,255,480. The value of the products was $601,488,472, as compared with $546,499,264 in 1923 and $374,038,000 in 1921. The chief industries according to value of product were: knitted goods, $44,006,467; food preparations, $40,297,255; timber products, $35,527,699; flour and grain mill products, $31,810,028; construction and repair in steam railway shops, $26,711,694; planing-mill products, $26,086,641; cotton goods, $23,706,355; cotton-seed oil, meal and cake, $23,045,442; printing and publishing, $21,404,448; chewing and smoking tobacco and snuff, $16,819,438.

The steam railway mileage of Tennessee increased continuously until 1920, when the total was 4,078, but by 1925 this had decreased to 4,063. The chief railways operating in the State in 1925 were: Louisville and Nashville; Nashville, Chattanooga and St. Louis; Southern Railway; Tennessee Central; and Illinois Central. In the above year there were 417 m. of electric railway within the State, operated chiefly as city systems. The navigable waterways include the Mississippi, Tennessee and Cumberland rivers. The State highway department controlled 5,051 m. of roadways in 1927, of which 3,555·5 m. were surfaced. New surfacing placed during the year amounted to 291·7 miles.

HISTORY

Exploration and Early Settlements.—What is now Tennessee was visited and claimed in turn by Spaniards, French and English. The final success of the English was achieved only after the desperate struggle which ended in the Treaty of Paris of 1763. By its provisions France was driven from North America and the power of Spain was greatly limited.

The daring Spanish explorer Hernando de Soto reached the Mississippi river in 1541, at a high bluff occupied by Chickasaw villages, believed to be the present site of Memphis. After a brief halt to collect food from the Indians and to build rafts, De Soto left the territory by crossing the Mississippi. It was 132 years before another white man saw Tennessee. The French missionary and explorer Father Marquette, in his voyage down the Mississippi by canoe in 1673, camped upon the western border, and eight years later La Salle and his companions left Canada to complete the exploration of the river. La Salle built Ft. Prud'homme in 1682 upon the Chickasaw Bluff, near the present site of Memphis, but it was soon abandoned. Later the French built Ft. Assumption, where Memphis now stands, and kept a garrison there, but made no attempt at colonization. The territory was a part of the English grant to Sir Walter Raleigh in 1584, and of the later Stuart grants, including that in 1663 to the proprietors of Carolina. James Adair, of South Carolina, a fur trader and explorer, is supposed to have been the first to go from the English colonies into Tennessee. A party of Virginians led by Dr. Thomas Walker (1715–94) in 1750 reached the Cumberland river and Cumberland mountains and named them in honour of the royal duke. In 1756 or 1757, Ft. Loudon, named in honour of John Campbell, earl of Loudon, was built on the Little Tennessee river, about 30 m. south of the present site of Knoxville, as an outpost against the French who were now active in the whole Mississippi valley, and was garrisoned by royal troops. The fort was captured by the Cherokee Indians in 1760, and both the garrison and the neighbouring settlers were massacred.

Eastern Tennessee was recognized as a common hunting-ground by the Cherokees, Creeks, Miamis and other Indian tribes. The Iroquois of New York claimed much of the central portion by right of conquest, and the western section was the home of the Chickasaws. By the treaty of Ft. Stanwix, in 1768, the Iroquois ceded whatever claim they had to the English, and in 1769 several cabins were built along the Holston and Watauga rivers upon what was thought to be Virginia soil. A settlement near the present Rogersville was made in 1771, and in the next year another sprang up about the store of Jacob Brown on the Nollichucky. After the failure of the Regulator insurrection in North Carolina in 1771, hundreds of the Regulators made their way into the wilderness. A survey of the western boundary-line between Virginia and North Carolina showed the settlements to be in North Carolina, but that colony made no effort to assert jurisdiction nor to protect the settlers from Indian depredations. Therefore in 1772 the residents of the first two settlements met to establish a form of government since known as the Watauga Association. A general committee of 13 was elected to exercise legislative powers. This committee elected from its members a committee of five in whom executive and judicial powers were lodged. A sheriff, an attorney and a clerk were elected, and regulations for recording deeds and wills were made. Courts were held, but any conflict of jurisdiction with Virginia or North Carolina was avoided. In 1775 the settlement on the Nollichucky was forced to join the association, and in the same year the land was bought from the Cherokee Indians in the hope of averting war. With the approach of the American Revolution, the dream of becoming a separate colony with a royal governor was abandoned, and on petition of the inhabitants the territory was annexed to North Carolina in 1776 as the Washington district, which in 1777 became Washington county, with the Mississippi river as the western boundary. The population increased rapidly, and soon several new counties were created.

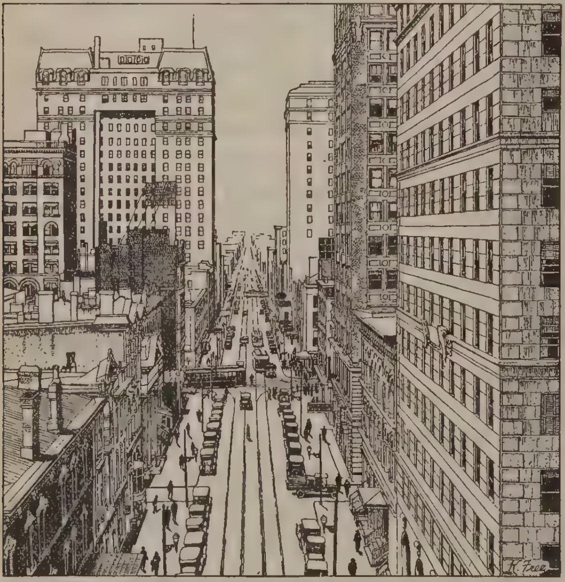
During the American Revolution the hardy mountaineers under John Sevier and Evan Shelby did valiant service against both the royal troops and the Loyalists in South Carolina, chiefly as partisan rangers under Charles McDowell (1743–1815). Major Patrick Ferguson, with several hundred Loyalists and a small body of regulars, made a demonstration against the western settlements; but at King's Mountain in South Carolina, he was completely defeated by the Americans.

Relations with North Carolina.—After the American Revolution the legislature of North Carolina in 1784 offered to cede her western territory to the general Government, provided the cession be accepted within two years. The Watauga settlers, indignant at this transfer without their consent, and fearing to be left without any form of Government whatever, assembled in convention at Jonesboro on Aug. 23, 1784, and chose delegates to a later convention to form a new State. Meanwhile North Carolina repealed the act of cession and created the western counties into a new judicial district. A second convention, in November, broke up in confusion without accomplishing anything; but a third adopted a Constitution, which was submitted to the people, and ordered the election of a legislature. This body met early in 1785, elected Sevier governor of the new State of Franklin (at first Frankland), filled a number of offices, and passed several laws in anticipation of an autonomous existence. On account of the scarcity of a circulating medium more than 20 articles were valued and declared legal tender. Among them were fox skins, 1s. 6d.; beaver skins, 6s.; bacon, 6d. per lb.; rye whisky, 2s. 6d. the gallon. Four new counties were created, and taxes were levied. Later in the year another convention, to which the proposed Constitution had been referred, adopted instead the Constitution of North Carolina with a few trifling changes, and William Cocke was chosen to present to Congress a memorial requesting recognition as a State. Congress, however, ignored the request, and the diplomacy of the North Carolina authorities caused a reaction. For a time two sets of officials claimed recognition, but when the North Carolina legislature a second time passed an act of oblivion and remitted the taxes unpaid since 1784, the tide was turned. No successor to Sevier was elected. He was arrested on a charge of treason, but was allowed to escape, and soon afterwards was again appointed brigadier-general of militia.

Meanwhile, settlers had pushed on farther into the wilderness. On March 17, 1775 Col. Richard Henderson and his associates extinguished the Indian title to an immense tract of land in the valleys of the Cumberland, the Kentucky and the Ohio rivers (*see* KENTUCKY). In 1778 James Robertson (1742–1814), a native of Virginia, who had been prominent in the Watauga settlement, set out with a small party to prepare the way for permanent occupation. He arrived at French Lick (so called from a French trading post established there) early in 1779, and in the same year a number of settlers from Virginia and South Carolina arrived. Another party, led by John Donelson, arrived in 1780, and after the close of the War of Independence the immigrants came in a steady stream. A form of Government similar to the Watauga Association was devised, and blockhouses were built for defence against the Indians. Robertson was sent as a delegate to the North Carolina legislature in 1783, and through his instrumentality the settlements became Davidson county. Nashville, which had been founded as Nashborough in 1780, became the county seat. Finally, in 1843, it became the State capital. Robertson, the dominant figure in the early years, struggled to counteract the efforts of Spanish intriguers among the Indians, and when diplomacy failed, he led the settlers against the Indian towns.

Tennessee Becomes a Separate State.—On Feb. 25, 1790 North Carolina again ceded the territory to the United States Government, stipulating that all the general provisions of the ordinance of 1787 should apply except that forbidding slavery. Congress accepted the cession and, on May 26, 1790, passed an act for the government of the "Territory south of the River Ohio." William Blount was appointed the first governor, and in 1792 Knoxville became the seat of Government. The chief events of Blount's administration were the contests with the Indians, the purchase of their lands, and the struggle against Spanish influence. A census ordered by the Territorial legislature in 1795 showed more than 60,000 free inhabitants (the number prescribed before the Territory could become a State), and accordingly a convention to draft a State Constitution met in Knoxville on Jan. 11, 1796. The instrument, which closely followed the Constitution of North Carolina, was proclaimed without submission to popular vote. John Sevier was elected governor, and William Blount and William Cocke United States senators. In spite of the opposition of the Federalist party, whose leaders foresaw that Tennessee would be Republican, it was admitted to the Union as the 16th State on June 1, 1796.

With the rapid increase of population, the dread of Indian and Spaniard declined. Churches and schools were built, and soon many of the comforts and some of the luxuries of life made their appearance. The question of a circulating medium was acute during the first half of the 19th century, and State banks were organized, which suspended specie payments in times of financial stringency. The bank of Tennessee, organized in 1838, had behind it the credit of the State, and it was hoped that money for education and for internal improvements might be secured from its profits. The management became a question of party politics, and during the Civil War its funds were used to advance the Confederate cause. The development of the western section along the Mississippi was rapid after the beginning of the century. Memphis, founded in 1819, was thought as late as 1832 to be in Mississippi, and not until 1837 was the southern boundary, which according to the North Carolina cession was Lat. 35°, finally established. As in other river towns, the disorderly element in Memphis was large, and the gamblers, robbers and horse thieves were suppressed only by local vigilance committees. The peculiar topographical conditions made the three sections of the State almost separate commonwealths, and demand for better means of communication was insistent. The policy of State aid to internal improvements found advocates very early, in spite of the Republican affiliations of the State, but a definite programme was not laid out until 1829, when commissioners for internal improvements were appointed and an expenditure of $150,000 was authorized. In 1835 the State agreed to subscribe one-third to the capital stock of companies organized to lay out turnpikes, railways, etc., and four years later the proportion became one-half. Though these agreements were soon repealed, the general policy was continued, and in 1861 more than $17,000,000 of the State debt was due to these subscriptions, from which there was little return.



BY COURTESY OF THE MEMPHIS CHAMBER OF COMMERCE

MADISON AVENUE, THE WALL STREET OF MEMPHIS, LOOKING EAST

Though President Andrew Jackson was for many years practically a dictator in Tennessee politics, his arbitrary methods and his intolerance of any sort of independence on the part of his followers led to a revolt in 1836, when the electoral vote of the State was given to Hugh Lawson White, then United States senator from Tennessee, who had been one of Jackson's most devoted adherents. White's followers called themselves anti-Van Buren Democrats, but the proscription which they suffered drove most of them into the Whig party, which carried the State in presidential elections until 1856, when the vote was cast for James Buchanan, the Democratic candidate. The Whig party was so strong that James K. Polk (Democrat), a resident of the State, lost its electoral vote in 1844. With the disintegration of the Whig party, the State again became nominally Democratic, though Union sentiment was strong, particularly in East Tennessee. There were few large plantations and few slaves in that mountainous region, while the middle and western sections were more in harmony with the sentiment in Mississippi and Alabama. In 1850 representatives of nine Southern States met in a convention at Nashville (*q.v.*) to consider the questions at issue between the North and the South. The vote of the State was given for Bell and Everett in 1860, and the people as a whole were opposed to secession.

The Civil War.—The proposition to call a convention to vote on the question of secession was voted down on Feb. 9, 1861, but after President Lincoln's call for troops the legislature submitted the question of secession directly to the people, and meanwhile, on May 7, 1861, entered into a "Military League" with the Confederacy. An overwhelming vote was cast on June 8 in favour of secession, and on the 24th Gov. I. G. Harris (1818–97) issued a proclamation declaring Tennessee out of the Union. Andrew Johnson, then a United States senator from Tennessee, refused to resign his seat, and was supported by a large element in East Tennessee. A Union convention, including representatives from all the eastern and a few of the middle counties, met on June 17, 1861 and petitioned Congress to be admitted as a separate State. The request was ignored, but the section was strongly Unionist in sentiment during the war, and has since been strongly Republican.

The State was, next to Virginia, the chief battle-ground during the Civil War, and a historian has counted 454 battles and skirmishes that took place within its borders. In Feb. 1862, General U. S. Grant and Commodore A. H. Foote captured Ft. Henry on the Tennessee river and Ft. Donelson on the Cumberland. The Confederate line of defence was broken and General D. C. Buell occupied Nashville. Grant next ascended the Tennessee river to Pittsburg, landing with the intention of capturing the Memphis and Charleston Railway, and on April 6 and 7 defeated the Confederates in the battle of Shiloh. The capture of Island No. 10 in the Mississippi on April 7 opened the river as far S. as Memphis, which was captured in June. On Dec. 31 and Jan. 2 General William S. Rosecrans (Federal) fought with General Braxton Bragg (Confederate) the bloody but indecisive battle of Stone river (Murfreesboro). In June, 1863 Rosecrans forced Bragg to evacuate Chattanooga. Bragg, however, turned upon his pursuer, and on Sept. 19 and 20 one of the bloodiest battles of the war was fought at Chickamauga. General Grant now assumed command, and on Nov. 24–25 defeated Bragg at Chattanooga, thus opening the way into East Tennessee. There General A. E. Burnside at first met with success, but was shut up in Knoxville by General James Longstreet, who was not able, however, to capture the city, and on the approach of General W. T. Sherman retired into Virginia. Almost the whole State was now held by Federal troops, and no considerable military movement occurred until after the fall of Atlanta in Sept. 1864. Then General J. B. Hood moved into Tennessee, expecting Sherman to follow him. Sherman, however, sent reinforcements to Thomas and continued his march to the sea. Hood fought with General John M. Schofield at Franklin, and on Dec. 15–16 was utterly defeated by Thomas at Nashville, the Federals thus securing virtually undisputed control of the State.

Reconstruction and Politics.—After the occupation of the State by the Federal armies in 1862, Andrew Johnson was appointed military governor by the President (confirmed March 3, 1862), and held the office until he was inaugurated vice president on March 4, 1865. Republican electors attempted to cast the vote of the State in 1864, but were not recognized by Congress. Tennessee was the first of the Confederate States to be readmitted to the Union (July 24, 1866), after ratifying the Constitution of the United States with amendments, declaring the ordinance of secession void, voting to abolish slavery, and declaring the war debt void. Tennessee freed her own slaves by an amendment to the State Constitution ratified by a vote of the people on Feb. 22, 1865, but suffrage was not conferred upon the negro until two years later (Feb. 25, 1867). The State escaped "carpet bag" government, but the native whites in control, under the leadership of William G. Brownlow, exhibited almost every phase of the reconstruction policy. All persons who had either directly or indirectly taken part in the war against the Union or had given aid to the Confederacy were denied the right of suffrage. In the election of 1869, the acting governor, D. W. C. Senter, ordered the election commissioners to issue to all actual citizens of the State permits to vote. The Democrats united with the Conservative Republicans and Senter was easily elected. At the same time a Democratic and Conservative legislature was elected, thus placing the State Government again in the control of officers elected by the majority of the people. The Ku Klux Klan, originating in 1865 as a youthful prank at Pulaski, Tenn., spread over the State and the entire South, and in 1869 nine counties in the middle and western section were placed under martial law because of the Klan's activities against the Loyal League and the negroes. A constitutional convention, which met in Jan., 1870, revised the old Constitution, and the revision became the present Constitution when ratified by the people the following May. In 1873 a school law was passed which provided for State and county superintendents and separate schools for white and coloured children and levied a State tax to aid in paying the expenses of these schools. Another progressive step was the final compounding of the old State debt at 50 cents on the dollar by an act of the legislature in 1883. With the exception of the administration of Alvin Hawkins, 1881–83, the Democratic Party controlled the executive office from 1871 to 1911; but in 1890 the Farmers' Alliance was able to control the Democratic Party. In 1920, for the first time since 1868, the State's electoral votes were cast for the Republican candidate for President. The prohibition question long played an important rôle in State politics, and many acts were passed tending toward the abolition of the liquor traffic.

Twentieth Century Reforms.—In 1904 the Adams law, prohibiting the sale of intoxicating liquors in towns of 5,000 inhabitants or less, was passed, largely through the efforts of the Anti-Saloon League; an act prohibiting the manufacture of intoxicating liquor in the State became effective on Jan. 1, 1910; in Oct. 1913 Governor Hooper called a special session of the legislature and secured the passage of the so-called Nuisance Act, designed to close every saloon in the State by enforcing the law forbidding the sale of intoxicating liquor within four miles of any school; in 1915 provision was made for removal from office of State, county or city officials who failed to enforce the prohibition laws; and on Feb. 2, 1917, Governor Rye signed a bill forbidding the importation of liquor into the State. In 1915 a law was passed providing for mothers' pensions. In 1917 the letting of prison labour to private contractors was prohibited, and an act was passed forbidding the limiting of the output of coal in order to increase the price. In the same year a State budget commission was created. On Aug. 18, 1920, the house, by 50 to 46, voted for concurrence in the senate resolution (adopted on Aug. 13, by 5 to 4) ratifying the proposed amendment to the Federal Constitution, providing for woman suffrage. As the 36th State (out of the 48 in the American Union) to ratify, Tennessee brought the number to the requisite three-fourths. Many progressive school laws were passed in the years between 1913 and 1925, when the revised school code was adopted. Additional revenue was made accessible for all branches of education, better supervision was provided and ages for compulsory attendance were extended.

Bibliography.—The best bibliography of material relating to Tennessee is *Calvin Morgan McClung Historical Collection* (Knoxville, 1921). There is no complete history of Tennessee that is entirely satisfactory. S. E. Scates, *A School History of Tennessee* (1925), gives a brief elementary survey up to 1925. *Tennessee, the Volunteer State, 1769–1923,* edited by J. T. Moore and Austin P. Foster (4 vols., 1923), is a more detailed work. Historical works of greater merit are: James Phelan, *History of Tennessee* (1888); W. R. Garrett and A. V. Goodpasture, *History of Tennessee* (1903); G. R. McGee, *A History of Tennessee from 1663 to 1919;* J. Haywood, *Civil and Political History* (1823; reprinted, 1891); J. G. M. Ramsey, *Annals* (1853); A. W. Putnam, *History of Middle Tennessee, or the Life and Times of General James Robertson* (1859); Theodore Roosevelt, *The Winning of the West* (1889–96); John Carr, *Early Times in Middle Tennessee* (1857); Edward Albright, *Early History of Middle Tennessee* (1908); Constance L. Skinner, *Pioneers of the Old Southwest* (1919). A confused mass of history and biography can be found in the following: W. T. Hale and D. L. Merritt, *A History of Tennessee and Tennesseans* (8 vols., 1913); Samuel G. Heiskell, *Andrew Jackson and Early Tennessee History* (3 vols., 1920–21); and Samuel C. Williams, *History of the Lost State of Franklin* (1924). For the Civil War period see *Report of Joint Committee on Reconstruction* (U.S. Public Documents, 1866); James W. Fertig, *Secession and Reconstruction of Tennessee* (1898); John R. Neal, *Disunion and Reconstruction in Tennessee* (1899); O. P. Temple, *East Tennessee and the Civil War* (1899). On administration *see* the *Reports* of the various administrative departments; *Tennessee Directory* (annual); *Baldwin's Cumulative Code Supplement, Tennessee* (1920); *Tennessee Statutes;* and J. W. Caldwell, *Studies in the Constitutional History of Tennessee* (1895; new ed., 1907). For education see *Public School Laws of Tennessee* (1925) and *Reports* of the State department of education. For population, agriculture and manufactures consult the *Fourteenth U.S. Census,* the *Agricultural Yearbook* and the volumes of the *Census of Manufactures.* The mineral resources and physical features are described in the *Reports of the Tennessee Geological Survey* (1840 *seq.*) and *Mineral Resources of the United States* (U.S. bureau of mines; annual). (C. E. A.)

TENNESSEE RIVER, the largest tributary of the Ohio river, U.S.A. It is formed by the confluence of the Holston and the French Broad rivers 4.5m. above Knoxville (Tenn.), flows south south-west to Chattanooga, there turns west through the Cumberland Plateau and into the north-east corner of Alabama, continues west across the northern part of Alabama, turns north on the boundary between Alabama and Mississippi, and continuing north across Tennessee and Kentucky unites with the Ohio at Paducah. Its principal tributaries rise in the Appalachian Mountains; the Holston and the Clinch on the mountain slopes that flank the Appalachian valley in western Virginia; and the French Broad, the Little Tennessee and the Hiwassee in the mountains of western North Carolina. The Tennessee itself is 652m. long, and with the Holston and the North Fork of the Holston forms a channel about 900m. long. Its drainage basin covers about 44,000sq.m., and its low-water discharge at Paducah is 10,600cu.ft. per second. Its average fall is 0·79ft. per m.—0·956ft. from Knoxville to Chattanooga; 1·19ft. from Chattanooga to Florence (Ala.), and 0·39ft. from Florence to its mouth. The banks are everywhere easily accessible except at Knoxville and Chattanooga, where, for short distances, high elevations rise precipitously, from the water; and as the banks are mostly of clay or rock the channel is permanent and the river is unusually free from silt. The Tennessee is navigable by steamboats throughout its entire course of 652m. for several months of the year.

In 1904 the Federal Government authorized the construction, with private capital, of a lock and dam at Hales Bar to provide a channel 6ft. deep between it and Chattanooga, the water-power to be used by the company furnishing the capital. The Colbert and Bee Tree shoals were improved by the Colbert Shoals lock and canal, opened in 1911. In 1917 the U.S. Government undertook the construction of a navigation power dam (Wilson or dam No. 2), 95ft. high at Muscle shoals (*q.v.*) and by 1926 the work had been completed, except the lock, at a cost of $43,387,709 for construction and $359,592 for maintenance. A second lock and dam (known as No. 1), below Wilson dam, was completed and put in operation in March 1926, at a cost of $960,515. The Federal Government had spent, up to 1927, about $30,000,000, exclusive of the Muscle Shoals dams, on improving navigation on the Tennessee and its tributaries. The total commerce carried on the various sections of the Tennessee had, in 1925, an aggregate value of $12,441,364; the commerce of its principal tributaries amounted to $142,959.

TENNGLER, ULRICH, German jurist, was born in the middle of the 15th century in Heidenheim near Nördlingen. He served as chief clerk of Nördlingen, 1479–83, and afterwards, until his death, was governor of Höchstädt. He died sometime in the first four months of 1511. He is noted chiefly as the author of the *Layenspiegal* (1509 and later editions. After 1516 the work was frequently issued in editions containing also Sebastian Brant's *Klagspiegal*). This was a systematic encyclopaedia of popular jurisprudence, which had wide influence and for more than half a century was the authority in Germany for the settlement of legal questions.

TENNIEL, SIR JOHN (1820–1914), knighted 1893, English humorous and satirical artist—specially identified with *Punch* —was born in London on Feb. 28, 1820. Although he became a probationer, and then a student, of the Royal Academy, he soon left the schools, where at that time there was little teaching. In 1836 he sent his first picture to the exhibition of the Society of British Artists, and in 1845 contributed a 16-ft. cartoon, "An Allegory of Justice," to the competition, held in that year, of designs for the mural decoration of the new Palace of Westminster. For this he received a £200 premium and a commission to paint a fresco in the Upper Waiting Hall (or "Hall of Poets") in the House of Lords. He was already known and appreciated as a humorist, and his early companionship with Charles Keene fostered and developed his talent for scholarly caricature. In 1850 he was invited by Mark Lemon to fill the position of joint cartoonist (with John Leech) on *Punch,* in succession to Richard Doyle. His first "cartoon" was "Lord Jack the Giant Killer"; it showed Lord John Russell, whose letter on the "aggression" had recently been published, valiantly assailing with the sword of truth and liberty Cardinal Wiseman armed with a crozier. In 1852 we find Tenniel's first superb lion, and his first obituary cartoon. Gradually he took over altogether the weekly drawing of the political "big cut," which John Leech was happy to resign into his hands in order to restrict himself to his pictures of life and character. Leech's work consisted for the most part of farce; Tenniel's was high comedy, and not infrequently tragedy; and the freedom of the humorist heightened the severer beauties of the satirist. When Leech died his friend continued his work alone. About 2,300 cartoons, innumerable minor drawings, double-page cartoons for *Punch's Almanac* and other special numbers, and 250 designs for *Punch's Pocket-books,* comprise the sum of Sir John Tenniel's work for the periodical in the service of which he spent the greater portion of his life. He retired in 1901. In 1874 he had been made a member of the Royal Institute of Painters in Water Colours. He died on Feb. 25, 1914.

The main quality of Sir John Tenniel's work is accuracy of drawing, precision of touch, grace and dignity of conception, and —so far as such things can be compatible—geniality of satire. Tenniel raised the political cartoon into a classic composition, from which a sense of nobility is rarely absent. The beauty and statuesqueness of his ideal figures recall the influence, perhaps, of Cornelius and Overbeck—that German manner which was characteristic of many of our finer draughtsmen upon wood in the middle of the 19th century. But Tenniel's work is always original, unforced and fresh; and it never suggests, what is the fact, that the artist's work is drawn exclusively from memory, and never from the model. It may be mentioned that Tenniel's wonderful observation has been conducted, and his knowledge accumulated, literally through a single eye, the other having been lost during a fencing bout in his youth. It was in recognition not only of his ability as an artist in black and white, but of his service in infusing good humour and good taste into one phase of political life, that a knighthood was conferred upon him on Mr. Gladstone's recommendation in 1893. Without pronounced political opinions of his own, Sir John Tenniel adopted in his work those of his paper, of which the Whig proclivities were to some degree softened by his pencil. The political history not of England only, but to some extent of the world, of half a century appears in Sir John Tenniel's weekly cartoons, which are dignified by a number of types invented by the artist, the classic beauty of which may be looked for in vain in kindred work by any previous cartoonist. (Take, for example, Sir John's famous picture of "Dropping the Pilot," which appeared in *Punch* on March 20, 1890, xcviii. 150–51.) Public exhibitions of Sir John Tenniel's work were held in 1895 and in 1900. Sir John Tenniel is also the author of one of the mosaics, "Leonardo da Vinci," in the South Court in the Victoria and Albert Museum, while his highly stippled water-colour drawings appeared from time to time in the exhibitions of the Royal Institute of Painters in Water Colours, of which society he was elected a member in 1874. As an illustrator on the wood-block he stands very high; his "Lalla Rookh" is perhaps the finest of all his work in point of conception, refinement, power and technical excellence.

WORKS ILLUSTRATED.—(1) *Juvenile Verse and Picture Book* (1846); (2) *Undine* (1846); (3) *Aesop's Fables,* 100 drawings (1848); (4) Blair's *Grave* (1858); (5) Shirley Brooks's *The Gordian Knot* (1860), and (6) *The Silver Cord* (1861); (7) Moore's *Lalla Rookh,* 69 drawings (1861); (8) Lewis Carroll's *Alice's Adventures in Wonderland* (1866); (9) *The Mirage of Life* (1867); (10) Carroll's *Through the Looking-Glass* (1870); and the following in collaboration: (11) Pollok's *Course of Time* (1857); (12) *Poets of the Nineteenth Century* (1857); (13) Poe's Works (1857); (14) *Home Affections* (1858); (15) Cholmondeley Pennell's *Puck on Pegasus* (1863); (16) *The Arabian Nights* (1863); (17) *English Sacred Poetry* (1864); (18) *Legends and Lyrics* (1865); (19) Tupper's *Proverbial Philosophy;* (20) Barry Cornwall's *Poems,* and other books. He also contributed to *Once a Week,* the Art Union publications, etc. *See* also *Cartoons by Sir John Tenniel* (1901); M. H. Spielmann, *History of Punch* (1895); Cosmo Monkhouse, *Life and Works of Sir John Tenniel* (*Art Annual,* 1901).

TENNIS: *see* LAWN TENNIS AND TENNIS.

TENNON, in architecture, a projecting tooth, peg or lug, cut upon the end or edge of a structural member, and arranged to fit into a socket or mortice designed to receive it in an adjacent structural member, in order to strengthen and stiffen the connection between them.

TENNYSON, ALFRED TENNYSON, 1st BARON (1809–1892), English poet, was born at Somersby, Lincolnshire, on Aug. 6, 1809. He was the fourth of the 12 children of the Rev. George Clayton Tennyson (1778–1831) and his wife Elizabeth Fytche (1781–1865). The Tennysons were an old Lincolnshire family settled at Bayon's Manor. The poet's grandfather, George Tennyson, M.P., had disinherited the poet's father, who was settled hard by in the rectory of Somersby, in favour of the younger son, Charles Tennyson D'Eyncourt. The rich pastoral scenery of this part of Lincolnshire influenced the imagination of the boy, and is plainly reflected in all his early poetry. At a very early age he began to write in prose and verse. At Christmas 1815 he was sent to the grammar school at Louth, where he remained for five years, and then returned to Somersby to be trained by his father. In the rectory the boys had the run of an excellent library, and here the young poet based his wide knowledge of the English classics. The news of Byron's death (April 19, 1824) made a deep impression on him. "It was a day," he said, "when the whole world seemed to be darkened for me"; he went out into the woods and carved "Byron is dead" upon a rock. Tennyson was already writing copiously—he had constructed "an epic of 6,000 lines" at the age of twelve, composed a drama in blank verse when he was 14, and so on.

In 1827 Frederick Tennyson (1807–1898), the eldest surviving brother, uniting with his younger brothers Charles and Alfred, published at Louth an anonymous collection of *Poems by Two Brothers*. The "two" were Charles and Alfred (whose contributions predominated), and who shared the surprising profits, £20. On Feb. 20, 1828, Charles and Alfred matriculated at Trinity college, Cambridge, where Frederick was already a student. The poet subsequently told Edmund Gosse that his father would not let him leave Somersby till, on successive days, he had recited from memory the whole of the odes of Horace. The brothers took rooms at 12 Rose Crescent, and afterwards moved into Trumpington Street (now 157 Corpus Buildings). They were shy, and at first made few friends; but they gradually gathered selected associates around them, and Alfred grew to be looked up to in Cambridge "as to a great poet and an elder brother" by a group which included Richard Chenevix Trench, Monckton Milnes (Lord Houghton), James Spedding, W. H. Thompson, Edward FitzGerald, W. H. Brookfield, and, above all, A. H. Hallam (1811–1833). Charles Tennyson (1808–1879) afterwards took the additional name of Turner. He published four volumes of sonnets which have been highly praised. In June 1829 Alfred Tennyson won the Chancellor's prize medal for his poem called "Timbuctoo." With great imperfections, this study in Miltonic blank verse displays the genius of a poet, in spite of obscurity both of thought and style. Here are already both richness and power. But by this time Tennyson was writing lyrics of still higher promise, and, as Arthur Hallam early perceived, with an extraordinary earnestness in the worship of beauty. The results of this enthusiasm and this labour of the artist appeared in the volume of *Poems, chiefly Lyrical*, published in 1830. This book would have been astonishing as the production of a youth of 21, even if, since the death of Byron six years before, there had not been a singular dearth of good poetry in England. Here at least, in the slender volume of 1830, was a new writer revealed, and in "Mariana," "The Poet," "Love and Death," and "Oriana," a singer of wonderful though still unchastened melody. Through these, and through less perfect examples, was exhibited an amazing magnificence of fancy, at present insufficiently under control, and a voluptuous pomp of imagery, tending to an over-sweetness.

In the summer of 1830 Tennyson and Hallam volunteered in the army of the Spanish insurgent Torrijos, and marched about a little in the Pyrenees, without meeting with an enemy. Tennyson came back to find his father ailing, and in Feb. 1831 he left Cambridge for Somersby, where a few days later Dr. George Tennyson died. The new incumbent was willing that the Tennysons should continue to live in the rectory, which they did not leave until six years later. Arthur Hallam was now betrothed to Emily Tennyson (afterwards Mrs. Jesse, 1811–1889), and stayed frequently at Somersby. This was a very happy time, and one of great physical development on Alfred's part. He took his share in all kinds of athletic exercises, and it was now that Brookfield said, "It is not fair that you should be Hercules as well as Apollo." This high physical zest in life seems to have declined after 1831, when his eyes began to trouble him, and he became liable to depression. The poetical work of these three years, mainly spent at Somersby, was given to the world in the volume of *Poems* which (dated 1833) appeared at the end of 1832.

This was certainly one of the most astonishing revelations of finished genius ever produced by a young man of less than four-and-twenty. Here were "The Lady of Shalott," "The Dream of Fair Woman," "Oenone," "The Lotos-Eaters," "The Palace of Art," and "The Miller's Daughter," with a score of other lyrics, delicious and divine. The advance in craftsmanship and command over the *matériel* of verse shown since the volume of 1830 is astonishing. It was well that its publication was completed before the blow fell upon Tennyson which took for a while all the light out of him. In Aug. 1833 Arthur Hallam started with his father, the historian, for Tirol. On the way young Hallam died suddenly (Sept. 15) of a broken blood-vessel at Vienna. His body was brought back to England, and buried on Jan. 3, 1834.

Hallam's death affected Tennyson extremely. He grew less than ever willing to come forward and face the world; his health became "variable and his spirits indifferent." The earliest effect of Hallam's death upon his friend's art was seen, in the summer of 1834, in *The Two Voices;* and to the same period belong the beginnings of the *Idylls of the King* and of *In Memoriam*, over both of which he meditated long. In 1835 he visited the Lakes, and saw much of Hartley Coleridge, but would not "obtrude on the great man at Rydal," although "Wordsworth was hospitably disposed." Careless alike of fame and of influence, Tennyson spent these years mainly at Somersby, in a uniform devotion of his whole soul to the art of poetry. In 1837, to their great distress, the Tennysons were turned out of the Lincolnshire rectory where they had lived so long. They moved to High Beech, in Epping Forest, which was their home until 1840. The poet was already engaged, or "quasi-betrothed," to Emily Sellwood, but ten years passed before they could afford to marry. At Torquay, in 1838, he wrote *Audley Court* on one of his rare excursions, for he had no money for touring, nor did he wish for change; he wrote at this time, "I require quiet, and myself to myself, more than any man when I write." In 1840 the Tennysons moved to Tunbridge Wells, and a year later to Boxley, near Maidstone, to be close to Edmund Lushington, who had now married Cecilia Tennyson. Alfred was from this time frequently a visitor in London.

In 1842 the two-volume edition of his *Poems* broke the ten years' silence which he had enforced himself to keep. Here, with many pieces already known to all lovers of modern verse, were found rich and copious additions to his work. These he had originally intended to publish alone, and an earlier privately printed *Morte d'Arthur, Dora, and other Idylls*, of 1842, is the despair of book-collectors. Most of those studies of home-life in England, which formed so highly popular a section of Tennyson's work—such as "The Gardener's Daughter," "Walking to the Mail," and "The Lord of Burleigh"—were now first issued, and, in what we have grown to consider a much higher order, "Locksley Hall," "Ulysses," and "Sir Galahad." To the older and more luxurious lyrics, as reprinted in 1842, Tennyson did not spare the curbing and pruning hand, and in some cases went too far in restraining the wanton spirit of beauty in its youthful impulse. It is from 1842 that Tennyson took his place as the leading poet of his age in England. Among the friends whom he now made, or for the first time cultivated, were Carlyle, Rogers, Dickens, and Elizabeth Barrett.

Material difficulties now, however, for the first time intruded on Tennyson's path. He became the victim of a certain "earnest-frothy" speculator, who induced him to sell his little Lincolnshire estate at Grasby, and to invest the proceeds, with all his other money, and part of that of his brothers and sisters, in a "Patent Decorative Carving Company"; in a few months the whole scheme collapsed, and Tennyson was left penniless. He was attacked by so overwhelming a hypochondria that his life was despaired of, and he was placed for some time under the charge of a hydropathic physician at Cheltenham, where absolute rest and isolation gradually brought him round to health again. The state of utter indigence to which Tennyson was reduced greatly exercised his friends, and in Sept. 1845, at the suggestion of Henry Hallam, Sir Robert Peel was induced to bestow on the poet a pension of £200 a year. Tennyson's health slowly became restored, and in 1846 he was hard at work on *The Princess;* in the autumn of this year he took a tour in Switzerland, and saw great mountains and such "stateliest bits of landskip" for the first time. In 1847 nervous prostration again obliged him to undergo treatment at Prestbury: "They tell me not to read, not to think; but they might as well tell me not to live." Dr. Gully's water-cure was tried, with success.

The Princess was now published, in a form afterwards considerably modified and added to. Carlyle and FitzGerald "gave up all hopes of him after *The Princess*," or pretended that they did. It was true that the bent of his genius was slightly altered, in a direction which seemed less purely and austerely that of the highest art; but his concessions to public taste vastly added to the width of the circle he now addressed. The home of the Tennysons was now at Cheltenham; on his occasional visits to London he was in the habit of seeing Thackeray, Coventry Patmore, Browning and Macready, as well as older friends, but he avoided "society." In 1848, while making a tour in Cornwall, Tennyson met Robert Stephen Hawker of Morwenstow, with whom he seems—but the evidence is uncertain—to have talked about King Arthur, and to have resumed his intention of writing an epic on that theme.

In his absent-minded way Tennyson was very apt to mislay objects; in earlier life he had lost the ms. of *Poems, chiefly Lyrical,* and had been obliged to restore the whole from scraps and memory. Now a worse thing befell him, for in February 1850, having collected into one "long ledger-like book" all the elegies (*In Memoriam*) on Arthur Hallam which he had been composing at intervals since 1833, he left this only ms. in the cupboard of some lodgings in Mornington Place, Hampstead Road. By extraordinary good chance it had been overlooked by the landlady, and Coventry Patmore was able to recover it. *In Memoriam* was published, in its original anonymous form, in May 1850. The public was at first greatly mystified by the nature and object of this poem, which was not merely a chronicle of Tennyson's emotions under bereavement, nor even a statement of his philosophical and religious beliefs, but, as he long afterwards explained, a sort of *Divina Commedia,* ending with happiness in the marriage of his youngest sister, Cecilia Lushington. In fact, the great blemishes of *In Memoriam,* its redundancy and the dislocation of its parts, were largely due to the desultory manner of its composition. The poet wrote the sections as they occurred to him, and did not think of weaving them together into a single poem until it was too late to give them real coherency.

On June 13, 1850, Tennyson was married at Shiplake to Emily Sarah Sellwood (1813–1896). Of this union no more need be said than was recorded long afterwards by the poet himself, "The peace of God came into my life before the altar when I wedded her." On Nov. 19, 1850, Queen Victoria appointed Tennyson poet laureate, in succession to Wordsworth. The salary connected with the post was very small, but it had a secondary value in stimulating the sale of his books. The young couple took a house at Warninglid, in Sussex, which did not suit them, and then one in Montpelier Row, Twickenham, which did better. In April 1851 their first child was born dead. At this time Tennyson was brooding much upon the ancient world, and reading little but Milton, Homer and Virgil. This condition was elegantly defined by Carlyle as "sitting on a dungheap among innumerable dead dogs." In the summer of 1851 was made the tour in Italy, of which *The Daisy* is the immortal record. Of 1852 the principal events were the birth of his eldest son Hallam, the second Lord Tennyson, in August, and in November the publication of the *Ode on the Death of the Duke of Wellington.*

In the winter of 1853 Tennyson took a little house and farm called Farringford, near Freshwater, in the Isle of Wight, which he leased at first, and afterwards bought; this beautiful place, ringed round with ilexes and cedars, entered into his life and coloured it with its delicate enchantment. In 1854 he published *The Charge of the Light Brigade,* and was busy composing *Maud* and its accompanying lyrics; and this volume was published in July 1855, just after he was made D.C.L. at Oxford: he was received on this occasion, which may be considered his first public appearance, with a "tremendous ovation." The reception of *Maud* from the critics, however, was the worst trial to his equanimity which Tennyson had ever had to endure, nor had the future anything like it in store for him. He had risen in *Maud* far above his ordinary serenity of style, to ecstasies of passion and audacities of expression which were scarcely intelligible to his readers.

It is odd that this irregular poem, with its copious and varied music, its splendid sweep of emotion, its unfailing richness of texture—this poem in which Tennyson rises to heights of human sympathy and intuition which he reached nowhere else, should have been received with bitter hostility, have been styled "the dead level of prose run mad," and have been reproved more absurdly still for its "rampant and rabid bloodthirstiness of soul." There came a reaction of taste and sense, but the delicate spirit of Tennyson had been wounded. For some years the world heard nothing from him; he was at Farringford, busying himself with the Arthurian traditions. He had now become an object of boundless personal curiosity, being already difficult to find, and the centre of amusing legends. It was in 1857 that Bayard Taylor saw him, and carried away the impression of a man "tall and broad-shouldered as a son of Anak, with hair, beard and eyes of southern darkness." This period of retirement embraced a tour in Wales in 1857, a visit to Norway in 1858, and a journey through Portugal in 1859.

In 1857 two Arthurian poems had been tentatively and privately printed, as *Enid and Nimue, or the True and the False,* to see how the idyllic form would be liked by the inner circle of Tennyson's friends. In the summer of 1859 the first series of *Idylls of the King* was at length published, and achieved a popular success far beyond anything experienced before by any English poets, save perhaps Byron and Scott. Within a month of publication, 10,000 copies had been sold. The idylls were four in number, "Enid," "Vivien" (no longer called "Nimue"), "Elaine" and "Guinevere." These were fragments of the epic of the fall of King Arthur and the Table Round which Tennyson was so long preparing, and which he can hardly be said to have ever completed, although nearly thirty years later he closed it. The public and the critics alike were entranced with the "sweetness" and the "purity" of the treatment. A few, like Ruskin, were doubtful about "that increased quietness of style"; one or two already suspected that the "sweetness" was obtained at some sacrifice of force, and that the "purity" involved a concession to Victorian conventionality.

Urged by the duke of Argyll, Tennyson now turned his attention to the theme of the Holy Grail, though he progressed with it but fitfully and slowly. In 1861 he travelled in Auvergne and the Pyrenees, with Clough, who was to die a few months later; to this year belong "Helen's Tower" and the "Dedication" of the *Idylls* to the prince consort, "These to his Memory." The latter led to Tennyson's presentation in April 1862 to the queen, who "stood pale and statue-like before him, in a kind of stately innocence," which greatly moved his admiring homage. From this time forth the poet enjoyed the constant favour of the sovereign, though he could never be moulded into a conventional courtier. He now put the Arthurian legends aside for a time, and devoted himself to the composition, in 1862, of "Enoch Arden," which, however, did not appear until 1864, and then in a volume which also contained "Sea Dreams," "Aylmer's Field" and, above all, "The Northern Farmer," the first and finest of Tennyson's remarkable studies in dialect.

In April of this year Garibaldi visited Farringford; in Feb. 1865 Tennyson's mother died at Hampstead in her 85th year; in the ensuing summer he travelled in Germany. The time slipped by with incidents but few and slight, Tennyson's popularity in Great Britain growing all the time to an extent unparalleled in the whole annals of English poetry. This universality of fame led to considerable practical discomfort; he was besieged by sightseers, and his nervous trepidation led him perhaps to exaggerate the intensity of the infliction. In 1867 he determined to make for himself a haven of refuge against the invading Philistine, and bought some land on Blackdown, above Haslemere, then a secluded corner of England; here Mr. (afterwards Sir) James Knowles began to build him a house, ultimately named Aldworth. This is the time of two of his rare, privately printed pamphlets, *The Window; or, the Loves of the Wrens* (1867), and *The Victim* (1868).

The noble poem *Lucretius,* one of the greatest of Tennyson's versified monographs, appeared in May 1868, and in this year *The Holy Grail* was at last finished; it was published in 1869, together with three other idylls belonging to the Arthurian epic, and various miscellaneous lyrics, besides *Lucretius.* The reception of this volume was cordial, but not so universally respectful as that which Tennyson had grown to expect from his adoring public. The fact was that the heightened reputation of Browning, and still more the sudden vogue of Swinburne, Morris and Rossetti (1866–70), considerably disturbed the minds of Tennyson's most ardent readers, and exposed himself to a severer criticism than he had lately been accustomed to endure. His next volume (1872), *Gareth and Lynette* and *The Last Tournament,* continued, and, as he then supposed, concluded *The Idylls of the King*, and for the time being he dismissed it from his mind. In 1873 he was offered a baronetcy by Gladstone, and again by Disraeli in 1874; in each case the honour was gracefully declined.

Believing that his work with the romantic Arthurian epics was concluded, Tennyson now turned his attention to the drama. He put before him a scheme of illustrating "the making of England" by a series of great historical tragedies. His *Queen Mary*, the first of these chronicle-plays was published in 1875, and played by Sir Henry Irving at the Lyceum in 1876. Although it was full of admirably dramatic writing, it failed on the stage. Extremely pertinacious in this respect, the poet went on attempting to storm the theatre, with assault upon assault, all practically failures until the seventh and last, which was unfortunately posthumous. Meanwhile *Harold*, a tragedy of doom, was published in 1876; but, though perhaps the finest of its author's dramas, it was not staged. During these years Tennyson's thoughts were largely occupied with the building of Aldworth. His few lyrics were spirited ballads of adventure, inspired by an exalted patriotism—"The Revenge" (1878), "The Defence of Lucknow" (1879)—but he reprinted and finally published his old suppressed poem, *The Lover's Tale*, and a little play of his, *The Falcon*, versified out of Boccaccio, was produced by the Kendals in 1879.

In 1880, when he was over 70, he published the earliest of six important collections of lyrics, this being entitled *Ballads and other Poems*, and containing the sombre and magnificent "Rizpah." In 1881 *The Cup* and in 1882 *The Promise of May*, two little plays, were produced without substantial success in London theatres: the second of these is perhaps the least successful of all the poet's longer writings, but its failure annoyed him unreasonably. In September 1883 Tennyson and Gladstone set out on a voyage round the north of Scotland, to Orkney, and across the ocean to Norway and Denmark. At Copenhagen they were entertained by the king and queen, and after much fêting, returned to Gravesend: this adventure served to cheer the poet, who had been in low spirits since the death of his favourite brother Charles, and who now renewed his vigour. During the voyage Gladstone had determined to offer Tennyson a peerage. After some demur, the poet consented to accept it, but added, "For my own part, I shall regret my simple name all my life." On March 11, 1884, he took his seat in the House of Lords as Baron Tennyson of Aldworth and Farringford. He voted twice, but never spoke in the House. In the autumn of this year his tragedy of *Becket* was published, but the poet at last despaired of the stage, and disclaimed any hope of "meeting the exigencies of our modern theatre." Curiously enough, after his death *Becket* was the one of all his plays which enjoyed a great success on the boards.

In 1885 was published another interesting miscellany, *Tiresias and other Poems*, with a posthumous dedication to Edward FitzGerald. In this volume, it should be noted, *The Idylls of the King* was completed at last by the publication of "Balin and Balan"; it contained also the superb address "To Virgil." In April 1886 Tennyson suffered the loss of his second son, Lionel, who died in the Red Sea on his return from India. The untiring old poet was steadily writing on, and by 1886 he had another collection of lyrics ready, *Locksley Hall Sixty Years After*, etc.; his eyes troubled him, but his memory and his intellectual curiosity were as vivid as ever. He was past 80 when he published the collection of new verses entitled *Demeter and other Poems* (1889), which appeared almost simultaneously with the death of Browning, an event which left Tennyson a solitary figure indeed in poetic literature. His latest drama, *The Foresters*, was produced in New York in March 1892, with Miss Ada Rehan as Maid Marian. During this year Tennyson was steadily engaged on "Akbar's Dream," "Kapiolani" and other contents of the posthumous volume called *The Death of Oenone*, 1892.

Soon after entering his eighty-fourth year, however, symptoms of weakness set in, and early in September his condition began to give alarm. He retained his intellectual lucidity and an absolute command of his faculties to the last, reading Shakespeare with obvious appreciation until within a few hours of his death. With the splendour of the full moon falling upon him, his hand clasping his Shakespeare, and looking, as we are told, almost unearthly in the majestic beauty of his old age, Tennyson passed away at Aldworth on the night of Oct. 6, 1892. *Cymbeline*, the play he had been reading on the last afternoon, was laid in his coffin, and on the 12th he received a public funeral at Westminster Abbey. Lady Tennyson survived until Aug. 1896.

The physical appearance of Tennyson was very remarkable. Of his figure at the age of 33 Carlyle has left a superb portrait: "One of the finest-looking men in the world. A great shock of rough, dusky, dark hair; bright, laughing, hazel eyes; massive aquiline face, most massive yet most delicate; of sallow brown complexion, almost Indian-looking, clothes cynically loose, free-and-easy, smokes infinite tobacco. His voice is musical, metallic, fit for loud laughter and piercing wail, and all that may lie between; speech and speculation free and plenteous; I do not meet in these late decades such company over a pipe." He was unusually tall, and possessed in advanced years a strange and rather terrifying air of sombre majesty. But he was, in fact, of a great simplicity in temperament, affectionate, shy, still exquisitely sensitive in extreme old age to the influences of beauty, melancholy and sweetness. Although exceedingly near-sighted, Tennyson was a very close observer of nature, and at the age of eighty his dark and glowing eyes, which were still strong, continued to permit him to enjoy the delicate features of country life around him, both at Aldworth and in the Isle of Wight. His *Life*, written with admirable piety and taste by his son, Hallam, second Lord Tennyson, was published in two volumes in 1897.

No living poet has ever held England—no poet but Victor Hugo has probably ever held any country—quite so long under his unbroken sway as Tennyson did. As he recedes from us, however, we begin to see that he has a much closer relation to the great Georgian writers than we used to be willing to admit. He is more the last of that great school than the first of any new one. The qualities in which he seems to surpass his immediate predecessors are exactly those which should be the gift of one who sums up the labours of a mighty line of artists. He is remarkable among them for the breadth, the richness, the substantial accomplishment of his touch; he has something of all these his elders, and goes farther along the road of technical perfection than any of them. We still look to the earlier masters for supreme excellence in particular directions: to Wordsworth for sublime philosophy, to Coleridge for ethereal magic, to Byron for passion, to Shelley for lyric intensity, to Keats for richness.

Tennyson does not excel each of these in his own special field, but he is often nearer to the particular man in his particular mastery than any one else can be said to be, and he has in addition his own field of supremacy. This consists, perhaps, in the beauty of the atmosphere which Tennyson contrives to cast around his work, moulding it in the blue mystery of twilight, in the opaline haze of sunset: this atmosphere, produces an almost unfailing illusion or mirage of loveliness, so that, even where (as must sometimes be the case with every poet) the thought and the imagery have little value in themselves, the fictive aura of beauty broods over the otherwise undistinguished verse. In his luminous subtlety and his broad undulating sweetness, his relationship with Virgil has long been manifest; he was himself aware of it. But he was also conscious that his exquisite devotion to mere lucidity and beauty might be a snare to him, and a happy instinct was always driving him to a study of mankind as well as of inanimate nature.

Few English writers have known so adroitly as Tennyson how to bend the study of Shakespeare to the enrichment of their personal style. It should be added that he was a very deep and original student of literature of every description, and that the comparatively few specimens which have been preserved of his conversation contain some of the finest fragments of modern appreciation of the great poets which we possess. This is worthy of consideration in any attempt made to sketch the mind of a man who was above all other masters of recent literature an artist, and who must be studied in the vast and orbic fullness of his accomplishment in order to be appreciated at all. (E. G.)

The standard biography is *Alfred, Lord Tennyson: A Memoir*, by

Hallam, 2nd Baron Tennyson (2 vols., 1897), who also edited Tennyson's *Works* with a memoir in 1913 (9 vols.); A. E. Baker published a *Concordance to the poetical and dramatical works of Tennyson* in 1914. For bibliography *see* R. H. Shepherd, *Tennysoniana* (1866, new ed. 1879). For biography and criticism consult A. C. Bradley, *A Commentary on Tennyson's In Memoriam* (1901); A. Lang, *Alfred Tennyson* (1901); A. C. Benson, *The Life of Lord Tennyson* (1904); T. R. Lownsbury, *Life and Times of Lord Tennyson* (1916); H. I. 'A. Fausset, *Tennyson; A modern portrait* (1923); H. Nicolson, *Tennyson* (1925).

TENNYSON-D'EYNCOURT, SIR EUSTACE (HENRY WILLIAM) (1868–), British naval architect, was born on April 1, 1868, and educated at Charterhouse and at the Royal Naval college, Greenwich. He was apprenticed at the Elswick works, to which he returned as naval architect in 1902, after four years at Fairfield. He subsequently received an Admiralty appointment, which he held until 1924. He continued to advise the Admiralty on naval construction after his appointment as managing director of Armstrong Whitworth and Co.'s Newcastle shipyards. In addition to designing and constructing ships, Tennyson-d'Eyncourt was closely associated with the development of tanks during the World War. He presided over the first Admiralty committee on the question, and in 1918 became vice-president of the Tank board. He was responsible for the successful design and construction of many tanks. He was created K.C.B. in 1917, and elected F.R.S. in 1921.

TENREC (*Centetes ecaudatus*), one of the largest representatives of the Insectivora, the length being from 12 to 16in. It is restricted to Madagascar. The coat consists chiefly of bristles and hairs, with an admixture of flexible spines, in the adult limited to the back of the neck. The general hue is brown tinged with yellow. From 12 to 16 or even 20 young are produced at a birth. In habits the tenrec is nocturnal; its home is in the brush in the mountain regions, and in the cool season it hibernates in deep burrows. The long flexible snout is used to root up worms and grubs, and ground-insects form part of its nourishment. When fat before hibernation, tenrecs are much valued as food by natives. (*See* INSECTIVORA.)

TENSOR ANALYSIS. The concept of tensors and the knowledge of some of their properties can be traced back to Gauss, Riemann and Christoffel, but their algebra and analysis have been shaped into a systematic method only recently, 1900, by Ricci and Levi-Civita, who coined for this powerful branch of mathematics the name of *absolute differential calculus.* Its chief aim is to construct and discuss relations or laws *generally covariant;* such, that is, as remain valid in passing from one to any other system of co-ordinates. It has especially become the object of a very widespread interest since the advent of *generalized relativity* (1916), whose principal requirement is precisely such unrestricted covariance of physical laws.

Definitions, Algebra of Tensors.—Consider a continuous n-dimensional manifold or "space" S_n (*see* MANIFOLDS), whose element or point $P(x_\iota)$ is determined by assigning the values of n real independent variables or co-ordinates x_ι. Let $Q(x_\iota+dx_\iota)$ be another point of S_n. Then the ordered point-pair P, Q or the set of differentials dx_ι is called a *vector.* (To begin with, the idea of "size" or "length" is foreign to this concept, S_n being thus far a non-metrical manifold.) Let the x_ι be transformed into any other system of n co-ordinates x'_ι, the former being continuous functions of the latter with continuous derivatives $\partial x_\iota/\partial x'_\kappa$ and non-vanishing, finite Jacobian $J=\left|\dfrac{\partial x_\iota}{\partial x'_\kappa}\right|$; then dx_ι are transformed into

$$dx'_\iota=\frac{\partial x'_\iota}{\partial x_\alpha}\,dx_\alpha$$

to be summed over $\alpha=1$ to n, and vice versa, $dx_\iota=(\partial x_\iota/\partial x'_\alpha)dx'_\alpha$. (The convention will be adopted that every term in which an index occurs *twice*, is to be summed over all its values.) Any set of n magnitudes A^ι, functions of the x, which are transformed by this rule, *i.e.*, into

$$A'^\iota=\frac{\partial x'_\iota}{\partial x_\alpha}\,A^\alpha,$$

is called a *contravariant tensor* of rank one, the A^ι being its n^1 *components.* For contravariant tensors upper indices are used, an exception being made for dx_ι, the prototype of all such tensors. Next, any n magnitudes A_ι which are transformed as the differentiators $\partial/\partial x_\iota$, *i.e.*, into

$$A'_\iota=\frac{\partial x_\alpha}{\partial x'_\iota}\,A_\alpha,$$

form a *covariant* tensor of rank 1, lower indices being used for such tensors. These two kinds of tensors, of rank 1, are also termed *vectors; e.g.*, three-vectors, four-vectors (such as the relativistic four-velocity or four-potential, in space-time, S_4), etc., according as $n=3$, 4, etc. Similarly, any n^2 magnitudes $A_{\iota\kappa}$ transformable into

$$A'_{\iota\kappa}=\frac{\partial x_\alpha}{\partial x'_\iota}\;\frac{\partial x_\beta}{\partial x'_\kappa}\,A_{\alpha\beta}$$

form a covariant, and any $A^{\iota\kappa}$ transformable into

$$A'^{\iota\kappa}=\frac{\partial x'_\iota}{\partial x_\alpha}\;\frac{\partial x'_\kappa}{\partial x_\beta}\,A_{\alpha\beta}$$

form a contravariant tensor of *rank two.* Again, n^2 magnitudes $A_\iota^{\ \kappa}$ transformable into

$$A'^{\ \kappa}_\iota=\frac{\partial x_\alpha}{\partial x'_\iota}\;\frac{\partial x'_\kappa}{\partial x_\beta}\,A^\beta{}_\alpha$$

are said to form a *mixed* tensor of rank 2, covariant in ι and contravariant in κ. The extension to any rank is obvious. Any $n^{r_1+r_2}$ magnitudes $A^{ik\cdots}_{\iota\kappa\cdots}$, with r_1 lower and r_2 upper indices, which are transformed according to the rule

$$\left(A^{ik\cdots}_{\iota\kappa\cdots}\right)'=\frac{\partial x_\alpha}{\partial x'_\iota}\;\frac{\partial x_\beta}{\partial x'_\kappa}\cdots\frac{\partial x'_i}{\partial x_a}\;\frac{\partial x'_k}{\partial x_b}\cdots A^{ab\cdots}_{\alpha\beta\cdots}\tag{1}$$

form a mixed tensor of rank $r=r_1+r_2$. This is the most general concept of a tensor.

A tensor of rank zero, called also a *scalar*, is a single function of the x, *invariant* with respect to any transformations of co-ordinates, $f'=f$. $A_{\iota\kappa}$ is *symmetrical* if $A_{\iota\kappa}=A_{\kappa\iota}$, and *antisymmetrical* or a *skew* tensor if $A_{\iota\kappa}=-A_{\kappa\iota}$, implying $A_{\iota\iota}=0$. Similarly for $A^{\iota\kappa}$. Analogous definitions hold for mixed tensors, and for higher ranks. Symmetry and antisymmetry are invariant properties.

The transformed tensor components being linear homogeneous functions of the original ones, the sums of corresponding components of tensors of same rank and kind form again a tensor. Thus, A_ι, B_ι being covariant vectors, so is $A_\iota+B_\iota=C_\iota$. Similarly, $A_{\iota\kappa}+B_{\iota\kappa}=C_{\iota\kappa}$, etc. The addends, functions of x_ι, must be taken at the same point of S_n. If a tensor vanishes in one, it will vanish also in any other co-ordinate system. Consequently, any tensor equation, if valid in one, holds also in any other co-ordinate system. This is the chief reason of the importance of tensors in pure geometry and relativistic physics.

The *outer product* of two tensors of ranks r and s, *i.e.*, the array of n^{r+s} products of their components is again a tensor, of rank $r+s$, with r_1+s_1 covariant and r_2+s_2 contravariant indices. Thus $A_\iota B_\kappa=C_{\iota\kappa}$; $A_{\iota\kappa}B_\lambda=C_{\iota\kappa\lambda}$, $A_{\iota\kappa}B^\lambda=C^\lambda{}_{\iota\kappa}$. The *contraction*, an operation of almost magical efficiency, applicable to any mixed tensor, consists in equating one of its r_1 lower to one of its r_2 upper indices and summing over it from 1 to n. The result is again a tensor, with r_1-1 covariant and r_2-1 contravariant indices; *e.g.*, the contraction of $A^{\lambda}_{\iota\kappa}$ gives $A^\kappa{}_{\iota\kappa}=A_\iota$, a vector; $B^{\lambda\mu}_{\iota\kappa}$ contracted once becomes $B^{\lambda\kappa}_{\iota\kappa}=B^\lambda{}_\iota$, and this yields $B^\iota{}_\iota=B$, a scalar.

The *inner product* is the outer product (supposed mixed) contracted once or more. Thus, the inner product of A_ι, B^κ is $A_\kappa B^\kappa$, an invariant; that of $A_{\iota\kappa}$, $B^{\lambda\mu}$ gives $A_{\iota\kappa}B^{\lambda\kappa}=C^\lambda{}_\iota$, a mixed tensor, and, after a second contraction, $A_{\iota\kappa}B^{\iota\kappa}=C^\iota{}_\iota=C$, an invariant. (Unlike $A_\kappa B^\kappa$, $A_\kappa B_\kappa$ is *not* invariant; it has no tensor character, and likewise for $A^\kappa B^\kappa$. Thus also $A_{\iota\kappa}$, unlike $A^\kappa{}_\iota$, has no invariant of its own.) Again, the inner product of $A_{\iota\kappa}$, B^λ is a covariant vector, etc. Conversely, if $A_\kappa B^\kappa$ is a scalar for *any* covariant vector A_κ, B^κ is a contravariant vector. Similarly, if $A_{\iota\kappa}B^{\iota\kappa}$ is a scalar for any covariant $A_{\iota\kappa}$, $B^{\iota\kappa}$ is contravariant; if $A^{\iota\kappa}B_{\iota\kappa\lambda}=C_\lambda$ is covariant for any contravariant $A^{\iota\kappa}$, then $B_{\iota\kappa\lambda}$

is covariant. This is an efficient method of establishing the tensor character of a set of n, n^2, n^3, etc. magnitudes.

Differentiation.—The differentiation of tensors with respect to the co-ordinates yields, in certain circumstances, further tensors. If f is a scalar function of the x, or scalar field, $\partial f/\partial x_\iota = f_\iota$ is a covariant vector, the *gradient* of f (but $\partial^2 f/\partial x_\iota \partial x_\kappa$ is not a tensor; again, if du be an invariant, dx_ι/du is, but d^2x_ι/du^2 is not a vector). Further, if A_ι be a vector, $B_{\iota\kappa} = \partial A_\iota/\partial x_\kappa - \partial A_\kappa/\partial x_\iota$ is a skew tensor, *the rotation* of A_ι. Finally, if $A_{\iota\kappa}$ be antisymmetric, $B_{\iota\kappa\lambda} = \partial A_{\iota\kappa}/\partial x_\lambda + \partial A_{\kappa\lambda}/\partial x_\iota + \partial A_{\lambda\iota}/\partial x_\kappa$ is again such a tensor, *the expansion* of $A_{\iota\kappa}$. Differentiation, unaided by metrics, does not seem to yield any other noteworthy tensors.

In what precedes only such properties of tensors were treated as are independent of any metrical considerations, the space S_n being thus far a non-metrical, amorphous manifold. Let now its metrics be fixed by laying down the *line-element*, a quadratic differential form with coefficients $g_{\iota\kappa} = g_{\kappa\iota}$, prescribed functions of the x,

$$ds^2 = g_{\iota\kappa} dx_\iota dx_\kappa, \tag{2}$$

to be considered as *invariant* and to serve as the measure of the (squared) size or length of the vector dx_ι. Then, dx_ι being contravariant, $g_{\iota\kappa}$ will be covariant. Equivalently we may say that a certain symmetrical tensor $g_{\iota\kappa}$ is being impressed upon S_n as the *fundamental* or *metrical tensor*, converting it into a metrical manifold, a *Riemannian space*. Then $g_{\iota\kappa} dx_\iota dx_\kappa$ will be an invariant, the squared size, of the vector dx_ι which had no invariant of its own. In relation to or with the aid of $g_{\iota\kappa}$, all other vectors and higher tensors will now acquire some new properties. These, and these only, will be their metrical properties. Thus, $g_{\iota\kappa} A^\iota A^\kappa$ is the invariant squared size (A^2) or *norm* of a vector A^ι, $g_{\iota\kappa} B^{\iota\kappa} = B$ the scalar of $B^{\iota\kappa}$, and $g_{\iota\kappa} g_{\lambda\mu} C^{\iota\kappa\lambda\mu}$ that of $C^{\iota\kappa\lambda\mu}$.

The minors $g^{\iota\kappa}$ of $g = |g_{\iota\kappa}|$, divided by g, form again a symmetrical tensor, the contravariant metrical tensor, to be used along with $g_{\iota\kappa}$. Thus $g^{\iota\kappa} X_\iota X_\kappa$ is the norm of X_ι. With every vector A_ι there is metrically associated a contravariant vector $g^{\iota\kappa} A_\kappa = A^\iota$, the *conjugate* of A_ι; similarly, $g_{\iota\kappa} B^\kappa = B_\iota$, the conjugate of B^ι. The conjugate of the conjugate is the original vector. Conjugate vectors, B_ι and B^ι, have the same size, the norm of either being expressible by $B_\iota B^\iota$. These properties follow from the important formula $g_{\kappa\alpha} g^{\kappa\beta} \equiv g_\alpha^\beta = \delta_{\alpha\beta}$, where $\delta_{\alpha\beta}$ is Kronecker's symbol, 0 or 1, according as $\alpha \neq \beta$ or $\alpha = \beta$. This symbol, more appropriately δ_α^β is itself a mixed tensor. Similarly, metrical associates are constructed from higher tensors. Thus, to $A_{\iota\kappa}$ belongs $A^{\iota\kappa} = g^{\alpha\iota} g^{\beta\kappa} A_{\alpha\beta}$, its *supplement*. The supplement of the supplement is the original tensor. With the covariant $A_{\iota\kappa}$ is metrically associated the mixed tensor $A_\kappa^\iota = g^{\iota\alpha} A_{\kappa\alpha}$ and the covariant tensor $a_{\iota\kappa} = g_{\iota\kappa} g^{\alpha\beta} A_{\alpha\beta} = A g_{\iota\kappa}$, *the reduced* of $A_{\iota\kappa}$.

The angle θ between two (copunctal) vectors is defined by the invariant $\cos\theta = g^{\iota\kappa} A_\iota B_\kappa / AB = A^\kappa B_\kappa / AB$; A, B being their sizes. For contravariant vectors, $\cos\theta = g_{\iota\kappa} A^\iota B^\kappa / AB$. The unit vector $\dot{x}_\iota = dx_\iota/ds$ determines, locally, a *direction* in S_n. The angle between two directions $\dot{x}_\iota$, $\dot{y}_\iota$ is given by $\cos\theta = g_{\iota\kappa} \dot{x}_\iota \dot{y}_\kappa$.

Integrals.—The integral $\int dx_1 \dots dx_n$, briefly $\int dx$, extended over a region of S_n, is transformed into $\int J dx'$, and the determinant g into $g' = J^2 g$. Consequently, $\int \sqrt{g} dx$ is an invariant metrically impressed upon that region, its size or *volume* (area, if $n = 2$). This concept is readily extended to any sub-manifold of S_n characterized by x_ι as functions of $m < n$ parameters p_a, the rôle of metrical tensor being taken over by

$$h_{ab} = g_{\iota\kappa} (\partial x_\iota / \partial p_a)(\partial x_\kappa / \partial p_b).$$

If, by a proper choice of the co-ordinate system, all components $g_{\iota\kappa}$ are reducible to constants, the metrical space S_n is Euclidean or homoloidal (flat). This is but a very special case of a Riemannian space. In general such a reduction is not possible, and S_n is non-Euclidean (*v. infra*).

Differentiation of tensors, aided by metrics, yields an unlimited number of new tensors. The oldest of such is Riemann's set of four-index symbols, of 1861. The simplest metrically differential tensor, however, was discovered in 1869 by Christoffel. This is *the covariant derivative* of a vector A_ι,

$$A_{\iota\kappa} = \frac{\partial A_\iota}{\partial x_\kappa} - \{\iota\kappa, \lambda\} A_\lambda, \tag{3}$$

where $\{\iota\kappa, \lambda\} = g^{\lambda\mu} [\iota\kappa, \mu] = \{\kappa\iota, \lambda\}$ and

$$[\iota\kappa, \mu] = \tfrac{1}{2}(\partial g_{\mu\iota}/\partial x_\kappa + \partial g_{\kappa\mu}/\partial x_\iota - \partial g_{\iota\kappa}/\partial x_\mu)$$

are Christoffel's symbols (*not* forming a tensor). Again,

$$B^\iota_\kappa = \partial B^\iota / \partial x_\kappa + \{\alpha\kappa, \iota\} B^\alpha$$

is a mixed tensor, and $g^{\kappa\lambda} B^\iota_\kappa = B^{\iota\lambda}$ is *the contravariant derivative* of B^ι. Likewise,

$$C^{\iota\kappa}_\lambda = \partial C^{\iota\kappa}/\partial x_\lambda + \{\lambda\alpha, \iota\} C^{\alpha\kappa} + \{\lambda\alpha, \kappa\} C^{\iota\alpha}, \tag{4}$$

$$C_{\iota\kappa\lambda} = \partial C_{\iota\kappa}/\partial x_\lambda - \{\iota\lambda, \alpha\} C_{\alpha\kappa} - \{\kappa\lambda, \alpha\} C_{\iota\alpha} \tag{5}$$

are the covariant derivatives of $C^{\iota\kappa}$ and $C_{\iota\kappa}$. The covariant derivative of $g_{\iota\kappa}$ itself vanishes identically. Noteworthy for their applications are

$$A^\iota = \operatorname{Div}(A^{\iota\kappa}) \equiv \frac{1}{\sqrt{g}} \frac{\partial}{\partial x_\kappa} (\sqrt{g} A^{\iota\kappa}) \text{ and } \operatorname{div}(A^\kappa) \equiv \frac{1}{\sqrt{g}} \frac{\partial}{\partial x_\kappa} (\sqrt{g} A^\kappa),$$

the vector divergence of a skew $A^{\iota\kappa}$ and *the scalar divergence* of A^κ; *e.g.*, one group of Maxwell's equations is represented by $\operatorname{Div}(F^{\iota\kappa}) = C^\iota$, where C^ι is the four-current and $F^{\iota\kappa}$ the electromagnetic skew tensor (six vector); the second group being expressed by equating to zero the "expansion" (*v. supra*) of $F_{\iota\kappa} = g_{\iota\alpha} g_{\kappa\beta} F^{\alpha\beta}$.

Geodesics, Null-lines.—The most characteristic lines of the metrical S_n are its *null* or *minimal-lines*, $ds = 0$, and "shortest" lines or *geodesics* defined by $\delta \int ds = 0$, with fixed terminals. The equations of a geodesic are

$$\ddot{x}_\iota + \{\alpha\beta, \iota\} \dot{x}_\alpha \dot{x}_\beta = 0, \tag{6}$$

where $\dot{x} = dx/ds$. They determine, *e.g.*, in the case of space-time, the motion of a free particle in the metrical, and gravitational, field $g_{\iota\kappa}$. The null-lines are imaginary or real according as (2) is a definite or non-definite form. The former is the case of spaces proper as contemplated by the pure geometer, and the latter that of space-time with one positive and three negative $g_{\kappa\kappa}$. The null-lines of space-time represent light propagation. The definiteness or non-definiteness of the quadratic form and its *index of inertia* (number of negative $g_{\kappa\kappa}$'s) are invariant properties.

Differential Parallelism.—A fruitful contribution to tensor analysis, due to Levi-Civita (1917), is the concept of differential *parallelism*. The metrical S_n can always be imagined as hypersurface embedded in a Euclidean space E, of $\frac{1}{2}n(n+1)$ dimensions. $O(x_\iota)$ and $O'(x_\iota + dx_\iota)$ being points of S_n, and OP a vector, Levi-Civita transfers OP by a Euclidean parallel shift to $O'P_e$ and defines $O'P'$, the orthogonal projection of $O'P_e$ upon the E-plane tangential to S_n at O, as *parallel* to OP. In spite of the ultra-spacial construction, parallelism is intrinsic, expressible by the S_n-metrics alone. If A^ι be the components of OP, and $A^\iota + \delta A^\iota$ those of $O'P'$,

$$\delta A^\iota = -\{\kappa\lambda, \iota\} A^\kappa dx_\lambda. \tag{7}$$

For covariant components, $\delta A_\kappa = \{\kappa\lambda, \iota\} A_\iota dx_\lambda$. These formulae give, in any co-ordinates, the changes of the components of a vector produced by its translation or parallel shift through dx_λ. In local geodesic co-ordinates ($g_{\iota\kappa}$ stationary at O), $\delta A_\kappa = 0$. Alternatively, after Weyl, parallelism may be defined in the non-metrical S_n by putting $\delta A^\iota = -\Gamma^\iota_{\lambda\kappa} A^\kappa dx_\lambda$, where $\Gamma^\iota_{\lambda\kappa} = \Gamma^\iota_{\lambda\kappa}$ are freely prescribable functions of position, fixing *the affine connection* of the otherwise amorphous manifold. One can continue to hold this more general, affine view in developing further consequences, as of late was done by many writers; but this subject cannot here be dwelled upon. If metrics are impressed upon the affine manifold, the requirement that the size of a vector shall remain unaltered by a translation, $\delta(g_{\iota\kappa} A^\iota A^\kappa) = 0$, gives $\Gamma^\iota_{\lambda\kappa} = \{\kappa\lambda, \iota\}$, leading again to (7).

The parallel shift is a powerful means of obtaining differential tensors. Being the difference of not copunctal vectors, δA_κ is not a vector; but, if A_κ be considered as a field, its value at O' is $A_\kappa + \dfrac{\partial A_\kappa}{\partial x_\lambda} dx_\lambda$, while the vector transferred from O to O' is

$A_\kappa+\delta A_\kappa$. These two being copunctal, their difference

$$[\partial A_\kappa/\partial x_\lambda-\{\kappa\lambda,\iota\}A_\iota]dx_\lambda$$

is a covariant vector; and dx_λ being arbitrary, the bracket is a tensor $A_{\kappa\lambda}$. This establishes the covariance of Christoffel's derivative (3), which now appears as the point-to-point change of the field A_κ *less* that due to translation. The same process can be applied to a $C_{\iota\kappa}$, defining its translation by the requirement $\delta(C_{\iota\kappa}A^\iota B^\kappa)=0$, for any vectors A^ι, B^κ. This leads to the covariant derivative $C_{\iota\kappa\lambda}$ (5). Similarly for higher-rank tensors. Any of these covariant differentiations can be written

$$\mathfrak{D}_\lambda=\frac{\partial}{\partial x_\lambda}-\frac{\delta}{dx_\lambda},$$

where δ/dx_λ stands for the factor of dx_λ in the expression of δ.

Let it be required to construct a line whose elements follow from each other by parallel shifts along the line itself. This gives $\delta\dot{x}_\iota=-\{\alpha\beta,\iota\}\dot{x}_\alpha dx_\beta$ and $\delta\dot{x}_\iota=\ddot{x}_\iota ds$, so that the line is a geodesic. The latter is thus throughout "parallel to itself"—an interesting generalization of the property of Euclidean straights. Accordingly, a vector transferred along a geodesic remains equally inclined to it.

The concept of parallelism opens also an easy road to the very important Riemann-Christoffel tensor. This is formed of the $g_{\iota\kappa}$ and their first and second derivatives, and represents thus a differential, second-order property of the metrical field itself. Significantly enough, there is no such property of the first order; in fact, the tensor $\mathfrak{D}_\lambda g_{\iota\kappa}$ vanishes, and there is no other. This lends additional interest to the second-order tensor.

If a vector X^ι be carried by successive parallel shifts along two different paths a, b from O to a distant point O', the two vectors at O', equal in size, generally differ in direction. One is parallel to X^ι "*via a*," the other "*via b*." In fine, parallelism depends on the route of transfer or is non-integrable (unless S_n is Euclidean). Thus also, if the vector be carried around a *circuit*, it returns at O with its direction changed. The total change of X^κ,

$$\Delta X^\kappa=\int\delta X^\kappa=-\int\{\kappa\lambda,\iota\}X^\kappa dx_\lambda,$$

being the difference of copunctal vectors, is itself a vector. Evaluate the integral for a quadrilateral x, $x+dx$, $x+dx+dy$, $x+dy$. Then

$$\Delta X^\kappa=\left[\frac{\partial}{\partial x_\beta}\{\iota\alpha,\kappa\}-\{\alpha\gamma,\kappa\}\{\iota\gamma,\beta\}\right]X^\iota\sigma^{\alpha\beta},$$

where $\sigma^{\alpha\beta}=dx_\alpha dy_\beta-dx_\beta dy_\alpha$. This, the oriented surface-element, being antisymmetric, the equation holds also when α,β are interchanged. Thus,

$$\Delta X^\kappa=-\tfrac{1}{2}R^\kappa_{\iota\alpha\beta}X^\iota\sigma^{\alpha\beta}, \qquad (8)$$

where

$$R^\kappa_{\iota\alpha\beta}=\frac{\partial}{\partial x_\alpha}\{\iota\beta,\kappa\}-\frac{\partial}{\partial x_\beta}\{\iota\alpha,\kappa\}$$
$$+\{\alpha\gamma,\kappa\}\{\iota\beta,\gamma\}-\{\beta\gamma,\kappa\}\{\iota\alpha,\gamma\} \qquad (9)$$

is again antisymmetric in α,β. Therefore, and since ΔX^κ is a vector, $R^\kappa_{\iota\alpha\beta}$ is a mixed tensor. This is *the Riemann-Christoffel* or *curvature tensor*. Its meaning is best expressed by (8) itself, which reads: the change of a vector carried around an oriented surface-element is half the inner product of the curvature tensor into that element and the vector. An alternative deduction of $R^\alpha_{\iota\kappa\lambda}$ can be briefly expressed by

$$(\mathfrak{D}_\lambda\mathfrak{D}_\kappa-\mathfrak{D}_\kappa\mathfrak{D}_\lambda)X_\iota=R^\alpha{}_{\iota\kappa\lambda}X_\alpha.$$

The vanishing of the curvature tensor is the necessary and sufficient condition for the reducibility of $g_{\iota\kappa}$ to a constant tensor, or the criterion of a homaloidal (Euclidean) space. In fact, if $g_{\iota\kappa}(x)$ is constant throughout S_n, all Christoffel symbols and $R^\kappa{}_{\iota\alpha\beta}$ vanish in x and therefore also in any co-ordinate-system. Conversely, if $R^\kappa_{\iota\alpha\beta}$ vanishes, $\Delta X^\kappa=0$ for every circuit, parallelism becomes independent of the route of transfer and applicable to any pair of distant places. This however can be shown to be sufficient for constructing the Euclidean geometry. Analytically, the sufficiency of this condition for the reducibility of $g_{\iota\kappa}dx_\iota dx_\kappa$ to a form with constant coefficients was proved by Lipschitz as early as 1869.

Riemann's Four-index Symbols and Curvature.—Riemann's own set of *four-index symbols* is the covariant tensor $(\iota\mu,\lambda\kappa)\equiv R_{\iota\mu\lambda\kappa}=g_{\mu\alpha}R^\alpha_{\iota\kappa\lambda}$. Conversely, $R^\alpha{}_{\iota\kappa\lambda}=g^{\mu\alpha}(\iota\mu,\lambda\kappa)$. Like (9), the symbols are antisymmetric in κ,λ. Three more linear relations hold between them. This reduces the number of independent symbols to $\frac{1}{12}n^2(n^2-1)$; *e.g.*, six for a three-space, twenty for an S_4, and but *one* for a surface, say (12, 12). This symbol divided by g is an invariant of the surface, its *Gaussian curvature* (K.) (*See* DIFFERENTIAL GEOMETRY.) Formula (8) gives for the rotation of a two-vector carried around a surface-element (of area $d\sigma=\sqrt{g}\sigma^{12}$), $\Delta\theta=Kd\sigma$; the vector on its return overshoots its original direction or falls short of it by $|K|d\sigma$ according as $K\gtrless 0$. The Gaussian curvature thus appears as the rotation per unit area. As a consequence, *the excess* (over π) of the angle sum in any geodesic triangle is $\int Kd\sigma$, the "total curvature" of the triangle, a famous theorem due to Gauss.

In the case of three or more dimensions the curvature properties can no longer be expressed by a single magnitude, but require for their description the knowledge of the whole curvature tensor or the associated Riemann symbols. The concept of Gaussian curvature is now replaced by that of *Riemannian curvature*. This is, at any point $O(x)$ of S_n, the set of Gaussian curvatures K_ν of geodesic surfaces of all possible orientations laid through O. If $h_{\alpha\beta}$ be the metrical tensor of such a surface as sub-manifold, then $K_\nu=\frac{1}{h}(12,12)_h$, the symbol to be calculated with $h_{\alpha\beta}$. This and the determinant h can be expressed in terms of the tensor $g_{\iota\kappa}$ of the manifold and the vector pair, $d\xi_\iota$, $d\eta_\iota$, fixing the orientation. The result is

$$K_\nu=\frac{(\iota\lambda,\kappa\mu)\sigma^{\iota\lambda}\sigma^{\kappa\mu}}{(g_{\iota\kappa}g_{\lambda\mu}-g_{\iota\mu}g_{\lambda\kappa})\sigma^{\iota\lambda}\sigma^{\kappa\mu}}, \qquad (\iota<\lambda,\ \kappa<\mu), \qquad (10)$$

where $\sigma^{\iota\lambda}=d\xi_\iota d\eta_\lambda-d\xi_\lambda d\eta_\iota$ is the oriented surface-element (the suffix ν indicating its normal). In general, K_ν will depend on position and on orientation. In other words, with regard to curvature, S_n may be non-homogeneous as well as anisotropic (*e.g.*, space-time within or around matter); but if K_ν is everywhere isotropic, it is also constant throughout S_n. This is Schur's theorem. By (10) the necessary and sufficient condition for isotropy of Riemannian curvature becomes $(\iota\lambda,\kappa\mu)=K(g_{\iota\kappa}g_{\lambda\mu}-g_{\iota\mu}g_{\lambda\kappa})$ or $R^\alpha{}_{\iota\kappa\lambda}=K(\delta^\alpha{}_\kappa g_{\iota\lambda}-\delta^\alpha{}_\lambda g_{\iota\kappa})$ with constant K.

The tensor (9), being mixed, yields the contracted curvature tensor $R^\alpha{}_{\iota\kappa\alpha}=R_{\iota\kappa}$ which turns out to be symmetrical. Its scalar, $R=g^{\iota\kappa}R_{\iota\kappa}$, is the *curvature invariant* of the manifold. For an isotropic n-fold, $R=-(n-1)nK$ and $R_{\iota\kappa}=g_{\iota\kappa}R/n$. A capital use of $R_{\iota\kappa}$ was made by Einstein for constructing the gravitational field-equations, $R_{\iota\alpha}-\frac{1}{2}Rg_{\iota\alpha}=-\kappa T_{\iota\alpha}$, where $\kappa\backsim$ gravitation constant, and $T_{\iota\alpha}$ is the tensor of matter, embodying energy, momentum, and stress. The covariant derivative of $R_{\iota\kappa}$ is connected with grad R by the n relations $g^{\kappa\lambda}R_{\iota\kappa\lambda}=\frac{1}{2}\partial R/\partial x_\iota$, which were again utilized by Einstein and which follow from the identical relations $\mathfrak{D}_\nu(\iota\kappa,\lambda\mu)+\mathfrak{D}_\lambda(\iota\kappa,\mu\nu)+\mathfrak{D}_\mu(\iota\kappa,\nu\lambda)=0$. These remarkable identities, discovered by Bianchi, give also a very simple proof of Schur's theorem.

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(L. SN.)

TENTERDEN, CHARLES ABBOTT, 1ST BARON (1762–1832), lord chief justice of England, was born at Canterbury on

Oct. 7, 1762, the son of a hairdresser. He was educated at Canterbury King's school and Corpus Christi college, Oxford, and entered at the Middle Temple in 1787. For several years he practised as a special pleader under the bar, and was finally called at the Inner Temple in 1796. He joined the Oxford circuit and made rapid headway. In 1801 he was appointed recorder of Oxford. In 1802 appeared his *Law relative to Merchant Ships and Seamen,* which is still an authoritative work. Its publication brought to him so much commercial and other work that in 1808 he was in a position to refuse a seat on the bench; this, however, he accepted in 1816, being made a judge of the court of common pleas. On the resignation of Lord Ellenborough in 1818 he was promoted to the chief justiceship of the king's bench, and presided over several important state trials, notably that of Arthur Thistlewood and the Cato Street conspirators (1820). He was raised to the peerage in 1827 as Baron Tenterden of Hendon. Never a great lawyer and with no pretence to eloquence, Tenterden made his way by sound common sense and steady hard work. He was an uncompromising Tory, and had no sympathy with the reform of the criminal law carried out by Romilly; while he strongly opposed the Catholic Relief bill and the Reform bill. He died on Nov. 4, 1832.

See Foss, *Lives of the Judges* (1870).

TENTERDEN, a market town and municipal borough in the Ashford parliamentary division of Kent, England, 53 m. S.E. by E. of London by the S. railway. Pop. (1921) 3,438. It lies on an elevation above the Newnill channel, a tributary of the Rother, whose flat valley, called the Rother Levels, was an estuary within historic times; and even as late as the 18th century the sea was within 2 m. of Tenterden, which is a member of the affiliated Cinque Port of Rye. The church of St. Mildred is Early English and later, and its tall, massive Perpendicular tower is well known for the legend connecting it with Goodwin Sands. The story is that the abbot of St. Augustine, Canterbury, diverted the funds by which the sea-wall protecting Earl Godwin's island was kept up, for the purpose of building Tenterden steeple, the consequence being that in 1099 an inundation took place and "Tenterden steeple was the cause of the Goodwin Sands." The church of High Halden, in the neighbourhood, is remarkable for its octagonal wooden tower constructed of huge timbers, with a belfry of wooden tiles (shingles), of the time of Henry VI.

Tenterden (*Tenterdenne, Tentyrden*) figures frequently in contemporary records from 1300 onwards. In 1449 it was united to Rye, and granted a charter which, however, did not come into operation till 1463 under Edward IV. In return for these and other privileges it was to contribute towards the services due from Rye as one of the Cinque Ports. In 1600 it was incorporated under the title of the "Mayor, Jurats and Commons" of the town and hundred of Tenterden, in the county of Kent, the members of the corporation ranking henceforward as barons of the Cinque Ports. A weekly corn market on Friday and a yearly cattle and wool fair on the first Monday in May were granted, both of which are held at the present day. In 1790 a contemporary writer mentions the market as being little frequented, whilst the fair was large and resorted to by all the neighbourhood. The size and importance of Tenterden can be estimated from a receipt of 1635 for £90 ship-money, as compared with £70 contributed by Faversham, and £60 by Hythe. Under Edward III. several refugee Flemings settled in the town and established the woollen manufacture. By 1835 this trade died out.

TENURE, in law, the holding or possession of land. The holding of land in England was originally either *allodial* or *feudal.* Allodial land was land held not of a superior lord, but of the king and people. Such ownership was absolute (*see* ALLODIUM). The Saxon invasion tended, without doubt, to re-establish the principle of common village ownership which formed the basis of both Celtic and German tenure. In the later Saxon period, however, private ownership became gradually more extended. Then the feudal idea began to make progress in England, much as it did about the same time on the Continent of Europe, and it received a great impetus from the Norman conquest. When English law began to settle down into a system the principle of feudalism was taken as the basis, and it gradually became the undisputed maxim of English law that the Sovereign was the supreme lord of all the land and that every one held under him as tenant (*see* FEUDALISM). All tenures, except free and common socage tenures, were abolished by the Law of Property Act, 1925 (s. 56), and provision has been made for the abolition of copyhold and customary tenure and the extinction of manorial incidents, with a saving for grand and petty serjeanty services (*ibid.* ss. 128, 136, 139–143). The following modern cases may be consulted with regard to native tenures of land: *In re Southern Rhodesia* (1919) A.C. 211, 233 (aboriginal rights generally); *Sobhn Za II.* v. *Miller* (1926) A.C. 518 (West African); *Amadu Tijani* v. *Secretary for Southern Nigeria* (1921) 2 A.C. 399 (West African); *A.G. for Quebec* v. *A.G. for Canada* (1921) 1 A.C. 401 (Indian Reserves): but it should be noted that in several colonies the matter has been the subject of legislation. In the United States the term tenure ordinarily is used to denote the manner whereby lands or tenements are held, excluding lands held in fee simple. As an example, a person may have a life estate or tenure in land, or a tenure for a term of years. (*See* also ESTATES; LAND; MANOR.)

TEOSINTE (*Euchlaena mexicana*), a tall, stout, annual grass, native to Mexico, very closely allied botanically to maize (*q.v.*). Usually branching at the base, it grows in large clumps, with tassels (staminate flowers) like those of maize. The bundles of fruiting spikes, enclosed in husks, with the silk (long styles) hanging from the upper ends, are somewhat similar to the ears of maize. Teosinte is grown in Mexico as a fodder plant and sparingly in the southern parts of the United States as a soiling crop. In Mexico hybrids of teosinte and maize are found, giving rise to the view that the two plants have developed from a common ancestral form.

TEPIDARIUM, the warm room of a Roman bath (*see* BATHS), or a similar chamber in a modern bath establishment. In the great imperial thermae at Rome the tepidarium constituted the large central hall and served, apparently, as a general lounge and meeting room as well as for bathing.

TEPLICE-ŠANOV, a spa in Bohemia, Czechoslovakia, in the valley of the Bilina. It owes its popularity as a watering-place to its mild climate and to the thermal mineral springs of the locality. The saline-alkaline waters, 79° to 122° F, are used almost exclusively for bathing in the treatment of gout, rheumatism and some skin complaints and are prescribed as an "after-cure" to Carlsbad, etc. Although traditionally believed to have been known and used since the 8th century, the springs are not historically mentioned until the 16th century, and to-day the function of the town as a watering-place is disappearing in face of the advance of industry, for the rich lignite field of Most-Chomůtov-Teplice has led to the establishment of numerous manufactures. Hardware, machinery, glass, pottery, chemicals, cotton and woollen goods are the principal products and in all of these Teplice has a brisk trade that increases yearly. Industrial life grows mainly in the suburbs. Pop. (1923) 28,892, of whom 22,489 were Germans.

TEPLITZ: *see* TEPLICE-ŠANOV.

TERAMO, an episcopal see of the Abruzzi, Italy, the capital of the province of Teramo, 16 m. by rail W.S.W. of Giulianova, a junction on the Ancona-Brindisi railway. Pop. (1921) 15,284 (town); 25,834 (commune). The town stands on the left bank of the Tordino, where it is joined by the Vezzola, at an altitude of 876 ft. above sea-level. The cathedral has a Romanesque Gothic portal of 1332 by a Roman marble worker named Deodatus; it contains a splendid silver antependium by Nicolo da Guardiagrele (1433–48). The tower is fine. The church of S. Antonio is also in the Romanesque Gothic style. Under the church of S. Anna dei Pompetti remains of Roman houses and of the original cathedral have been discovered. Two m. away is an important astronomical observatory, presented to the State by Vincenzo Cerulli in 1917. The ancient Interamna Praetuttiorum was the chief town of the tribe of the Praetuttii.

TERAPHIM, a Hebrew word, found only in the plural, of uncertain etymology. The name appears to be applied to some form of idol (*cf.* Gen. xxxi. 19 and 30), but details as to its precise configuration, etc., are lacking. From I. Sam. xix. 13, 16 it would seem that in the early monarchical period a regular place in every household was still reserved for the teraphim; while in the 8th century, Hosea (iii. 4) speaks of "ephod and teraphim" as essential elements in the national worship. Later the teraphim were banned by the prophets. The meaning of the story in Gen. xxxv. 2–4 clearly is that the employment of teraphim was given up by Israel in order that they might serve Jehovah alone at Bethel. In Judges and Hosea the teraphim are closely associated with the ephod; both are mentioned in connection with divination (*cf.* 2 Kings xxiii. 24; Ezek. xxi. 21 & 26; Zech. x. 2). In view of Ezek. xxi. 21 and Hosea iii. 4, it is difficult to suppose that the teraphim were purely household idols. *See* also EPHOD.

TERBIUM, a very rare metallic element (symbol Tb, atomic number 65, atomic weight 159·2) of the rare-earth group, was discovered by Mosander, who originally named the oxide erbia. The first pure compounds were obtained by G. Urbain in 1905. It is best separated from the other members of the group by the fractional crystallization of the bromates. The ignition of terbium oxalate or sulphate gives a black peroxide which slowly dissolves on heating with mineral acids, giving almost colourless solutions characterized by a rather faint absorption band in the blue region of the spectrum. *See* RARE EARTHS. (C. J.)

TER BORCH (or TERBURG), **GERARD** (1617–1681), Dutch subject painter, was born in 1617 at Zwolle, Holland. He received an excellent education from his father, also an artist, and developed his talent very early. The inscription on a study of a head proves that Ter Borch was at Amsterdam in 1632. In 1634 he studied under Pieter Molyn in Haarlem. A record of this Haarlem period is the "Consultation" (1635) at the Berlin gallery. In 1635 he was in London; in 1640 in Rome, when he painted the small portraits on copper of "Jan Six" and "A Young Lady" (the late Six collection, Amsterdam). In 1648 he was at Münster during the peace congress and executed his celebrated little picture, painted upon copper, of the assembled plenipotentiaries—a work which, along with the "Guitar Lesson" and a portrait of a "Man Standing," now represents the master in the National Gallery in London. The picture was presented to the nation by Sir Richard Wallace. At this time Ter Borch was invited to visit Madrid, where he received employment and the honour of knighthood from Philip IV., but, in consequence of an intrigue, it is said, he was obliged to return to Holland. He seems to have resided for a time in Haarlem; but he finally settled in Deventer, where he became a member of the town council. He died at Deventer on Dec. 8, 1681.

Ter Borch is excellent as a portrait painter, but still greater as a painter of *genre* subjects. He depicts with admirable truth the life of the wealthy and cultured classes of his time. His colouring is clear and rich, but his best skill lies in his unequalled rendering of texture in draperies, which is seen to advantage in such pictures as the "Letter" in the Dutch royal collection, and in the "Paternal Advice" (known as the "Satin Gown")—engraved by Wille—which exists in various repetitions at Berlin and Amsterdam, and in the Bridgewater gallery. Hofstede de Groot enumerates 464 works by Ter Borch. Seven of these are at the Hermitage, 12 at the Berlin museum, seven at the Louvre; six at the Dresden museum, two at the Wallace collection and 15 at the Amsterdam museum.

See Hofstede de Groot, *Catalogue of Dutch Painters* (1913).

TERCEIRA, an island in the Atlantic ocean, belonging to Portugal, and forming part of the Azores archipelago. Pop. (1911) 47,953; area, 224 sq.m. Terceira, *i.e.*, "the third," was so called as being the third island of the archipelago to be discovered by the Portuguese. From its central position it was long the seat of administration, but its capital, Angra (*q.v.*), has lost much of its commercial importance. The other chief towns are Ribeirinha (2,739), and Praia da Vitoria (3,195). (*See* AZORES.)

TEREBINTH, botanical name *Pistacia terebinthus,* a member of the family Anacardiaceae, usually a small tree, common in the south of Europe and the whole Mediterranean area. It has a purplish grey bark and compound leaves with two to four pairs, and an odd terminal one. The very small numerous unisexual flowers are borne on panicles. The fruit is a small roundish bright red drupe with a scanty pulp. The plant has been long known in English gardens. A liquid resinous exudation, known as Chian, Scio or Cyprus turpentine, is obtained by cutting the stem. An allied species, *P. lentiscus,* is the mastic tree.

TEREDO. From time immemorial seafaring men have known and dreaded the shipworm, which bores into and destroys the stoutest timbers in the sea. Nowadays, although the danger to ships is no longer to be feared, the timber of harbour works is still exposed to damage by the same pest. How serious the danger may become is shown, for example, by the outbreak of shipworm in San Francisco bay during the four years 1917–21 when the destruction of wharves and jetties was estimated to have cost the enormous sum of 25 million dollars.

The writers of antiquity did not distinguish clearly between the marine timber-worm and the wood-boring insect larvae of the land and they sometimes applied the name Teredo to both, but it was later restricted to the marine borer and is still in use as a general term for the shipworms, although in the nomenclature of zoological taxonomy it is the name of only one of the genera forming the family Teredinidae.

It was Godfrey Sellius who, in 1733, first showed that *Teredo* is a bivalve mollusc, although it differs widely in structure from the more familiar members of that group. When its burrow in the wood is laid open it is seen to have a long worm-like body bearing at its inner end a pair of small shelly plates which represent the valves of the shell. At the outer end, where the burrow narrows to a small opening, the body ends in a pair of siphons which can be extended from the surface of the wood and serve for the entrance and exit of the respiratory current of water. When the siphons are withdrawn the opening of the burrow is blocked by a pair of paddle-shaped plates of shell known as the pallets. The interior of the burrow is lined with shelly material which is usually merely a thin film but when exposed by the decay of the wood may be considerably thickened. The valves of the shell are nearly hemispherical, with a deep right-angled notch occupying the ventral half of the anterior margin. In the gap left by these notches is the round sucker-like foot with which the animal adheres now to one part and now to another of the interior of its burrow. Parallel with the edges of the notch, the surface of each valve is marked with two sets of fine ridges which are seen under the microscope to be rows of minute teeth like those of a file. It is by means of these teeth that the excavation of the wood is effected. While the foot is adhering to the wood a rocking movement is imparted to the valves by alternate contractions of the anterior and posterior adductor muscles and the wood is rasped away as a fine dust. This is swept into the mouth and passes into the stomach. It has been shown beyond doubt that the wood is acted on by the digestive ferments and utilized as food, but in addition the stomach is usually found to contain minute floating organisms drawn in with the respiratory current.

In some species of *Teredo* the eggs are discharged and float freely in the sea, in others they are retained in the gill-cavity and pass through the early stages of their development before they are set free. In either case, the earliest stage is a free-swimming ciliated larva which soon develops a bivalve shell. After a time the larva settles on the surface of the wood, creeping about by means of a large tongue-shaped muscular foot. Settling on a suitable spot it begins to scrape away the wood with the edges of the valves and soon disappears below the surface. As the burrow deepens the body lengthens so that the siphons can protrude from the surface while the valves are working at the inner end. In temperate seas shipworms rarely exceed a foot in length but some tropical species may reach six feet.

Many species of shipworms have been described and grouped in a number of genera forming the family Teredinidae, but the taxonomy is not in a satisfactory condition and much more work is required before the limits of species or genera can be properly defined. What is of importance to the engineer is that the different species differ considerably in their physiological requirements. Thus while many species are only able to flourish in places where the salinity of the water is nearly the same as that of the open sea, the typical species *Teredo navalis* can survive a considerable reduction in the salinity and is enabled to invade estuaries and harbours where the influx of fresh water excludes other species. It happens from time to time, as in the case of the San Francisco outbreak alluded to above, that a temporary increase of salinity resulting from reduced rainfall allows *T. navalis* to gain a footing in places where it had not previously existed.

Numerous methods have been tried for protecting timber against the attacks of shipworms. Metal sheathing for the hulls of wooden ships was employed in Greek and Roman times and copper sheathing came into extensive use in the 18th century. At the present day the piles of harbour works are sometimes sheathed with metal or enclosed in concrete "jackets." These methods, however, are only effective when the surface is completely covered. A small space left unprotected may admit enough shipworm larvae to destroy completely the interior of the timber. Certain kinds of timber, such as the South American greenheart, are comparatively resistant to shipworm attacks but it appears that this resistance is only temporary and that no kind of wood is permanently immune. Many methods for impregnating the wood with poisonous substances have been tried, but the only agent that has come into general use for this purpose is creosote. Heavy impregnation with creosote greatly lengthens the "life" of timbers exposed to attack, but lasting immunity is not attained owing to the gradual washing out of the creosote from the wood.

Besides the shipworms several species of Crustacea are the cause of serious damage to timber in the sea. The best known of these is the "gribble," a tiny isopod which burrows in the superficial layers of the wood, reducing them to a spongy mass which is easily washed away, exposing fresh layers to attack. It is common in European waters and has been found in many other parts of the world. The damage done by it is visible on the surface and is less likely to attain serious proportions without being noticed than is that caused by the shipworm. (W. T. C.)

TEREK, a river of Russia flowing from the Caucasus Range to the Caspian Sea, rising in glaciers on Mount Kasbek. It skirts the Kasbek group on the south and west, and flows through a series of gorges. The most famous is the Darial gorge by which the Terek escapes to the plains on the north, its furious torrent flowing between wild granitic bare rocks and forming a contrast to the wooded limestone mountains beyond. The Georgian military road, built 1811–64, passes through the gorge and enabled Russia to establish her rule among the wild Caucasian mountain tribes. Below Vladikavkaz at the foot of a vast declivity, it collects the waters of the Gusel-don, Fiag-don, Ar-don and later receives the Urukh, and the Malka, with its affluents the Cherek and Baksu. It then flows through the steppe country at the northern foot of the Caucasus to the Caspian, being joined before it reaches the delta by the Sunja, a tributary receiving the Chanti or Argun, and fed by numerous sulphur streams, one of them, the Melchihi, rising in five hot springs which affect the temperature of the Melchihi for some distance. In spite of losses by evaporation and irrigation, the Terek still has a sufficiently large volume to enable it to spread out in a great delta, with branches shifting in flood time and changing their relative importance. This delta stretches for 70 m. along the coast. The coast line, like that of the Volga delta, is encroaching on the Caspian, and old shore lines may be traced considerably west of the present coast. Fishing villages which in 1825 stood on the coast line were 10 m. inland in 1855. Among the more important irrigation canals are the Eristov and Kurskiy, fed from the Malka; plans are under consideration for irrigation of part of the Nogai steppe, recently included in the Dagestan A.S.S.R. In its lower course the Terek flows above the level of the surrounding country.

TEREK PROVINCE: *see* North Caucasian Area.

TERENCE (Publius Terentius Afer) (*c.* 190–*c.* 159 B.C.), Roman comic poet, was born in Carthage and came to Rome as a slave in the house of Terentius Lucanus, a senator, by whom he was educated and manumitted. The little that is known of his life is almost entirely derived from a fragment of Suetonius, *De viris illustribus*. At Rome he was on friendly terms with Scipio Africanus the younger, C. Laelius, and Furius Philus. His six plays were produced 166–160 B.C. After the production of the last he went to Greece, apparently to procure more of Menander's plays. From this voyage he did not return. The place and manner of his death are very variously given.

His first play, the *Andria*, was produced in 166 B.C. The plot, which may be taken as typical, tells of the adventures of an Athenian girl, Pasibula, who is left in the charge of an uncle while her father goes abroad; how she is shipwrecked off the coast of Andros, where she is brought up, under the name of Glycerium, as the daughter of an Andrian, and returns to Athens; of her love affair with Pamphilus and its threatened frustration; and of her rediscovery of her father and her eventual marriage with Pamphilus, whose crafty slave, Davus, is as usual the mainspring of the plot. The play is an adaptation from two plays—a procedure known as *contaminatio*—of Menander, as we learn from the prologue 9 *seq.* "Menander wrote the *Andria* and the *Perinthia;* he who knows either, knows both, for the plots are not very different, though they differ in language and style. The poet's enemies object to this and maintain that plays should not be contaminated (*contaminari non decere fabulas*). Their knowingness shows that they know nothing, for the same criticism applies to Naevius, Plautus and Ennius, whom the poet takes as his models, preferring their 'negligence' to the 'obscure diligence' of his detractors." The opening scene is twice referred to by Cicero, who in *De Inventione*, i. 23, cites lines 50–53, 157, 168, and in *De Oratore* 40, *hic parvae consuetudinis—faciet patri* (*Andr.* 110–112).

His second play, *Hecyra,* or the Mother-in-Law, adapted from a play by Apollodorus, was produced in 165. The third, *Heautontimorumenos,* or the Self-Avenger, appeared in 163; the fourth, the Eunuchus (Eunuch), a "contamination" (*cf.,* prol. 30 *seq.*) of two plays of Menander, the *Eunuchus* and the *Kolax* (flatterer), in 161; and in the same year also the *Phormio,* adapted from the *Epidicazomenos* of Apollodorus. His last play, the *Adelphoe,* or the *Brothers*, a "contamination" of the *"Adelphoi"* of Menander and the *Sunapothneskontes* of Diphilus, was produced in 160.

With regard to the economy of his plays, it is to be noted that Terence uses the prologue no longer to introduce a play by an exposition of the plot, but after the manner of the Aristophanic *parabasis,* chiefly to reply to his critics—*cf. Andria, prolog. 5 "Nam in prologis scribundis operam abutitur Non qui argumentum naeret sed qui malevoli Veteris poetae maledictis respondeat;" i.e.,* the poet wastes his labour in writing prologues, not to explain the plot, but to reply to abuse of a malevolent old poet (Lavinius Luscus, preferred by Vulcatius Sedigitus to Ennius as a comic poet. Aul. Gell. xv. 24).

The comedy of Terence, like that of his exemplars, is a comedy of manners. The reader is conscious of having travelled a long way from the Olympian humour of Aristophanes. His merit—purity of Latinity—and his demerit—lack of comic power (*vis comica*)—are summed up in the famous epigram of Julius Caesar (Sueton. *Vita Terentii*):

> Tu quoque, tu in summis, O dimidiate Menander,
> Poneris et merito puri sermonis amator:
> Lenibus atque utinam scriptis adiuncta foret vis
> Comica, ut aequato virtus polleret amore
> Cum Graecis neque in hac despectus parte iaceres.
> Unum hoc maceror et doleo tibi desse, Terenti.

(Thou too, O halved Menander, art placed among the highest and deservedly—lover of pure speech. And I would that to thy mild writings there had been joined comic power, so that thy excellence might have had equal honour with the Greeks and thou be not despised in that part. This one thing, Terence, thou lackest—to my distress and sorrow.) In his own time he appears to have been accused of plagiarism and also of receiving help in writing his plays from his friends—a charge which he several times refers to in his prologues and in that of the *Adelphoe* apparently admits to be true.

In using his Greek models, apart from "contamination" referred to above, he permits himself various liberties. Names are altered, individual scenes remodelled, *e.g., Eunuchus,* 539 *seq.* or abbreviated, cf. *Hecyra,* 825, and new characters, *e.g.,* Charinus and Burria in the Andria, introduced.

The judgment of Caesar already quoted seems to have been pretty generally endorsed in antiquity. Varro found his chief merit in the exhibition of character (*in ethesin Terentius poscit palman*); Cicero in his choice language.

In another passage—*De optimo genere oratorum*, i.—Cicero speaks of Terence as generically differing from Accius; Horace, *Epist.*, ii. 1.59 quotes as a received opinion that Caecilius (who, according to legend, Sueton *Vit. Ter.*, encouraged the young poet) excelled in dignity, Terence in art. Ovid, *Trist.* ii. 359 *seq.* contrasts him with Accius: *Accius esset atrox, conviva Terentius esset.* Quintilian (x. 1.99) says that the Romans make a poor show in comedy . . . "though the writings of Terence are ascribed to Scipio Africanus—writings which in this kind are most elegant and could have been still more pleasing if they had been confined to trimeter lines"—a criticism which seems to refer to some departures in prosody from the strict Menandrian model. According to Servius, Terence is preferred to the other comic poets solely on the ground of propriety, being in other respects inferior. Aulus Gellius, xv. 24 has preserved some lines of Vulcatius Sedigitus, in which the Roman writers of comedy are arranged by him in order of merit, thus—Caecilius, Plautus, Naevius, Licinius, Atilius, Terence. Turpilius, Trabea, Luscius and lastly, added, *causâ antiquitatis*, Ennius. In England and on the Continent, Terence has been popular and influential and imitations of his plays have been numerous, *e.g.*, the *Andria* was copied in the *Conscious Lovers* of Sir Richard Steele, the *Heautontimorumenos* in the *All Fools* of Chapman, the *Eunuchus* in Sedley's *Bellamira*, and La Fontaine's *L'Eunuque*, the *Phormio* in Molière's *Les Fourberies de Scapin*, the *Adelphoe* in the same author's *Ecole des Maris*.

See *Editio princeps:* Strasbourg (1470); R. Bentley (Cambridge, 1726); Fleckeissen (Leipzig, 1898). Editions of single plays are numerous. (A. W. Ma.)

TERENTIANUS, surnamed Maurus (a native of Mauretania), Latin grammarian and writer on prosody, flourished probably at the end of the 2nd century A.D. His references to Septimius Serenus and Alfius Avitus, who belonged to the school of "new poets" (*poetae neoterici* or *novelli*) of the reign of Hadrian and later, seem to show that he was a near contemporary of those writers. He was the author of a hexameter treatise in four books, on letters, syllables, feet and metres, of which considerable use was made by later writers. The most important part of it is that which deals with metres, based on the work of Caesius Bassus.

Best edition, by H. Keil, *Grammatici Latini*, vi.; with commentary by L. Santen (1825); *see* also Teuffel-Schwabe, *Hist. of Roman Literature* (Eng. tr.), 373*a*.

TERGESTE (mod. *Trieste, q.v.*), an ancient city of Istria, 26 m. E.S.E. of Aquileia by road, at the northern extremity of the peninsula of Istria, in a bay at the head of the Adriatic Sea. Its importance was in ancient days, as now, mainly due to its commerce as the outlet of Pannonia and Dalmatia. In 33 B.C. Augustus, during his Dalmatian wars, built a wall and towers there, as an inscription records. The cathedral of S. Giusto perhaps occupies the site of the Roman Capitol, or temple of Jupiter, Juno and Minerva, some of the walls and columns of which may be seen in the tower, which dates from 1337.

TERM, in logic, means the subject or predicate of a judgment (or proposition). It is, however, commonly used in a much wider sense so as to include also any word or combination of words that is capable of being used as the subject or predicate of a proposition. Of the different kinds of terms usually distinguished, the following are the most important. (a) *Connotative* terms are those which have a standard (or conventionally fixed) meaning. In this sense practically all terms except proper names are connotative. *Non-connotative* terms have no such fixed meaning. It is usual to restrict this distinction to concrete terms, on merely etymological grounds. (b) *Positive* terms are those which primarily indicate or suggest the presence of something (though indirectly they may also imply the absence of something). *Negative* terms primarily indicate the absence of something (though indirectly, and perhaps rather vaguely, they may also imply the presence of something). (c) *Singular* terms are such as are applicable in the same sense to one object only (or to one group treated as one object). *General* terms are those which can be applied in the same sense to any one of a class (or kind) of objects. (d) *Concrete* terms are those which denote anything that can be regarded as a whole having attributes and standing in various relations, even if it is *not* tangible (*e.g.*, mind, character, logic, as well as table, chair, etc.). *Abstract* terms are the names of some attribute, aspect or relationship considered apart from the things in which it exists (*e.g.*, size, beauty, friendship, etc.). (e) *Relative* terms are those the special function of which it is to draw attention to some definite relationship in which the object named stands to some other object (*e.g.*, husband, wife, partner, etc.). *Absolute* terms are those which have no such special function, although the things named will as a matter of fact stand in all sorts of relationships to other things (*e.g.*, John Smith, table, chair, etc.). Relative terms usually go in pairs, for every relationship requires at least two terms—"parent" and "child," "brother" and "brother" (or "sister"), and so on. (f) *Collective* terms denote groups of similar separate units as groups (*e.g.*, "army," "company," "library," etc.). *Non-collective* (or unitary) terms denote units that are not groups of similar separate units (*e.g.*, "table," "chair," "house," etc.).

Of the above classifications or distinctions the first (a) is mainly concerned with verbal terms or names. The others are primarily concerned with differences in the way in which we think about things, even the same things it may be. Sometimes a thing is regarded in all its individuality (as singular); sometimes as one of a kind (general); sometimes it is considered in relation to something else (relative); sometimes for its own sake (absolute); sometimes we think of what a thing is (positive), and sometimes of what it is not (negative); and so on. (*See* Logic and the bibliography given there.)

A Term of Years, in English law, is the time during which an interest in an estate for life or for years is enjoyed, also the interest itself, because such an interest must determine at a definite time. If the interest be for life, it is an estate of freehold; if for years, only a personal interest in real estate, and so personalty, even though the length of the term—for instance, 1,000 years—may far exceed in duration any possible life estate. (*See* the Law of Property Act, 1925.) The same act gives power to enlarge the unexpired residue of a term of 200 years in certain cases into the fee simple, and the Places of Worship (Enfranchisement) Act 1920 gives power to enlarge leases for lives or even 21 years.

Terms, in the sense of a limited and certain period of time during which the law courts are open, used to affect only what were called in England the superior courts—that is, the king's bench, common pleas and exchequer.

There were four terms, Hilary, Easter, Trinity, Michaelmas, the average duration of each being about three weeks. By the Judicature Act of 1873 terms were abolished so far as related to the administration of justice and sittings substituted. The dining-terms at the Inns of Court correspond in point of time with the old terms and not with the sittings.

At the University of Cambridge the academic year is divided into three terms, Michaelmas, Lent and Easter; while at the University of Oxford there are four terms in the year, Michaelmas, Hilary, Easter and Trinity. School years now generally consist of three terms, divided by Christmas, Easter and Summer holidays, the old half-years having gradually been abolished.

In Algebra, an expression not connected to another expression by the sign $+$ or the sign $-$. For example, ab^2 is a single term (monomial), whereas $a+b^2$ or a^2-ab^2 has two terms (binomial). (*See* Polynomial.)

TERMINATOR, in astronomy, the bounding line between light and darkness on the apparent disc of the moon or of a planet. At places on the terminator the sun is either rising or setting.

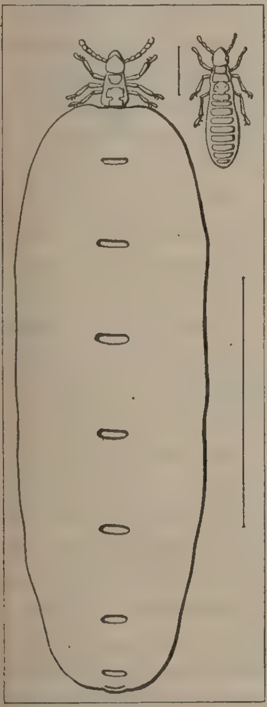
TERMINI IMERESE (anc. *Thermae Himerenses*), a seaport town of Sicily, in the province of Palermo, 23 m. E.S.E. of it by rail. Pop. (1921) 18,639. It is finely situated on a promontory above its harbour; it was founded in 408 B.C. by the Carthaginians, after their destruction of Himera, in the vicinity of hot springs mentioned by Pindar (*Od.* xii. 19) which are still resorted to and are well fitted up (temp. 110° F). Agathocles (*q.v.*) was born here. It was taken by Rome in the First Punic war. A

Roman road ran from it to Catana. Scanty remains of buildings of Roman times (baths, an amphitheatre and a so-called curia) exist in the upper part of the town; and outside it on the south are considerable remains of two Roman aqueducts.

TERMINOLOGY: *see* Nomenclature and Terminology.

TERMINUS [Lat. a boundary stone], a stone or post which was set up in the ground with the following religious ceremonies. A hole was dug and a fire lighted; a victim was sacrificed and its blood poured into the hole, together with incense and fruits, honey and wine, and the ashes of the sacrifice. Then the boundary stone, which had been previously anointed and crowned with garlands, was placed upon the hot ashes and fixed in the ground. Any one who removed a boundary stone was accursed (*sacer*) and might be slain with impunity; a fine was afterwards substituted for the death penalty. From this sacred object evolved the god Terminus. On Feb. 23 (the end of the old Roman year) the festival called *Terminalia,* according to Wissowa a festival not of the god but of the boundary stones (*termini*), was held. The owners of adjacent lands assembled at the common boundary stone and garlanded each his own side of the stone. An altar was set up and offerings of cakes, corn, honey and wine were made. Later a lamb or a sucking pig was sacrificed. The proceedings closed with songs to the god and a general merrymaking, in which all the members of the family and the servants took part.

A similar festival was held at the old boundary of the Roman territory between the fifth and sixth milestone on the road to Laurentum. When the Capitoline temple was to be built the auguries forbade the removal of one of these *termini* (a boundary mark of some old precinct?) and it was enclosed within the walls of the new sanctuary, an indication of the immovability of such stones and of the permanence of the Roman territory.


The royal pair of Termes nemorosus, the larger figure being the queen, the smaller the king, one-quarter the actual size

See Wissowa, *Religion und Kultus der Römer* (2nd ed.), p. 136; W. W. Fowler, *The Roman Festivals,* p. 324 (1899).

TERMITE, the name given to usually pale-coloured, soft-bodied insects living in large societies below ground or in other concealed situations. These societies consist of wingless, sterile individuals generally of two types —the soldier and the worker—and among them there develop reproductive forms, some of which are wingless, and others are endowed with two pairs of long, narrow, membranous wings. The latter individuals leave the colony in periodic swarms, cast their wings and proceed to establish new colonies. Termites form the scientific order Isoptera (*see* Insects) and are popularly known as white ants; but as they differ fundamentally from true ants and are rarely white, this designation is open to objection. Owing to their gnawing propensities these insects cause immense damage to the woodwork of buildings, and some species attack the roots of growing crops. For further information on termites *see* Social Insects.

TERMITE-PROOF CONSTRUCTION. Damage caused by termites to buildings or their contents can be prevented by proper construction of the buildings and chemical treatment of all wood with coal-tar creosote. Building codes are being revised in many American cities to require termite-proof construction. The best rule is to make the foundations entirely of stone, brick or concrete, including stone or metal columns or pillars in the basement. Basement floors should be of concrete on a gravel base. Where it is impracticable to use these materials all wood near the ground used should be chemically treated. Complete dryness of the foundation and of the basement floors and walls is an important factor. Since subterranean termites can not live or work without access to moist earth, it is only necessary to shut off this source of moisture to prevent damage by this type. Non-subterranean termites can be killed in infested wood by fumigation with hydrocyanic-acid gas.

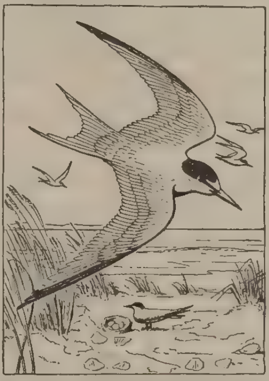
TERMONDE, a town in the province of East Flanders, Belgium, 25 m. S.W. of Antwerp, at the junction of the Dender and Scheldt. Pop. (1925), 9,648. It was before Termonde that Louis XIV., in 1667, was compelled to retreat through the opening of the dikes. The fortifications were demolished in 1910. The church of Notre Dame contains two fine pictures by Van Dyck, and one masterpiece of Crayer's. The fonts are of the 12th century. The town suffered greatly in the World War, the Hôtel-de-Ville and the church of Notre Dame being much damaged.

TERN, sea birds forming the sub-family *Sterninae* of the gulls (*Laridae*).

The largest British species is the Sandwich tern (*Sterna sandvichensis*), as big as a small gull, with a dark bill tipped with yellow, and dark legs. The common (*S. hirudo*) and Arctic (*S. macrura*) terns are only to be distinguished by the all-red bill of the latter, which is a bolder species with a more northern range, though both breed at Blakeney point in Norfolk. The little tern (*S. albifrois*) is known by its white forehead. *Hydroprogne caspia,* the Caspian tern, is the largest species known, measuring 2ft. in length. In addition to the last three British species, *S. dougalli,* the Roseate tern, is also common to Europe and North America.

In North America there also occur the noddy (*q.v.*), the sooty tern (*S. fuscata*), and the black tern (*Chlidonias niger*).

Terns breed usually on sand dunes and shingle banks and lay up to four eggs, two being the commonest number, great variation occurring with the season and the locality. They are said by fishermen to damage the fishing, but this has been proved to be a mistake, the birds feeding largely on crustacea, insects and sand eels, which they obtain by plunging into the water from a height of 3–8ft., and emerging with the food in their bills. The male usually feeds the female while she is brooding, often accompanying the presentation with the same play ceremony used in courtship. In the same way, in courtship, food is often presented by the male.


By courtesy of the National Association of Audubon Societies

Least tern (Sterna antillarum), showing its nest of eggs in the background

About 75 species are known; the group is cosmopolitan.

TERNATE, the northernmost of the line of islands off the western coast of Halmaheira, Dutch East Indies, which stretch southwards to the Bachian archipelago. It has an area of 25 sq.m., a width of six miles, and consists mainly of a conical volcano 5,600 ft. in height, with three peaks (Arfat, Madina and Kekan), its curious formation being due to many extremely destructive eruptions. Within the last four centuries there has been volcanic activity at Ternate on no less than 70 occasions, the worst recorded being the eruption in 1763, which overwhelmed the thriving little village and Ft. Takomi, which is situated on the north-west coast, and so completely devastated one slope with lava flow that it has since been known as Burnt cape (Batu Angus), whilst two small crater lakes were formed where the village stood. An eruption in 1840 destroyed nearly every house in the town of Ternate, and when A. R. Wallace was there in

1858 he experienced an earthquake and noted the destructive effects of former shocks. The northern half of the island has suffered most from volcanic activity. There, lava streams have flowed down the mountain side right to the sea, and there are numerous bare tracts of land, but on the southern and eastern coast there is forest and luxuriant vegetation, with a good deal of cultivated land on the flat strip by the shore; vegetation extends even far up the mountain side. Rice and maize are grown, also sago, coffee, pepper, nutmegs and fruit (good mangoes and durians); Ternate was once a leading centre of spice cultivation. It now has a population of 18,924, including 580 Europeans and Eurasians, 77 Chinese and 474 Arabs, the native population being of very mixed blood, probably Malay preponderating, but with Papuan elements, having a language of their own, written in the Arabic character, and Mohammedan by religion (also *Crang Seracci* descendants of natives converted to Christianity by the Portuguese). Ternate is of importance as one of the two residences which make up the Government of the Moluccas, Amboyna being the other. Ternate residency is composed of the Ternate-Tidore group (13 islands, and the Kayua and Goraityi groups), the Halmaheira group (Gilolo, west Halmaheira, Weda, south, and Tobelo, north and north-eastern Halmaheira, with the island of Morotai), the Bachian and Obi groups, the Sula group (with the State of Banggai, in east Celebes and the Banggai islands), west New Guinea (with the island of Bisol), Sorong (north-west New Guinea, with the islands Waigiu, Salwatti and Battanta), Manokwari (the westerly part of north New Guinea), Yappen (the island of that name, with a strip of the coast of New Guinea from the Mamberano river to the Wapangga), Hollandia (the easterly part of North New Guinea, from the Mamberano river to the boundary between Dutch and British New Guinea), and the Schouten islands (the group of islands of that name). The population of the residency in 1927 was 276,314.

Ternate Town, population 6,374, lies on a flat strip of land on the south side of the island, at the foot of the mountain. It is a very picturesque settlement, the houses interspersed amongst a wealth of trees, with the volcano for a background, and, being close to other volcanic islands, one of which, Tidore, is so close that it helps to form the fine harbour of Ternate, and to the coast of Halmaheira, it has magnificent views. The port, which possesses piers and a coaling jetty, is a regular place of call for vessels of the Royal Packet Navigation company, affording frequent communication with Celebes, Amboyna and New Guinea.

Although it is the headquarters of a residency, Ternate has now only the shadow of its former greatness. Its trade is small (chiefly copra and nutmegs), its sultan is a pensioner of the Dutch Government and many of its inhabitants live by his bounty on his lands.

History.—Ternate became known to Europe through the Portuguese, who settled there in 1521, and made it one of their chief spice-collecting centres. Conflict with the sultan, or king, as he was styled then, who objected to the establishment of a Portuguese spice monopoly, led to the expulsion of the Portuguese from the island in 1581. In the meantime, in 1579, Sir Francis Drake had called at Ternate, being received favourably by the king, and allowed to ship between four and five tons of cloves, but the visit was never followed up. Drake was much impressed with the wealth and state of the king of Ternate, and wrote, of his visit to the monarch: "The King had a very rich canopy with embossings of gold borne over him, and was guarded with twelve lances. From the waist to the ground was all cloth of gold, and that very rich; in the attire of his head were finely wreathed diverse rings of plaited gold, of an inch or more in breadth, which made a fair and princely show, somewhat resembling a crown in form; about his neck he had a chain of perfect gold, the links very great and one fold double; on his left hand was a diamond, an emerald, a ruby, and a turky (turquoise); on his right hand in one ring, a big and perfect turky, and in another ring many diamonds of a smaller size."

When the Dutch visited Ternate, at the beginning of the 17th century, the sultan, who was anxious to extend his power over the Moluccan islands generally, and even over a part of Celebes, arranged to give the Dutch a spice monopoly for their assistance against the Spaniards and Portuguese (Portugal had become incorporated with Spain and the Spaniards had reconquered Ternate). So Ternate rose to power and made many of the Moluccan islands, the eastern and northern part of Celebes and Buton suzerain, but the Dutch bolstered up the power of Ternate only so long as suited their purpose, and when, in their efforts to confine Moluccan spice cultivation to cloves in Amboyna and nutmegs in the Banda islands, they destroyed ruthlessly the spice gardens of the northern Moluccas, Ternate included, causing Ternate to revolt, an example which was followed in neighbouring islands. They found it convenient (in 1683), to declare all contracts with Ternate void, and the chiefs who had looked to Ternate as their suzerain were informed that henceforth they would hold their lands directly from the Dutch. Since that time, although the power of the sultan of Ternate as their vassal, has been recognized by the Dutch nominally, and he has certain privileges regarding the native population, the executive, in Ternate, and throughout the lands of the Residency, remains in Dutch hands.

See A. R. Wallace, *The Malay Archipelago* (London, 1890).

(E. E. L.)

TERNE-PLATE: *see* TIN-PLATE AND TERNE-PLATE.

TERNI (anc. *Interamna Nahars*), a town, episcopal see, and capital of a province of Umbria, Italy, situated among the Apennines, 426 ft. above sea-level, in the valley of the Nera (anc. *Nar*), from which the town took its distinguishing epithet, 5 m. below its junction with the Velino, and 70 m. N. by E. of Rome by rail. Pop. (1921) 27,893 (town), 36,324 (commune). It has important iron and steel works and iron foundries, at which armour-plates, guns and projectiles are made for the Italian navy, also steel castings, machinery and rails, a royal arms factory, a large jute factory, a carbide factory, a wool spinnery, etc., and lignite mining. Terni lies on the main railway line from Rome to Foligno and Ancona, and is the junction for Rieti and Sulmona. Its most interesting buildings are the cathedral (restored in 1653 with remains of the earlier 13th century façade and an early crypt), and the Romanesque churches of S. Pietro and S. Francesco. Its antiquities include traces of the city walls of rectangular blocks of travertine incorporated in the well-preserved mediaeval walls, remains of an amphitheatre, a temple, now the round church of S. Salvatore, theatre and baths (?), and numerous inscriptions. Five miles to the east are the falls of the Velino (*Cascate delle Marmore*), which took a very high place among European waterfalls; the cataract has a total descent of about 650 ft., in three leaps of 65, 330 and 190 ft., respectively. They owe their origin to M'. Curius Dentatus, who in 272 B.C. first opened an artificial channel by which the greater part of the Lacus Velinus in the valley below Reate was drained. They supply the motive power for the factories of the town and have lost much of their former beauty.

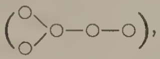
Terni is the ancient *Interamna* (*inter amnes,* "between the rivers," *i.e.* the Nar and one of its branches), originally belonging to Umbria, and founded, according to tradition in the year 672 B.C. The recent discovery of a neolithic village, and of cemeteries of the Villanovan period, with numerous inhumation graves of Picenes of 1200–1000 B.C. (*see* Randall MacIver, *Iron Age in Italy,* 1927, 140–144) shows that the site was occupied much earlier. It is first mentioned in history as being, along with Spoletium, Praeneste and Florentia, portioned out among his soldiers by Sulla. During most of the middle ages and up till 1860 Terni was subject to the popes. It was the scene of the defeat of the Neapolitans by the French on November 27, 1798.

TERPANDER, of Antissa in Lesbos, Greek poet and musician. About the time of the Second Messenian war, he settled in Sparta, whither, according to some accounts, he had been summoned by command of the Delphian oracle, to compose the differences which had arisen between different classes in the state. He is regarded as the real founder of Greek classical music, and of lyric poetry; but as to his innovations in music our information is imperfect. According to Strabo (xiii. p. 618) he increased the number of strings in the lyre from four to seven; others take the fragment of Terpander on which Strabo bases his statement (Bergk, 5) to mean that he developed the citharoedic nomos (sung to the accompaniment of the cithara or lyre) by making the divisions of the ode seven instead of four.

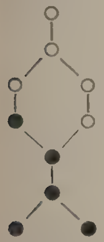
Fragments (the genuineness of which is doubtful) in T. Bergk, *Poetae Lyrici Graeci*, iii.; *see* also O. Löwe, *De Terpandri Lesbii aetate* (1869), who places him about 676 B.C.

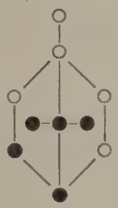
TERPENES, in chemistry, is the generic name of a number of unsaturated cyclic hydrocarbons, which are usually classified in three groups: terpenes proper, $C_{10}H_{16}$: sesquiterpenes, $C_{15}H_{24}$: and polyterpenes, $(C_5H_8)_n$. Sometimes hemiterpenes, C_5H_8, and also a series of so-called olefinic terpenes are included, but the latter are all open-chain compounds. (*See* CHEMISTRY: *Organic.*) Many terpenes and sesquiterpenes are widely distributed as constituents of essential oils, particularly of those secreted by plants belonging to the families *Coniferae* and *Myrtaceae* and the genus *Citrus*. The essential or fragrant oils occur usually in the flowers, fruit, leaves and stems, and sometimes in the roots and seeds of the plants, and differ from the fatty oils, found generally in the seeds, by their volatility in a current of steam. The majority contain a complex mixture of ingredients, but some are composed mainly of one constituent, as, for example, oil of turpentine which is chiefly pinene. In essential oils the terpenic hydrocarbons are commonly accompanied by products which usually are either alcohols or ketones and are often of greater importance as perfumes or as medicinal agents than the associated terpenes.

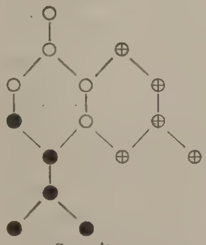
The hemiterpene *isoprene* $CH_2{:}C(CH_3)-CH{=}CH_2$, is related to the terpenes in several ways. Thus it can be obtained by heating the vapours of limonene or pinene to a high temperature, and on the other hand when isoprene is heated to 300° C in a sealed tube two molecules unite to form one molecule of dipentene, $C_{10}H_{16}$. (*See* POLYMERIZATION.) Theoretically the carbon skeletons of the terpenes proper may be built up from two, and those of the sesquiterpenes from three isoprene nuclei



as illustrated below:


Monocyclic terpene nucleus

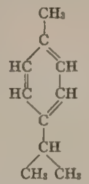

Bicyclic terpene nucleus


Sesquiterpene nucleus

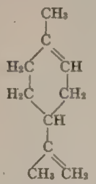
TERPENES PROPER

Most of the terpenes proper which occur naturally are colourless highly refractive fragrant liquids, of lower density than water; camphene and bornylene (the latter is a synthetic laboratory product) are crystalline solids of low melting points. They usually boil between 150° and 180° C and are readily volatile in steam. They are practically insoluble in water but dissolve freely in alcohol, ether and other organic solvents. Chemically very active, they tend to resinify by aerial oxidation and are easily attacked even by mild oxidizing agents, such as a dilute solution of potassium permanganate. They unite with hydrogen chloride, bromine, nitrosyl chloride, ozone, etc., forming additive compounds, and some at least are easily converted into isomerides in presence of acids. (*See* ISOMERISM.) Most of the naturally occurring terpenes are optically active, some being dextro- and others laevo-rotatory (*d*- and *l*-forms); optically inactive (*dl*-) modifications are also known.

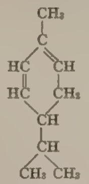
The terpenes proper are classified in three groups: (1) monocyclic terpenes, which unite with two molecules of halogens or halogen acids to form compounds such as $C_{10}H_{16}Br_4$ and $C_{10}H_{18}Cl_2$; (2) bicyclic terpenes, which combine with only one molecule of a halogen or halogen acid to form compounds such as $C_{10}H_{16}Br_2$ and $C_{10}H_{17}Cl$; and (3) tricyclic terpenes, which do not form additive compounds. Structurally, most of the monocyclic terpenes or *menthadienes* are related to the aromatic hydrocarbon cymene on the one hand and the cycloparaffin menthane on the other.



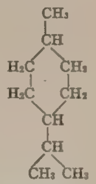
Cymene, $C_{10}H_{14}$



Limonene, $C_{10}H_{16}$



a-Phellandrene, $C_{10}H_{16}$



Menthane, $C_{10}H_{20}$

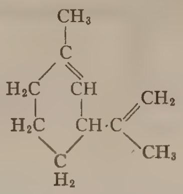
Thus such terpenes as limonene or α-phellandrene could be produced theoretically by the removal of two pairs of hydrogen atoms from menthane, and similarly the bicyclic and tricyclic terpenes could also be derived from menthane or an isomeride by withdrawal of two pairs of hydrogen atoms and resultant formation of "bridged rings." These bridges are distinguished by numbers denoting the number of carbon atoms contained in them, the direct union of the two tertiary carbon atoms being designated as O; if one carbon atom intervenes, then the number I is used, and so on. Thus three numbers serve as the "characteristic" of the compound. Hydrocarbons of this class with five atoms of carbon are termed "bicyclopentanes," with six atoms of carbon "bicyclohexanes," etc.

Monocyclic Terpenes.—Among the monocyclic terpenes one of the most widely distributed in essential oils is *limonene,* which appears to have been known in the 16th century, if not earlier. The dextro-rotatory form is best obtained by fractional distillation of bitter-orange oil, of which it forms the main constituent; it also occurs in oils of lemon, bergamot, caraway, etc.; the *l*-form is likewise found in nature, although not so commonly. The optically inactive or *dl*-form, likewise known as *dipentene,* is a constituent, frequently accompanied by other terpenes, of a large number of essential oils, and is also formed from other terpenes and polyterpenes at high temperatures. Thus the active limonenes and also pinene are converted into dipentene at 250°–270° C, and several oxygenated compounds of the terpene group, such as terpin hydrate and terpineol, easily yield it by loss of the elements of water when warmed with dehydrating agents. Moreover, it is one of the products of the destructive distillation of rubber, gutta percha and many resins. When warmed with alcoholic sulphuric acid it yields terpinene, whilst concentrated sulphuric acid or phosphorus pentasulphide convert it into paracymene. The constitution of dipentene was definitely established in 1904 when W. H. Perkin, jun., effected its synthesis—the first instance of the synthesis of any of the naturally occurring terpenes.

Limonene, a colourless fragrant liquid, boils at 175–176° C; it forms a characteristic crystalline tetrabromide, $C_{10}H_{16}Br_4$, and by the action of nitrosyl chloride is converted into a mixture of two stereoisomeric crystalline nitrosochlorides, $(C_{10}H_{16}{\cdot}NOCl)_2$, which can be separated by treatment with ether, in which the α-form is readily, and the β-form only sparingly, soluble. (*See* STEREOCHEMISTRY.)

Another monocyclic terpene widely distributed in nature is *α-phellandrene*. The laevo-rotatory modification is found in the essential oils of many species of eucalyptus, whilst the *d*-form occurs in bitter fennel oil, etc. This terpene, which has also been synthesized, is very unstable; it undergoes polymerization (*q.v.*) if distilled at the ordinary pressure and must therefore be fractionated in a vacuum, and by the action even of dilute acids it is converted into isomeric terpenes such as dipentene and terpinene. It does not yield solid compounds either with bromine or with hydrogen chloride, the only well-characterized crystalline derivative being the nitrosite $C_{10}H_{16}N_2O_3$, or rather the mixture of stereoisomeric nitrosites, obtained by the action of nitrous acid on the hydrocarbon. From these nitrosites phellandrene cannot be regenerated.

Sylvestrene is of interest as the only menthadiene of the *meta* series which has been found in natural products. As the formula shows, its constitution is similar to that of limonene except as regards the relative positions of the $-CH_3$ and $-C(CH_3):CH_2$



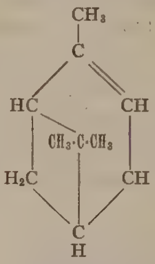
groups in the molecule. The dextro-rotatory form of sylvestrene is a constituent of Swedish and Russian oil of turpentine (from *Pinus silvestris*), and is best obtained in the pure state by heating its hydrochloride with aniline or with sodium acetate and acetic acid; these are general methods for the regeneration of terpenes from their hydrochlorides. It also is a colourless fragrant liquid, which boils at 176°–177° C. Unlike phellandrene, it is relatively a stable substance, not being easily converted into isomeric terpenes by heat or by the action of acids. An intense blue colour is developed if a drop of concentrated sulphuric acid is added to a solution of sylvestrene in acetic acid. A finely crystalline dihydrochloride $C_{10}H_{18}Cl_2$ is produced by the action of hydrogen chloride on sylvestrene; the tetrabromide $C_{10}H_{16}Br_4$ and the nitrosochloride $C_{10}H_{16}{\cdot}NOCl$ are also crystalline solids. The inactive (*dl-*) form, formerly known as carvestrene, has been synthesized by W. H. Perkin.

Of all the monocyclic terpenes *terpinene* is the most stable towards dilute mineral acids, and consequently is frequently produced by the intramolecular rearrangement of other less stable terpenes such as pinene, limonene and phellandrene, as well as from terpineol, cineole, etc., under the influence of these reagents. It is said to occur in cardamom oil, and is characterized by its crystalline nitrosite $C_{10}H_{16}{\cdot}N_2O_3$, m.p. 155° C.

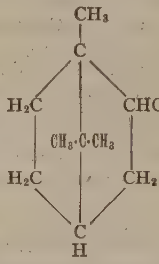
Terpinolene, produced along with terpinene and dipentene by the action of dilute acids on pinene, cineole, and terpineol, does not occur in nature. It is unstable, and easily converted into terpinene.

Bicyclic Terpenes.—The most familiar member of this group of hydrocarbons is *pinene,* which is the chief constituent of a large number of essential oils; the dextro-rotatory modification (australene) is found in many of the eucalyptus oils, and in the oils of fennel, rosemary, carrot, etc.; the laevo-form (terebenthene) is contained in oils of lemon, lavender, etc., and the inactive (*dl-*) form also occurs naturally. The chief source, however, is oil of turpentine. The oleo-resin known as turpentine, which exudes from various species of *Pinus,* when distilled in steam yields oil of turpentine, which volatilizes with the steam, and a non-volatile residue called rosin or colophony. French turpentine oil is laevo-rotatory, whilst the American and Burmese oils are dextro-rotatory, the turpentine from which these oils are distilled being obtained from different species of *Pinus; d*-pinene is also found in Russian, Swedish and German oils. Oil of turpentine is a solvent for resins, rubber, sulphur, phosphorus, etc., and is largely used in making varnishes and oil paints. When exposed to air it gradually darkens and resinifies through absorption of oxygen. Hydrogen peroxide and apparently ozone are produced during the process, so that by shaking oil of turpentine with warm water and air a solution results having disinfecting and deodorizing properties.

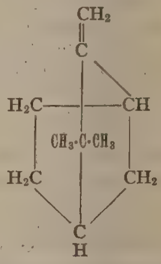
Pure pinene, prepared by heating its nitrosochloride with aniline, is a colourless aromatic liquid which boils at 156°–157° C. It very easily undergoes transformation into isomeric terpenes, for example, into dipentene when heated to 250°–270°, into terpinolene and terpinene when treated with alcoholic sulphuric acid, and into dipentene (or its derivative terpin hydrate) by the action of dilute sulphuric or nitric acids, whilst many other acids convert it into esters of the alcohol borneol. The crystalline nitrosochloride, $C_{10}H_{16}{\cdot}NOCl$, produced by the action of nitrosyl chloride, is on the other hand a true derivative of pinene, and is notable as being the only derivative from which the hydrocarbon can be regenerated. With hydrogen chloride it unites to form a crystalline compound $C_{10}H_{17}Cl$, the so-called pinene hydrochloride, which is very volatile, even at the ordinary temperature, and can be distilled with little or no decomposition. This substance, which resembles camphor in its odour and volatility, has been known for long as "artificial camphor," but must not be confused with synthetic camphor, which chemically is identical with the product obtained from natural sources. Pinene hydrochloride, however, is not a derivative of pinene, being in fact bornyl chloride; when heated with sodium acetate and acetic acid it yields not pinene but the isomeric terpene, camphene.



α-Pinene, $C_{10}H_{16}$



Bornyl chloride, $C_{10}H_{17}Cl$



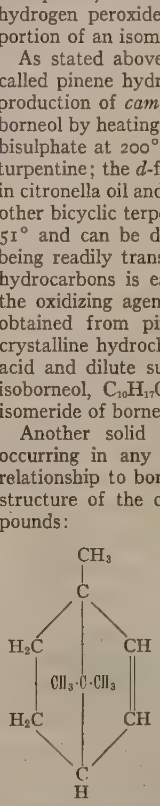
Camphene, $C_{10}H_{16}$

Both borneol and camphene are readily oxidized to camphor, and thus methods of obtaining camphor from pinene have been developed.

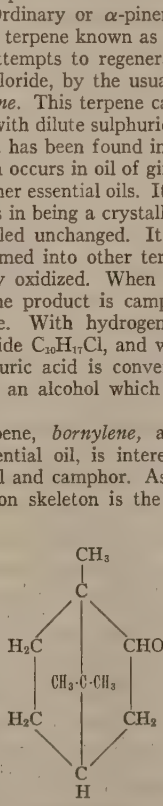
Pinene is easily attacked by various oxidizing agents, yielding many different products among which may be mentioned the finely crystalline compound, terpin hydrate, which is easily converted by loss of the elements of water into an unsaturated alcohol, α-terpineol, the chief product of the oxidation of pinene with hydrogen peroxide. Ordinary or α-pinene contains a small proportion of an isomeric terpene known as β-pinene.

As stated above, attempts to regenerate pinene from the so-called pinene hydrochloride, by the usual methods, result in the production of *camphene.* This terpene can also be obtained from borneol by heating it with dilute sulphuric acid, or with potassium bisulphate at 200°. It has been found in some varieties of oil of turpentine; the *d*-form occurs in oil of ginger, etc., and the *l*-form in citronella oil and other essential oils. It differs from most of the other bicyclic terpenes in being a crystalline solid, which melts at 51° and can be distilled unchanged. It is relatively stable, not being readily transformed into other terpenes, but like all these hydrocarbons is easily oxidized. When chromic acid is used as the oxidizing agent the product is camphor, which can thus be obtained from pinene. With hydrogen chloride it yields the crystalline hydrochloride $C_{10}H_{17}Cl$, and when warmed with acetic acid and dilute sulphuric acid is converted into the acetate of isoborneol, $C_{10}H_{17}OH$, an alcohol which appears to be a stereoisomeride of borneol.

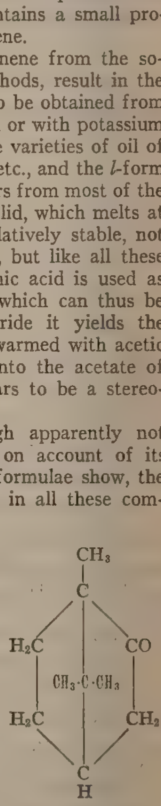
Another solid terpene, *bornylene,* although apparently not occurring in any essential oil, is interesting on account of its relationship to borneol and camphor. As the formulae show, the structure of the carbon skeleton is the same in all these compounds:



Bornylene



Borneol



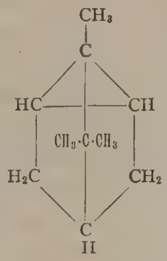
Camphor

Pinene unites with hydrogen iodide to form bornyl iodide, and this in turn yields bornylene when heated with alcoholic potash at 170° C. The latter is best prepared by converting borneol into bornyl methyl xanthate, $C_{10}H_{17}O \cdot CS \cdot SCH_3$, which when heated so decomposes that bornylene is produced. This decomposition is an excellent method for the preparation of terpenes from the corresponding alcohols.

Bornylene resembles camphene in appearance, but has a much higher melting point, 113°; it sublimes easily and its extreme volatility soon disappears if exposed to air at the ordinary temperature.

Among other bicyclic terpenes may be mentioned *sabinene*, a liquid, of which the *d*-form, along with the related alcohol sabinol, is a constituent of oil of savin; *carene*, which occurs in the oil of *Pinus longifolia;* the *fenchenes*, liquids which do not occur naturally but have been prepared from *d*- and *l*-fenchones, ketones which are found in fennel oil and thuja oil; and the *thujenes* which also are not natural products but have been prepared from the ketones *α*- and *β*-thujone (tanacetone) which occur in a number of essential oils.

Tricyclic Terpenes.—Under certain conditions a crystalline compound of the formula $C_{10}H_{16}Br_2$ is obtained by the action of bromine on pinene. When this so-called pinene dibromide is heated with zinc dust and alcohol a terpene known as *tricyclene* is obtained. This terpene, usually found in small quantities in specimens of camphene, is a crystalline solid, which melts at 67·5° C, and boils at 153° C. It is not capable of forming additive compounds with halogen acids, etc., and is regarded as having the formula shown at the right.

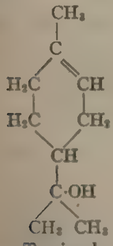


Oxygenated Derivatives.—Certain of the oxygenated derivatives of the terpenes already mentioned deserve further notice.

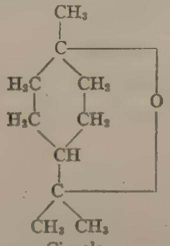
α-Terpineol, $C_{10}H_{17}OH$, found in a number of essential oils, can also be obtained by treatment of dipentene dihydrochloride with dilute aqueous caustic potash, by dehydration of terpin hydrate, or by oxidation of pinene with hydrogen peroxide. It usually occurs, mixed with smaller proportions of isomeric alcohols, as a thick oily liquid with a pleasant odour, but in the pure state is a crystalline solid of low melting point (37° C) and finds uses in perfumery and as a mild antiseptic. It is easily converted into terpenes by loss of the elements of water, yielding according to the conditions, dipentene, terpinene or terpinolene, and it can also be converted into cineole by warming with phosphoric acid.

Cineole, $C_{10}H_{18}O$, occurs in oils of wormseed, cardamom, etc., and also in many eucalyptus oils, and is separated by cooling the appropriate fraction of the oil; it can also be obtained by shaking terpin hydrate with dilute sulphuric acid. It is a colourless liquid which solidifies at 1° C and boils at 177°, and has a characteristic eucalyptus odour. With phosphoric acid, hydrobromic acid and some other substances it forms crystalline additive compounds. It finds considerable use in medicine on account of its mild antiseptic properties. Chemically it may be regarded as an oxide derived from the dihydric alcohol *Terpin*, $C_{10}H_{18}(OH)_2$.

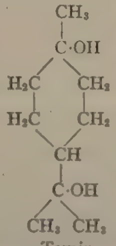
Terpin hydrate, $C_{10}H_{18}(OH)_2 \cdot H_2O$, best prepared by the action of dilute nitric acid on an alcoholic solution of pinene, forms beautiful crystals, and when heated is converted into terpin (the *cis*-form), which is also a solid, m.p. 105° C. The relationship of these compounds is shown by the following formulae:



α-Terpineol



Cineole



Terpin

Borneol or "Borneo Camphor," $C_{10}H_{17}OH$, occurs, in the dextrorotatory form, in *Dryobalanops camphora*, a tree which grows in Borneo and Sumatra, and the *l*-form likewise is found in a number of essential oils. It can be prepared by the reduction of camphor, *e.g.*, with sodium and alcohol, in admixture with its stereoisomeride, *iso*borneol. It crystallizes in large colourless plates which melt at 208° C and can be distilled without change. Chromic acid oxidizes it to camphor, the *d*- and *l*-forms yielding *d*- or *l*-camphor respectively.

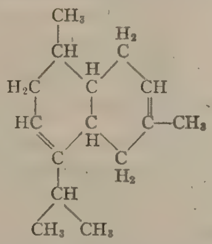
Camphor, or Japan camphor, $C_{10}H_{16}O$, is dealt with in a separate article, together with menthene and menthol. (*See* CAMPHORS.)

Piperitone (*q.v.*), also $C_{10}H_{16}O$, is of importance as being a large constituent (up to nearly 50%) of the oil of several species of eucalyptus.

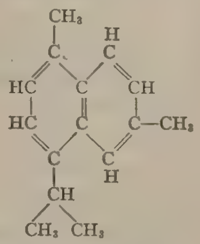
SESQUITERPENES, $C_{15}H_{24}$

Sesquiterpenes and also sesquiterpene alcohols, $C_{15}H_{25}OH$, are found in many essential oils. A very large number have been described but many have not been fully characterized.

Most of the sesquiterpenes are liquids, specifically lighter than water, with boiling points between 250° and 280° C, and usually with a more or less agreeable odour. They are more viscous than the terpenes proper, and are sparingly soluble in alcohol. Like the terpenes, they resinify easily on exposure to air, form additive compounds with the halogens, the halogen acids, nitrosyl chloride, etc., and in some cases can be directly converted into the corresponding alcohols. At least two groups of sesquiterpenes are known; (1) those which unite additively with two molecules of halogen acids, and which therefore are considered to be bicyclic in structure, and (2) the tricyclic sesquiterpenes, which will not combine with more than one molecule of a halogen acid. On the principle that the carbon skeleton of these hydrocarbons may be divided theoretically into three isoprene units, Otto Wallach suggested that there might be a relationship between the sesquiterpenes and derivatives of naphthalene somewhat similar to that existing between the terpenes proper and derivatives of benzene, and nearly 30 years later Leopold Ruzicka proved the correctness of this speculation, for on dehydrogenating a number of sesquiterpenes and sesquiterpene alcohols by heating them with sulphur he obtained one or other of two derivatives of naphthalene. Most of those examined in this way gave the same hydrocarbon, $C_{15}H_{18}$, named "*cadalene*," and this was proved by synthesis to be 4:7-dimethyl-isopropylnaphthalene. The relationship between a sesquiterpene and cadalene may be illustrated thus:

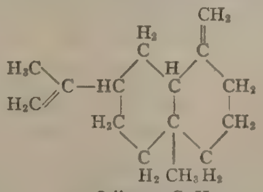


Cadinene, $C_{15}H_{24}$

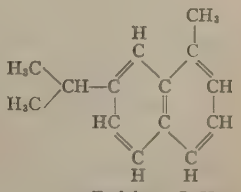


Cadalene, $C_{15}H_{18}$

On the other hand, a second series of sesquiterpenes, and related alcohols, *e.g.*, selinene and the alcohol eudesmol, have been found to yield on dehydrogenation a different hydrocarbon "eudalene," $C_{14}H_{16}$, which has also been synthesized and proved to be 1-methyl-7-*iso*propylnaphthalene.



Selinene, $C_{15}H_{24}$



Eudalene, $C_{14}H_{16}$

Among the sesquiterpenes which have been investigated the following may be mentioned. The laevo-rotatory form of *cadinene* is widely distributed in oil of cade, oil of cubebs and many other essential oils; the *d*-form apparently does not occur in nature. Cadinene is obtained in a pure state from its crystalline dihydrochloride, $C_{15}H_{26}Cl_2$, m.p. 117–118° C, by heating it with aniline. It boils at 274–275°. The alcohol cadinol, $C_{15}H_{25}OH$, is found in galbanum oil, etc., and on dehydration gives cadinene.

Caryophyllene occurs in carnation oil and copaiba oil and can be obtained in a pure state, although with some difficulty, from its dihydrochloride. Its boiling point is 259–261° C. The dihydrochloride forms crystals which melt at 69–70°; the nitrosochloride and the nitrosites (α and β) are also crystalline. When warmed with acetic acid and dilute sulphuric acid caryophyllene is converted into caryophyllene alcohol, $C_{15}H_{25}OH$, which crystallises in colourless almost inodorous prisms. When this alcohol is heated with the usual dehydrating agents, caryophyllene is not regenerated, but an isomeric sesquiterpene *clovene,* a liquid which boils at 261–263° C; the same result follows when caryophyllene dihydrochloride is heated with sodium acetate and acetic acid. Clovene will only unite with one molecule of hydrogen chloride, and is considered to be a tricyclic sesquiterpene. It has not been found in any essential oil.

Other naturally occurring sesquiterpenes are santalene, from sandal-wood oil, cedrene from cedar-wood oil, humulene from oil of hops, selinene from oil of celery-seed and zingiberene from ginger oil, the last being a monocyclic sesquiterpene.

Sesquiterpene Alcohols, $C_{15}H_{25}OH$.—These are found widely distributed and in large numbers in many essential oils. Many of them are oily liquids with high boiling points, *e.g.*, cadinol from cade oil, eudesmol from eucalyptus oils, calamenol from calamus-root oil, and cedrol from oil of cedar, whilst others are crystalline solids, for instance, "cubeb camphor" from cubeb oil and "patchouli camphor" from patchouli oil. These alcohols when heated with dehydrating agents are usually converted into the corresponding sesquiterpenes which, however, have not hitherto been observed in natural products.

POLYTERPENES

Diterpenes, $C_{20}H_{32}$, are found in resins and balsams, but hitherto have not been much investigated. They are generally obtained in the form of viscous oils, which usually boil at temperatures above 300° C, and although unsaturated do not readily form crystalline additive compounds. Such substances are *copaivene,* which has been separated from copaiba balsam, and *colophene,* obtained by distillation of colophony and by treatment of pinene with concentrated sulphuric acid; the latter is a thick yellow oil, boiling at 318–320° C. A liquid diterpene (b.p. 168°–169° C under 10 mm. pressure) has been obtained along with camphene by heating borneol with zinc chloride.

Triterpenes, $C_{30}H_{48}$.—The *amyrilenes,* obtained by dehydration of the crystalline alcohols α- and β-amyrin, $C_{30}H_{49}OH$, which are found in elemi resin, crystallize well from ether or benzene, but are sparingly soluble in alcohol. They cannot be distilled at the ordinary pressure without decomposition.

A *tetraterpene,* $C_{40}H_{64}$, has been produced by shaking oil of turpentine with antimony trichloride. This *tetraterebenthene* is an amorphous solid, as also is its dihydrochloride, $C_{40}H_{64}\cdot 2HCl$, and it decomposes when distilled.

Synthetic Rubber.—In 1892 Sir Wm. Tilden observed that a specimen of isoprene which had been kept for some time in a sealed tube had polymerized to form a substance almost indistinguishable, so far as physical properties are concerned, from rubber, and like the natural product capable of vulcanization. It was later discovered that this production of a synthetic rubber from isoprene took place much more rapidly in presence of metallic sodium, which appeared to act as a catalyst. Heating isoprene with acetic acid and other chemical agents also has the effect of producing a form of rubber. Moreover other unsaturated hydrocarbons of the isoprene series polymerize to yield rubber-like substances. These synthetic rubbers have been classified in two groups—the "normal" rubbers obtained by heating isoprene and other related hydrocarbons alone or with acetic acid, and the "sodium" rubbers prepared by the action of that metal on the hydrocarbons. The two series exhibit various differences, and apparently are not chemically identical.

These observations have led to the development of methods for the production of synthetic rubber, which may ultimately compete with the natural product, if its physical and mechanical qualities prove satisfactory and if it can be produced at a sufficiently low cost.

Bibliography.—Article "Terpenes," Thorpe's *Dictionary of Applied Chemistry,* vol. vii. (1926); O. Aschan, *Chemie der alicyklischen Verbindungen* (1905); O. Wallach, *Terpene und Camphor* (1909); Gildemeister and Hoffman, *The Volatile Oils* (1913); H. Finnemore, *The Essential Oils* (1926). (G. G. H.)

TERRACE CULTIVATION: *see* Agriculture, Primitive.

TERRACINA, a town and episcopal see of the province of Rome, Italy, 63 m. S.E. of Rome by rail (56 by the Via Appia), 40 ft. above sea-level. Pop. (1921) 9,780 (town), 12,555 (commune). Its position, at the point where the Volscian hills reach the coast, leaving no space for passage between them and the sea, commanding the Pomptine marshes and possessing a small harbour, was one of great strategic importance. It appears in 509 B.C. under Roman supremacy. In 406 it was stormed by the Romans, unsuccessfully attacked by the Volscians in 397, and finally secured in 329 B.C. The construction of the Via Appia in 312 B.C. added to its importance: the road at first crossed the hill at the back of the promontory (748 ft.) by a steep ascent and descent, which had its strategic advantages. It was not until the imperial period (probably under Trajan) that a cutting in the rocks at the foot of the promontory (Pisco Montano) finally solved the problem. The depth of the cutting is indicated by marks on the vertical wall at intervals of 10 Roman ft.—figures enclosed in large swallow-tail tablets—the lowest mark, 3 or 4 ft. above the present road, is CXX.

The construction of the Via Severiana, from Ostia to Terracina, added to the importance of the place; and the beauty of the promontory with its luxuriant flora and attractive view had made it frequented by the Romans as early as 200 B.C. Galba and Domitian possessed country houses here. It appears in the history of the Gothic wars, and Theodoric is said to have had a palace here. It was sacked in 409 and 595. In 872 John VIII. brought it under the domination of the Holy See.

The picturesque modern town occupies the site of the old; the present piazza is the ancient Forum, and its pavement of slabs of travertine with the inscription "A. Aemilius A. F.," in letters once filled in with bronze, is well preserved. It is supported by massive arched substructures, which extend under the surrounding houses. The cathedral of SS. Pietro e Cesareo, fronting upon it, is ensconced in a temple of Rome and Augustus. The vestibule, in the Cosmatesque style, is supported by ten ancient columns resting upon recumbent lions, with a mosaic frieze upon them. The interior has a fine Cosmatesque pulpit supported by ancient columns resting on lions, a Paschal candlestick of 1245, and a good pavement of the same period with beasts and dragons. There are remains of the town wall in the "polygonal" style, and also part of a later enceinte (4th [?] cent. A.D.) with towers.

The summit is occupied by a massive terrace, supported by arcades of fine *opus incertum* commanding a magnificent view seaward over the coast and over the Pomptine Marshes. On the terrace stood a temple of the early imperial period, 110 by 65 ft., probably of Jupiter Anxur, worshipped as a child. The lower town by the harbour had buildings of some importance (amphitheatre, baths, etc.), of the imperial period. Of the ancient harbour constructed by Antoninus Pius some remains exist.

Near the amphitheatre was found the famous statue of Sophocles now in the Lateran museum. The ancient aqueduct, bringing water some 35 m. from the slopes of the Volscian hills, has been repaired and is in use. Three miles to the north-west, at the foot of the Monte Leano, was the shrine of the nymph Feronia, where the canal following the Via Appia through the marshes ended. Along these 3 m. are numerous ancient tombs.

See G. Lugli, *Forma Italiae* I. i. 1 (Rome, 1926) *Anxur-Tarracina.* (T. A.)

TERRA-COTTA. The making of figures, bowls and vases of baked clay is one of the most primitive of the arts and has always been carried to a point rivalling all other arts in technical skill and finesse. Various prehistoric figures indicate a high degree of artistry and an excellent conception of the fundamentals of aesthetic appeal. Equal to the ancient cave paintings in vigour, movement and sureness of drawing, is a group of bison found in the cave of Tuc d'Audouberte, and there is no doubt but that terra-cotta was a widely used art at that period.

Pre-dynastic Egyptian figures, often showing indications of painting in brilliant colours, have been found decorated with designs. Melon-shaped vases, with a small foot and slightly flaring mouth, provided on their shoulders with cylindrical handles, have also been discovered. These vases are sometimes decorated with paintings of flora and fauna as well as some of the details of the life of these primitive inhabitants. In Assyria and Persia the art of making tiles (*see* TILE) was developed to a high point at a very early period and such beautiful friezes as those found at Susa, showing animals and warriors in rich browns, yellows and greenish blues, prove this early mastery. In China a recent discovery in the Province of Kansu brought to light a number of finely potted vases showing the utmost sureness of line and decorated with flowing curved conventional motives which probably date about 3000 B.C. and which undoubtedly formed the basis of design of bronzes of the Chow dynasty. So well made are these vases that there is no possible doubt but that terra-cotta had been made hundreds of years prior to this date.

In the invention of glaze it seems to be an established fact that the Near East antedated the Far East and this was possibly due to the discovery that Near Eastern clay made a lighter and more porous pottery. It was also discovered at a very early period that the glaze corrected this fault, and thus began the development of glaze.

Little is known concerning the early uses of terra-cotta in Central and South America, but primitive pottery is found in Guatemala in the form of vases, human figures and groups. The modelling, though lacking in perspective and anatomy, is often beautiful in design, and there seems no doubt but that this Mayan civilization had carried on the art from ancient times. In Peru the sculptural decoration is scarcer; the vases themselves are often made in human form.

But we are concerned in this article mainly with that more specific meaning of the term "terra-cotta" indicating modelled and usually unglazed figures. Among the most beautiful discoveries on the site of Carthage have been the funerary masks, figurines and even masks made for actual use; these show strong Grecian feeling, and yet have faces and figures which are Semitic in character. A large collection of Punic figures was discovered ten years ago at the old Carthaginian cemetery at Iviza.

Other interesting developments of the art were found at Knossos. Among these were the faience figures of pre-Hellenic priestesses with tightly corseted waists, bare breasts and flounced skirts, in whose hands writhed snakes. Some of these figures show a remarkable modelling, as do the small marine objects, found on the same site, with their true-to-life and decorative beauty. The vases, too, which were of unglazed earth decorated with a yellowish ochre colour and a darker earth colour, show a remarkable sense of design and proportion in structure as well as beauty of line. Some of these vases were modelled with relief designs and then treated with blue and white coloured glazes. The remarkable faience reliefs of animals which were discovered at Knossos, show a degree of sculptural beauty, design and life-like movement only surpassed by the best of the achievements in Greece.

China arrived at a point of some proficiency in the art during the Han dynasty, or a little before, and many of the tomb figures which were buried with the dead, though, in a sense, crude, are full of life and vigour. Immediately following this period, during the times of unrest between A.D. 26 and A.D. 618, the commencement of the T'ang dynasty, beautiful figures of men and animals were executed in a gray clay and painted with various colours, indications of which are evident on the specimens found to-day. Many of these statuettes were inspired by the Bactrian camels and the great horses which the Mongols introduced from the North into China. Imaginative forms were also created, prominent among which were three-horned, rhinoceros-like animals and dogs, sometimes of a ferocious nature.

With the dawn of the T'ang dynasty, which was a great period of refinement, China arrived at a point in this art parallel to that of the Greek achievements, and glazed and unglazed figures of great beauty were created. These were mortuary figures placed in the graves as symbols representing the living people whom it was the custom to entomb in earlier periods. The strength of the modelling of these figures surpasses that of the Tanagra figures but there is something lacking in the delicacy and charm which the Greeks succeeded in obtaining. (*See* POTTERIES AND PORCELAINS: *Near and Far East;* AEGEAN CIVILIZATION.)

(W. E. Cx.)

GREEK, ETRUSCAN AND ROMAN

Greek.—The uses of clay among the Greeks were varied and extensive. The pottery of terra-cotta vases are described in POTTERIES AND PORCELAINS.

Use in Architecture.—In architecture terra-cotta was extensively employed for roof tiles and other decorative details, as has been shown by discoveries made during research throughout Greece and the southern part of Italy, as well as in Asia Minor. In the Heraion at Olympia we have one of the oldest examples of a terra-cotta roof. A 7th-century temple at Thermon in Acarnania was constructed of wood and terra-cotta, with painted terra-cotta slabs in wooden frames for metopes. The generic term for a roof tile was *κέραμος*, and these are classified as flat square tiles (*στεγαστῆρες* or *σωλῆνες*) and semi-cylindrical covering tiles (*καλυπτῆρες*). Other varieties of ornamental tiles used in buildings are (1) the covering slabs along the raking-cornice (*γεῖσον*) of the pediment; (2) the *κυμάτιον* or cornice above the *γεῖσον*; (3) the cornice along the sides with lions' head spouts to carry off rain water; (4) the *ἀκρωτήρια* or antefixal ornaments surmounting the side-tiles. They were usually enriched with decoration in colour, the *κυμάτιον* being painted with elaborate patterns of lotos-and-honeysuckle or maeander, in red, blue, brown and yellow. The antefixes were usually modelled in the form of palmettes, but were sometimes adorned with reliefs of heads or figures, for instance in the temples at Olympia, Thermon, Kalydon, Capua and Tarentum. Many coloured roof tiles have been found at Olympia.

Use in Sculpture.—Terra-cotta is rare in Greece for large statues. In Italy, and also in Cyprus it was a favourite material. The difference is easily explained by the source of supplies, Greece having abundant provision of marble, Italy hardly any, at least until the opening of the Carrara quarries. From the Minoan period we have interesting examples of glazed and painted terra-cotta statuettes from Knossos and Petsofa (*see* Plate II., fig. 3) in surprisingly modern-looking costumes. Mycenaean examples are of a more schematic character.

Classical Greek traditions on the subject go back to one Butades of Sikyon, a potter who was credited with the invention of modelling clay in relief, and the Samian sculptors, Theodorus and Rhoikos, who lived about the end of the 7th century B.C. The small terra-cotta figures used as ornaments or household gods, buried in tombs or dedicated in temples have been found in large numbers on nearly all the well-known sites of antiquity, the most fruitful being Tanagra in Boeotia; Myrina and Smyrna in Asia Minor; Rhodes, the Cyrenaica, Athens, Sicily and some of the towns of southern Italy. They are also found in Cyprus and Sardinia, where, as to some extent in Rhodes, they follow a peculiar development, under the domination of Eastern influence. Many of the earlier types have a markedly oriental character. But in the Greek terra-cottas we may trace a steady development from the primitive types which correspond to the *ξόανα* of primitive Greek religion, and for the most part represent actual deities, down to the purely *genre* figures of Tanagra and other Hellenistic products. For beauty and charm the palm has by general consent been given to the Tanagra figures of the 4th and 3rd centuries B.C. so called after the little Boeotian town of Tanagra where such statuettes were first found in tombs about 1870. They were known in antiquity as *κόραι* or "Maidens," from the presence of seated or standing types of girls in various attitudes; and the makers of these figures were known as *κοροπλάσται*.

Manufacture.—The Greek terra-cotta statuettes, though occasionally modelled and solid, are usually moulded and hollow. The process of manufacture was briefly as follows: A mould of clay was first made and baked to considerable hardness (Plate II., fig. 13). Its surface was then covered with layers of well levigated, moist clay until the required thickness was reached. The shrinkage of the clay in drying allowed the figure to be easily removed from the mould. The back was made separately (either in another mould or, if summarily worked, by hand) with a vent-hole for evaporation. To insure the desired diversity the head and arms were often moulded separately and different moulds variously combined. The many hundred Tanagra statuettes in spite of their obvious similarity include few duplicates.

The painting of the baked statuettes was practically universal. They were first covered entirely with an *engobe* of white clay and over this the colours were added. The garments show a variety of bright shades—blue, red, pink, yellow, brown, violet and, rarely, green. The colour of the flesh where preserved is generally reddish or pinkish, of the hair auburn brown, of the lips red, of the eyes blue. Gilt and black appear for details. Unfortunately the white coating has largely flaked off and with it the colours, leaving only the drab terra-cotta surface.

The purposes for which these statuettes were used, (*a*) for religious rites, (*b*) in daily life, (*c*) in funeral ceremonies, have been the subject of much debate. Since the same types and subjects are common to each of these classes of discoveries it is obvious that the terra-cottas cannot have been intended for one purpose alone, but served all three.

Subjects and Types.—The earliest statuettes show a limited range of subjects. As in other materials, so also in clay, the female deity reigns supreme. The primitive Hellenic type of goddess adopts two chief forms, the board-form *σάνις* and the column form *κίων* or *ξόανον*; both of these forms are found also in the sculpture of that time. The limbs are wanting, or are at best rudimentary. Another primitive type from Cyprus is shown in (Plate II., fig. 1). Compared with these the Minoan ladies of a later period show a marked development. After this comes the retrogression observable in other products of the geometric epoch, out of which classical Greek art gradually emerges.

In Archaic Greek Art of the Sixth Century B.C.—The standing and seated goddesses (Plate II., fig. 4), in spite of their small dimensions often have a fine dignity and monumental character. A certain proportion of these deities are differentiated as nature-goddesses, either as a nude goddess in a shrine or a seated figure with a child in her lap who may be described as the Earth-Mother. Both types are of oriental origin. Another common archaic type is the funeral mask or bust, hollow at the back, which is found both in central Greece and Rhodes. Other characteristic products are little figures of animals, groups of men, women, and children, variously occupied, often of delightful spontaneity; and jointed dolls which can only have served the purpose of children's toys.

Terra-cotta statuettes are not nearly so common during the 5th century as in earlier or later times; the types continue those prevalent during the preceding epoch, but with an added serenity. The most flourishing period of production was from the later 4th to the 1st century, B.C., the period of the Tanagra and Myrina statuettes. These represent no longer divinities, but the people of their time as we might have seen them any day, only transformed into works of art by their makers' sense of beauty. Among the Tanagra statuettes, the most successful are the figures of the women and girls (Plate II., fig. 7). We see them standing in restful poses, sometimes leaning against a pillar, occasionally walking or sitting, but mostly quiet, serene and a little pensive. Only rarely are they portrayed in a definite action, such as doing their hair, carrying a child, or playing games. The youths are less successful, being somewhat conventional. Actors are occasionally found, wearing the customary insignia (Plate II., fig. 11), as well as such subjects as old nurses with infants (Plate II., fig. 12), and caricatures. In the Hellenistic period the centre of manufacture shifted from Tanagra to regions outside Greece proper. The little town of Myrina in Asia Minor, for instance, has been rendered famous by the extensive discoveries made there in 1880–1882. A comparison between these later statuettes and the Tanagra examples will show the differences which the Hellenistic spirit produced. Instead of the quiet, gentle women, youths and children of the preceding epoch, we have mostly figures in lively attitudes and often of mythological character; and even in the quieter types a new striving for effect is generally noticeable. Caricatures are now favourite subjects. Occasionally the statuettes are signed by their makers, so that we know a few names of these old artists (*e.g.*, Diphilos).

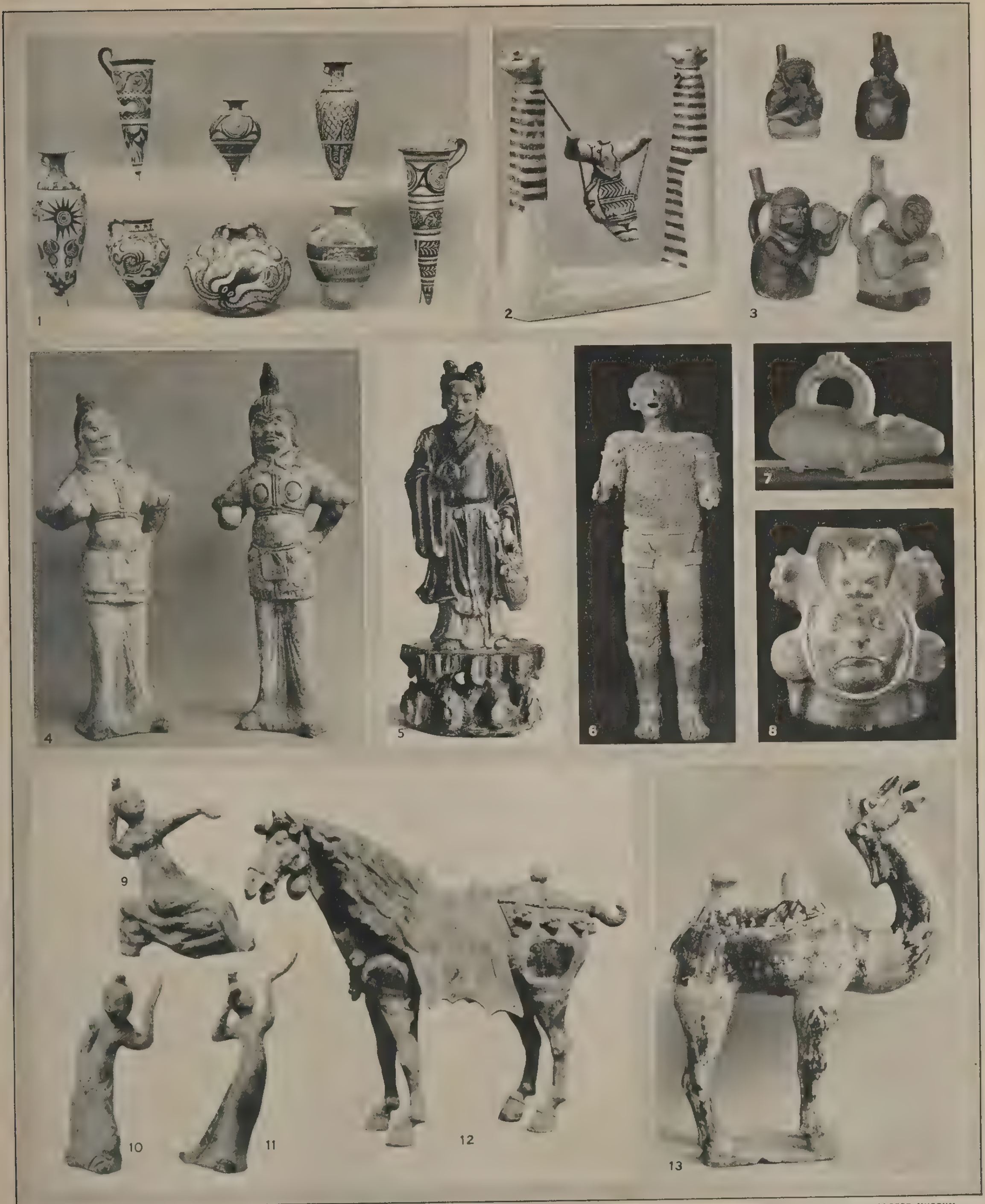
Clever forgeries of such Greek statuettes have been produced in large numbers and have found their way into many private and even public collections. Among them are large mythological groups, and though many of the figures copy fairly closely the standing and sitting types of the Tanagra figures, even these can generally be recognized by a certain affectation and theatrical quality which stamp them as un-Greek (Plate II., fig. 10). Sometimes the modern pieces are made from moulds taken from ancient statuettes, in which case it is occasionally difficult to pronounce judgment; but even here a certain indefiniteness in contour and often the addition of inappropriate details betray the hand of the forger.

Besides Tanagra and Myrina many other sites have yielded extensive finds of terra-cottas. From Sicily we possess a complete series, from archaic to later times, the earlier being best represented at Selinus, where a great variety of richly coloured figures have been found; there are also many fine heads of 5th century style, and figures of Aphrodite, Eros and other deities imitating the later types of Hellenistic art. At Naukratis in the Egyptian Delta the later terra-cottas are strongly influenced by Egyptian ideas, and figures like Bes and Horus are found in conjunction with orientalized Aphrodite types. The terra-cottas of Tarentum stand apart from those of other sites, being markedly funereal in character; many represent Dionysos reclining at a banquet. Elsewhere in southern Italy the types correspond to those of Sicily and other Mediterranean sites.

Among terra-cotta work in relief, apart from definitely architectural examples, two groups, known respectively as "Melian" and "Locrian" stand out in importance. They both belong to the early 5th century and consist of small plaques. The subjects of the Locrian reliefs, which mostly relate to the myth and cult of Persephone, seem to indicate that they at least were of a votive character. They occur at Locri in southern Italy, and similar examples dedicated to Athena have been found on the Acropolis at Athens. The Melian reliefs exhibit a wider scope of subjects, mainly mythological; the work is exceedingly delicate and refined in character. Some are simple plaques; others have the figures cut out without background, or sometimes with only the outer contours. These reliefs have been found on various Greek sites, some in Melos.

There is a class of vases which comes rather under the heading of terra-cotta than of pottery, from its technical character and general appearance. These are found at Canosa, Calvi, Cumae and elsewhere in southern Italy, and belong to the Hellenistic period. This terra-cotta work combines in a marked degree the characteristics of the vase and the statuette, some being vases with moulded reliefs or small figures in the round attached; others actual figures of colossal heads modelled in vase form, with the addition of mouth, handle and base. They are often of gigantic size, and do not appear to have served any practical purpose; probably they were made specially for the tomb. They are covered with a white slip like the statuettes, and are often richly coloured.

Etruscan Terra-cotta Work.—The people of Etruria employed this material both for finer works of art and for more utilitarian purposes. Pliny attributes its introduction to Corinthian refugees in the 7th century, and states that the art of modelling in clay was brought to perfection in Italy, and



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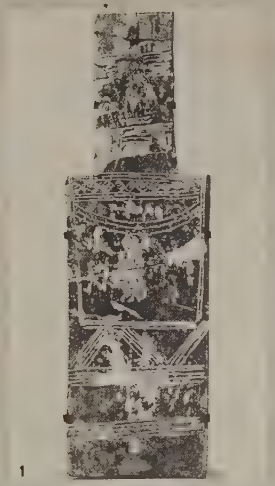
OLD GREEK, CHINESE, PERUVIAN AND MEXICAN TERRA-COTTAS

1. Cretan vases (1600–1500 B.C.). 2. Woman in a swing. Cretan, 1600 B.C. 3. Peruvian pottery vessels and figurines, showing men playing musical instruments. 4. Terra-cotta figurines representing mortuary warriors. Chinese, T'ang dynasty, 7th to 10th century. 5. Earthenware figurine of Lan Ts'ai-ho, glazed in blue and turquoise. Chinese, Ming dynasty (1368–1643). 6. Terra-cotta figurine representing warrior dressed in quilted armour. Mexican, 1400–1500. 7. Peruvian jar shaped like a Guinea pig. 8. Peruvian human portrait vase with forehead band ornamented with the head of a bat. 9, 10, 11. Three of a set of nine dancing girls in various postures. From a tomb figure. Chinese, Wei dynasty, 6th century A.D. 12. Terra-cotta horse figure from a tomb. Chinese, T'ang dynasty. 13. Figurine of mortuary camel. Chinese, Han dynasty, 3rd century B.C.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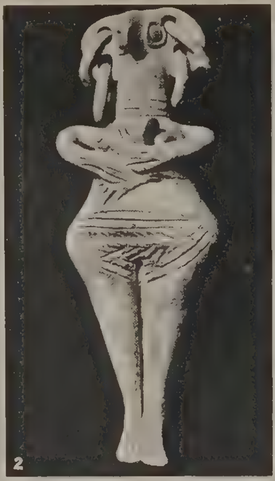
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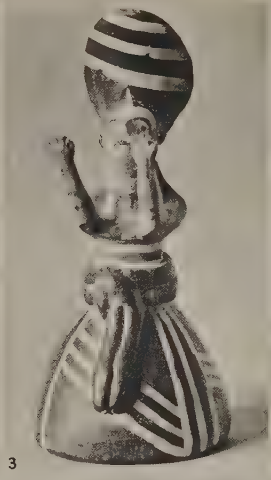
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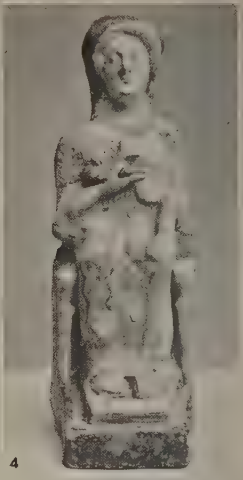
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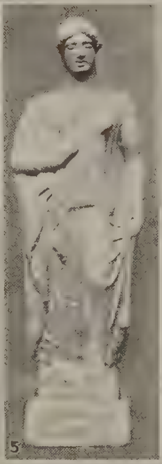
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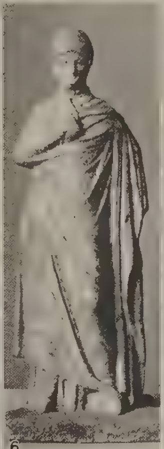
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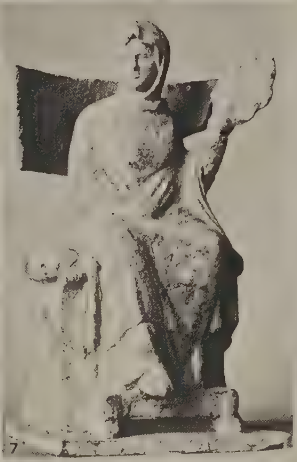
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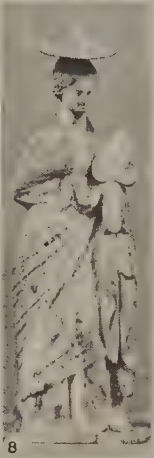
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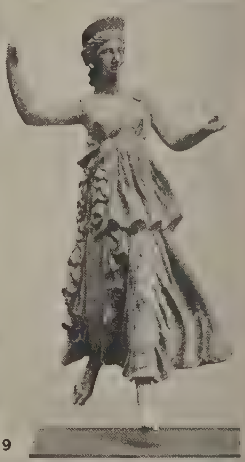
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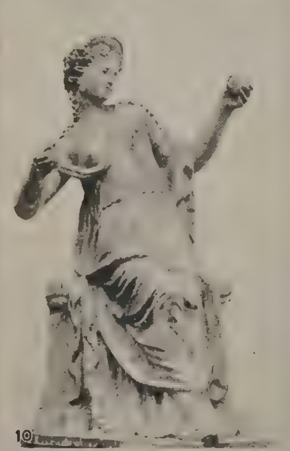
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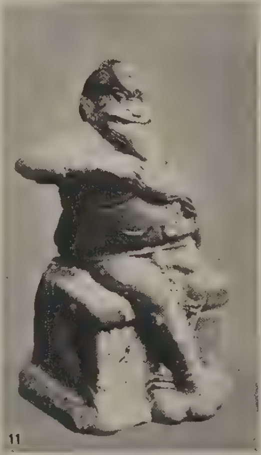
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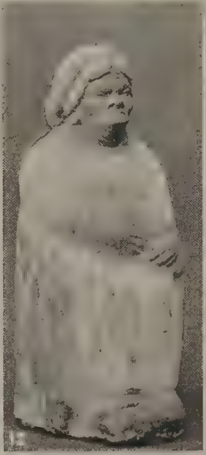
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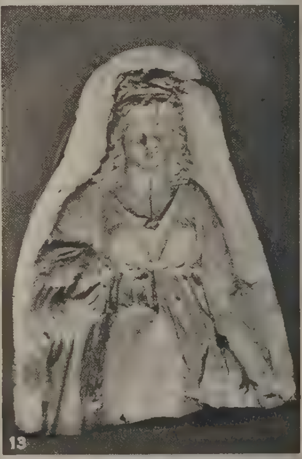
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BY COURTESY OF (1-4, 6-12) THE METROPOLITAN MUSEUM OF ART, NEW YORK, (5, 13) THE TRUSTEES OF THE BRITISH MUSEUM, FROM H. B. WALTER'S "CATALOGUE OF TERRA COTTA"

ARCHAIC TERRA-COTTA FIGURINES

1. Statuette of a human figure, modelled in a flat rectangular slab. Greek, 2000 B.C. 2. Greek statuette of a nude female figure holding fluttering bird, 1500–1200 B.C. 3. Painted statuette of a lady. Cretan, 1800–1600 B.C. 4. Greek Archaic statuette of a seated goddess. 5. Modelling of Persephone (Rhodes). 6. Statuette of draped woman. Greek, 4th–2nd cent. B.C. 7. Woman in chair. Greek, 4th–3rd cent. B.C. 8. Woman standing. Greek, 4th cent. B.C. or later. 9. Classical antique. 10. Classical forgery. 11. Statuette of Greek actor, from an Athenian grave. Greek, 4th cent. B.C. 12. Figurine, showing nurse holding a child. Greek, 4th cent. B.C. 13. A mould of a girl, her right hand holding a rabbit, her left patting a dog's head

especially in Etruria. The Romans employed Etruscan artists to decorate their temples, and the statue of Jupiter on the Capitol was made by Volca of Veii about 500 B.C., in clay painted vermilion, as was also the chariot on the pediment of the temple. Several painted clay statues of the end of the 6th century, have been found at Veii and are now in the Museo Papa Giulio. The statue of Apollo is the finest example we possess of Etruscan sculpture. For the decoration of temples terra-cotta remained in use even down to Roman times. Remains of temples with terra-cotta decoration have been found at Cervetri (Caere), at Alatri, and at Civita Castellana (Falerii), as well as at Civita Lavinia. Other remains of terra-cotta decorations come from Conca (Satricum), Orvieto, Pitigliano and Luni, where the pediment of the temple has the figures of Olympian deities, muses and the slaughter of Niobids, all executed in terra-cotta on a large scale. The date of these sculptures is about 200 B.C. At Alatri and Falerii the decoration consists of a complete system of terra-cotta plating over the woodwork of the roofs and architraves, ornamented with patterns in relief or painted and surmounted with carved antefixal ornaments.

The form of monument which best exhibits the Etruscan fondness for terra-cotta as a material for sculpture is the sarcophagus, of which some remarkable archaic examples exist, and a considerable number of later date. Among the former the most conspicuous example is the well-known Castellani sarcophagus in the British Museum, dating from the end of the 6th century B.C. The sides are decorated with friezes of figures in relief, and on the cover is a group of a man and a woman reclining, executed in the round life-size. There are similar examples in the Louvre, and in Museo di Papa Giulio at Rome, the British Museum (Plate III., fig. 5) and the Archaeological Museum in Florence. A large number of Etruscan terra-cotta urns for holding the ashes of the dead have been found on various sites. They date from the 3rd and 2nd centuries B.C. and in form are miniature sarcophagi with a figure reclining on the lid and reliefs on the front and sides (Plate III., fig. 6). The reliefs are often of a funerary character, representing the last farewell to the dead in the presence of Charon and other death-deities; others have mythological subjects, such as the combat of Eteokles and Polyneikes; the slaying of the dragon by Kadmos; or the parting of Admetos and Alkestis.

Roman Terra-cotta Work.—The uses of clay among the Romans were much the same as among the Greeks and Etruscans; the main differences were that in some cases its use was more extensive in Rome, in others less; and generally that the products of Roman workshops are inferior to those of earlier times. The Romans divided the manufacture of objects in clay into two classes: *opus figulinum* for fine ware made from *argilla* or *creta figularis* and *opus doliare* for tiles and common earthenware.

Ornamental tiles followed much on the lines of those used in Greece, though the latter are both simpler and inferior in design. Terra-cotta was largely used at Pompeii for this purpose. A characteristic feature of Pompeian houses is the trough-like gutter which formed an ornamental cornice to the *compluvium* or open skylight of the *atrium* and peristyle; these were adorned with spouts in the form of masks or animals heads, through which the rain-water fell from the gutters into the *impluvium*. Some good examples of roof-tiles and antefixal ornaments have also been found at Ostia.

Terra-cotta mural decoration was also largely employed by the Romans for both the interior and the exterior of their buildings. These were in the form of slabs ornamented with reliefs hung on the walls or round the cornices. Cicero speaks of fixing the bas-reliefs (*typos*) "on the cornice of his little atrium." These slabs usually measure about 18 by 9 to 12 in., and have nearly all been found in Rome, though isolated examples occur in other places. The reliefs were pressed in moulds, and the same subjects recur with slight variations due to retouching before the firing. A few modelled reliefs also exist. Circular holes are left in the slabs for the plugs by which they were attached to the walls.

Roman Sculpture in Terra-cotta.—Frequent allusions in classical writers indicate that the ancient statues of the Romans were mostly of terra-cotta, and Pliny notes that even in his day statuettes of clay were still preferred for temples. There are also references to *signa fictilia* placed on pediments of buildings such as the Capitoline temple. In 493 B.C. Gorgasus and Damophilus of Himera in Sicily ornamented with terra-cotta reliefs and figures of the temple of Ceres (now Santa Maria in Cosmedin). Towards the end of the republic modellers in clay are mentioned, such as Possis, who imitated grapes and other fruit, and the sculptor Arcesilaus. But their work in this material appears to have been confined to models for sculpture or metal work, and the invasion of the masterpieces of Greek art and the general adoption of marble by sculptors led to the neglect of terra-cotta as a medium of the glyptic arts. Few statues of any size in this material now exist. Some terra-cotta figures of considerable size were found at Pompeii, having formed the cult-statues of a temple; others were employed for adorning gardens, like a series from Rome in the British Museum. Terra-cotta figures were also employed as architectural members of the caryatid type. All these belong to the Augustan and succeeding period, or at least are not later than the reign of Nero.

This industry also extended from Rome to the provinces, and terra-cotta statuettes of local make have been found in Britain, as at Richborough, Colchester and London. In Gaul in particular, and in the Rhine district, there were very extensive manufactures of terra-cottas after the conquest of Julius Caesar in 58 B.C. They were made by local craftsmen for the Roman colonists, who introduced their own types of design. The principal centre of manufacture was the district of the Allier in central France. Potteries have been found at Moulins, as well as in other parts of France, in Belgium and Alsace, and along the Rhine.

Collections.—The best collections of Greek terra-cottas are in the British Museum, the Louvre and the museums of Berlin, Athens, Boston and New York. Etruscan terra-cottas are best represented in the museums of Florence and Perugia, and the Museo di Papa Giulio in Rome. The Roman examples are chiefly to be found in Rome and Naples as well as in provincial museums at Nîmes, Arles, in England and Germany.

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(H. B. WA.; G. M. A. R.)

RENAISSANCE PERIOD

After the downfall of the Roman empire in the west, the artistic use of terra-cotta was abandoned for many centuries, though, here and there, both in Italy and in the districts that had been once Roman provinces, decorated terra-cotta work was carried on sporadically both in parts of France and of Germany. The true renaissance of its use came during the 14th and 15th centuries, when it was adapted once more to architectural service in the Gothic buildings of northern Italy and of Germany. In Germany the mark of Brandenburg is especially rich in buildings enriched with modelled terra-cotta. The church of St. Catherine in the town of Brandenburg is decorated in the most lavish way with delicate tracery and elaborate string-courses and cornices enriched with foliage all modelled in clay; the town-hall of Brandenburg is another instance of the same use of terra-cotta. In northern Italy this use of terra-cotta was carried to an equally high pitch of perfection. The western façade of the cathedral of Crema, the communal buildings of Piacenza, and S. Maria delle Grazie in Milan are all striking examples of the extreme splendour of effect that can be obtained by terra-cotta work. Pavia itself is very rich in terra-cotta decoration.

With the revival of terra-cotta as an adjunct to mediaeval architecture we find the sculptors of the Italian renaissance turning to this material, as a medium for the production of reliefs, busts and even groups of many life-sized figures—again following the practice of classic times. Much of the Florentine terra-cotta sculpture of the 15th century is among the most beautiful plastic work the world has ever seen, especially that by Jacopo della Quercia, Donatello and the sculptors of the next generation. In the 16th century a more realistic style was heightened by painting the figures in oil colours. Many very clever groups of this kind were produced by Ambrogio Foppa (Caradosso) for S. Satiro at Milan and by Guido Mazzoni and Begarelli (1479–1565) for churches in Modena. The introduction of enamelled reliefs in terra-cotta which is so closely associated with the Florentine sculptor Luca della Robbia and his descendants, is specially treated in the article Della Robbia (*q.v.*).

From these two centres the development of architectural terra-cotta gradually spread over western Europe. The German school influenced the work done in the Low Countries and finally in England, where it also met the direct influence of the Italian school due to the invasion of England by Italian artists such as Torrigiano and others who were invited to England during the reigns of Henry VII. and Henry VIII.

France.—Another offshoot from the fertile plains of northern Italy was implanted in France during the 16th century. Many sculptors from northern and central Italy were attracted to France by Francis I. and his successors, and, among other arts, they introduced the making of artistic terra-cottas. The most famous name in the lists of these Italian artists is that of Girolamo della Robbia (*see* article Della Robbia), who executed, in 1529, the enamelled terra-cotta for the decoration of the "Petit Château de Madrid" in the Bois de Boulogne, Paris, for Francis I.

Spain.—At about the same period the Italian modellers or sculptors carried the art into Spain, and many extraordinary works are still extant in various Spanish churches remarkable for their vivid realism and for a too pictorial style which degrades them from their true rank as architectural decoration.

During the 17th and 18th centuries the architectural use of terra-cotta again fell away owing to the increasing use of marble, but that the art still survived in other forms is shown by the portrait busts of Dwight (17th century), though they were made in stoneware and not in unglazed terra-cotta; and the charming little statuettes and groups made in Lorraine and the adjacent parts of France by Guibal, Cyfflé and Lemire, sculptors employed at some of the pottery factories of the period.

It should be mentioned that during the 18th century ordinary clay had fallen into disrepute, but the porcelain figures made at Meissen, Sèvres and other continental factories show how persistent the vogue of figure-modelling in clay had become. (*See* Potteries and Porcelains.)

18TH AND 19TH CENTURIES

The last great revival of terra-cotta took place in the Sèvres plant and consisted of the "biscuit" figures and groups modelled with great skill by the best French sculptors of the day. Men like Pajou Pigalle, Clodion (Claude Michele), La Rue, Caffieri, Falconet, Boizot, Julien, Le Riche, etc., executed things of real artistic merit, for though lacking somewhat in the sculpturesque quality of stone-carving they were of great delicacy and life and obtained a sensual quality typical of the art of the day. This factory, however, from 1792 to 1801, as a result of the French Revolution, barely existed and was only revived later by Napoleon after which time, however, very little terra-cotta was executed.

Sculptors of the 19th and 20th centuries have been less inclined to this art for the reason that it involves a personal retouching of the detail of each piece, while the casting in bronze can be executed by skilled artisans. The unfortunate result is that few works are being done and those only from time to time in an experimental mood by various sculptors. (*See* Sculpture Technique: *Terra-Cotta.*) (W. E. Cx.)

TERRAMARA, the term used of a Bronze age culture in northern Italy which was brought in by invaders who cremated their dead, in contrast to the practice of inhumation employed by the earlier Neolithic inhabitants. "The bodies were burned on a funeral pyre, and the ashes, together with the remains of offerings made at the burial, were placed in a large urn of pottery. Rows of these urns were then laid side by side in a separate area, which formed a village of the dead. . . . Such was the custom of the people of the Terra Mare who occupied the whole valley of the Po on either side, but, except for one or two quite isolated colonies, did not penetrate into central or southern Italy." (D. Randall-MacIver, *The Iron Age in Italy,* 1927.)

See work cited and T. E. Peet, *The Stone and Bronze Ages in Italy and Sicily* (1909); also D. R. MacIver, *Villanovans and Early Etruscans* (1924).

TERRANOVA DI SICILIA: *see* Gela.

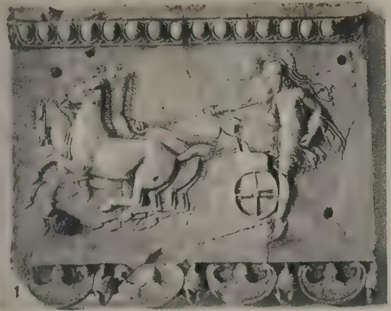
TERRANOVA PAUSANIA, a seaport of Sardinia, in the province of Sassari, situated on the east coast, 72 m. E. of Sassari by rail, and in the innermost recess of the sheltered gulf of Terranova. Pop. (1921) 5,071 (town); 6,593 (commune). It occupies the site of the ancient Olbia, and is the port of embarkation for Italy as in ancient times, the steamers plying nightly to and from Civitavecchia. There is some trade in cork and charcoal. The place is low-lying and malarious. The only building of interest is the Romanesque church of S. Simplicio, which dates from the 11th century. Pausania is a corruption of Fausiana, a town and episcopal see of Sardinia mentioned by Gregory the Great, the site of which is in reality uncertain.

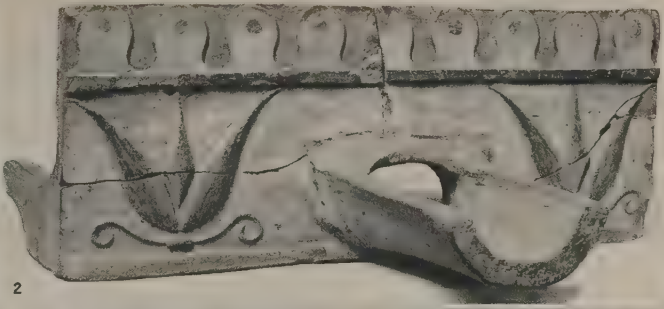
TERRAPIN, the name given to certain fresh-water aquatic reptiles of the order Chelonia. (*See* Tortoise.)

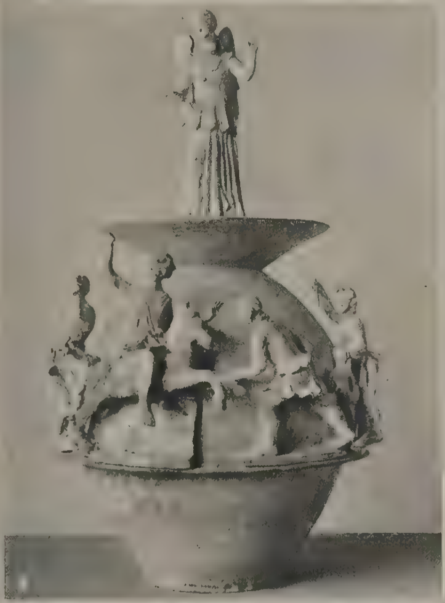
TERRE HAUTE (tĕr'ę hōt), a city of western Indiana, U.S.A., on the Wabash river, 73 m. W.S.W. of Indianapolis; county seat of Vigo county. It is on Federal highways 40 and 41; has a municipal airport; and is served by the Big Four, the Chicago and Eastern Illinois, the Chicago, Milwaukee, St. Paul and Pacific, and the Pennsylvania railways. Pop. (1920) 66,083 (89% native white); estimated locally at 80,000 (including suburbs) in 1928. The city occupies 10 sq.m., 60 ft. above the river. It has 16 parks, covering 538 ac.; municipal swimming pools and golf courses; a stadium seating 16,000; 36 public and 8 parochial schools; 68 churches; and 3 daily newspapers. It is the seat of the Indiana State Normal School (established 1865 and opened 1870) and the Rose Polytechnic Institute, founded by Chauncey Rose (1794–1877) and opened in 1883; and 4 m. N.W. is the college (for girls) of St. Mary-of-the-Woods, founded in 1840 by the Sisters of Providence. Oil in commercial quantities has been found in Vigo county and in Sullivan (adjoining), and Terre Haute has a well which has been yielding for 40 years. Terre Haute is in the heart of a bituminous coal field and the output of the county was 4,468,773 tons in 1926. The city has a by-product coke plant with a capacity of 750 tons daily. Other important industries are railway shops, stamping works, paper and box factories, rolling mills, glass works and flour mills. The total factory output in 1925 was valued at $22,846,355.

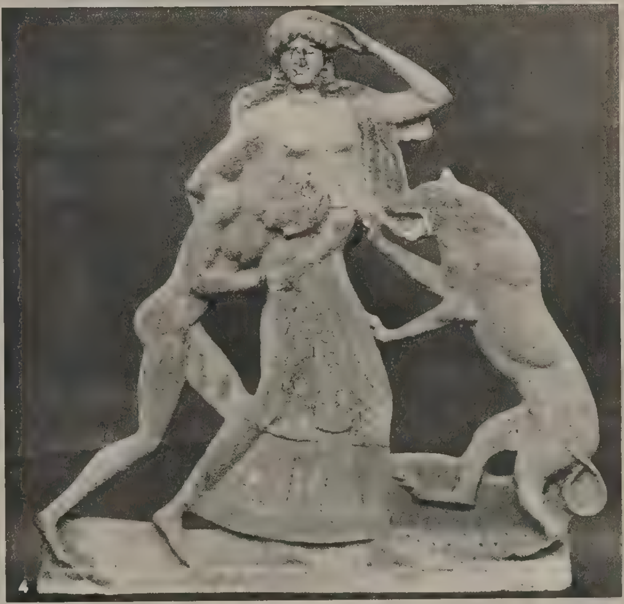
Terre Haute is one of the oldest cities of Indiana. Fort Harrison (abandoned 1817) was erected here in 1810–11. In 1812 the fort was successfully defended against an attack of the Indians by its commandant Captain Zachary Taylor. Round the fort grew up a settlement, which developed after the War of 1812 into an important commercial centre. The town was incorporated in 1838 and became a city in 1853. In 1860 it had a population of 8,594, which increased to 26,042 in 1880 and 36,673 in 1900.

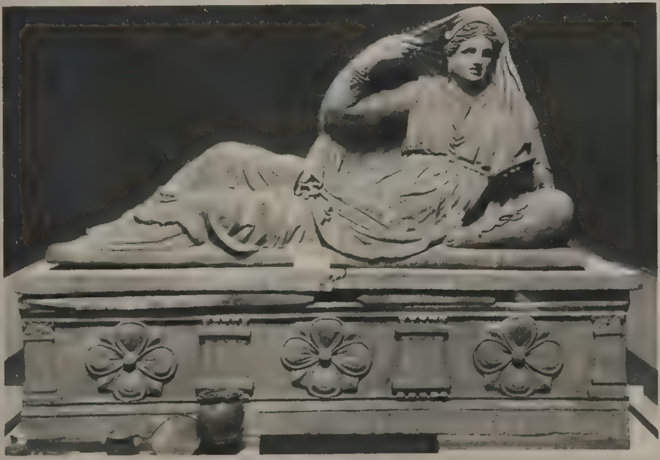
TERRELL, a city of Kaufman county, Texas, U.S.A., 32 m. E. of Dallas, on Federal highway 80, and served by the Texas and Pacific and the Southern Pacific railways. Pop. (1920) 8,349 (26% negroes). It is the seat of Texas Military College. There are cotton gins and compresses handling 35,000 bales in a season. Terrell was founded in 1873, when the first railway reached this point, and was chartered as a city in 1874. Since 1914 it has had a commission-manager form of government.

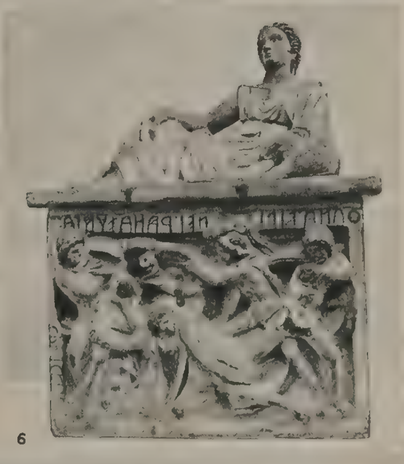












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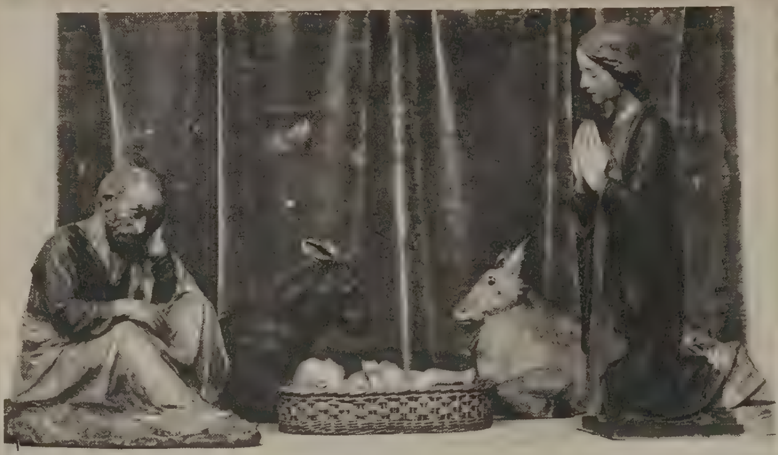
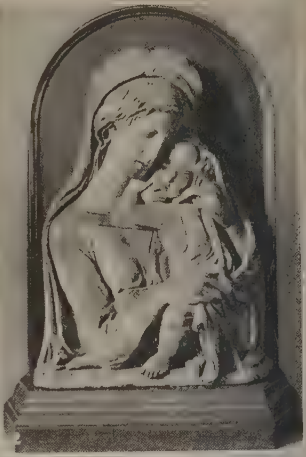
CLASSICAL TERRA-COTTAS

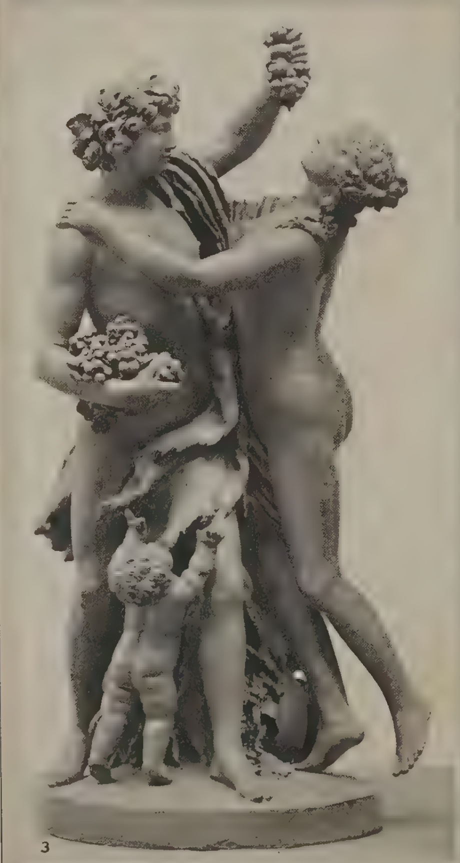
1. Greek chariot scene picturing Oenomaus and Myrtilus, his charioteer (31 B.C.–A.D. 14)
2. Ornamental tile and spout
3. Greek vase of the 3rd century B.C.
4. Terra-cotta statuette, Greek (470 B.C.), showing Peleus seizing Thetis
5. Etruscan sarcophagus of Selanti Thanunia (150 B.C.)
6. Etruscan urn in the form of a sarcophagus with woman reclining on the cover and the front picturing a battle scene (3rd century B.C.)

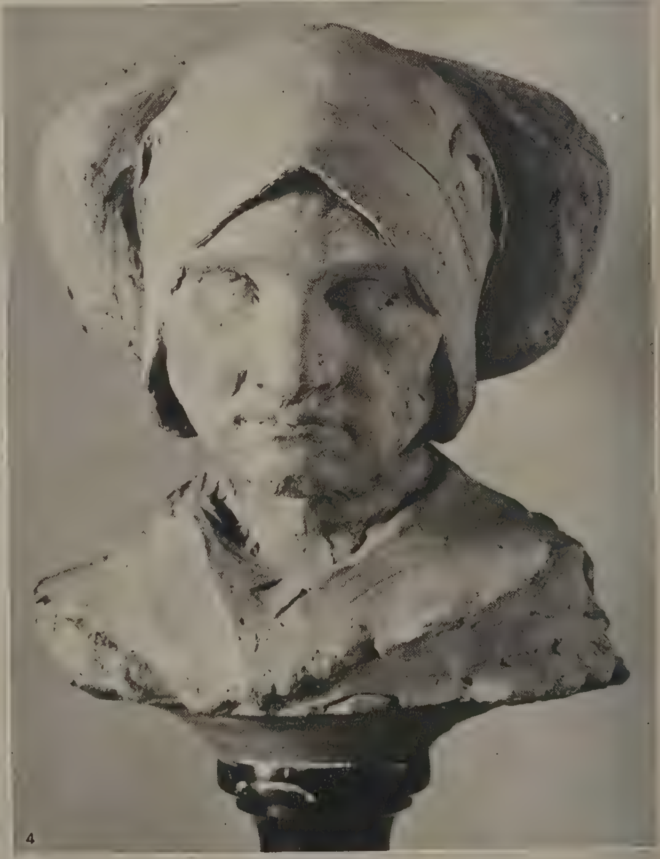
PLATE IV

TERRA-COTTA









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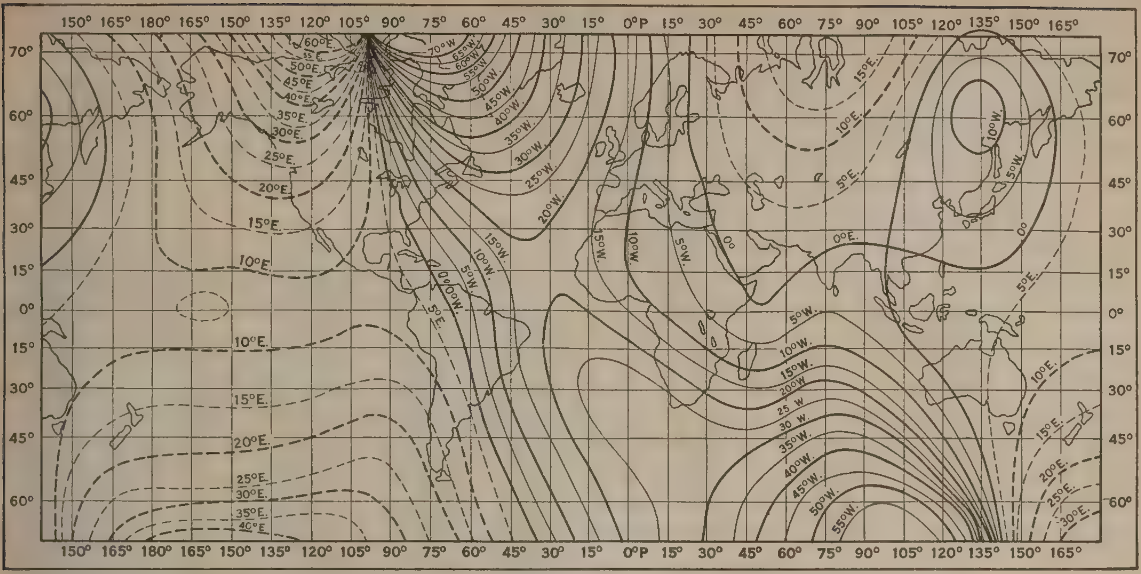
ITALIAN AND FRENCH EXAMPLES OF TERRA-COTTA SCULPTURE

1. "Nativity Group," glazed terra-cotta figurines by Antonio Rosselino (1427–79), Italian
2. "Madonna and Child," statuette in glazed terra-cotta by Donatello (1386–1466), Italian
3. "Bacchus and Nymph with Cupid," terra-cotta statuette by Claude Michel (Clodion) (1738–1814), French
4. "Peasant Woman," terra-cotta bust by Jules Dalou (1838–1902), French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5°E.
5°W.
10°W.
15°W.
20°W.
25 W.
30 W.
35°W.
40°W.
45°W.
50°W.
55°W.
10°E.
15°E.
20°E.
25°E.
30°E.

COMPILED FROM BRITISH ADMIRALTY CHARTS WITH THE PERMISSION OF THE CONTROLLER OF H.M. STATIONERY OFFICE AND OF THE HYDROGRAPHER OF THE NAVY

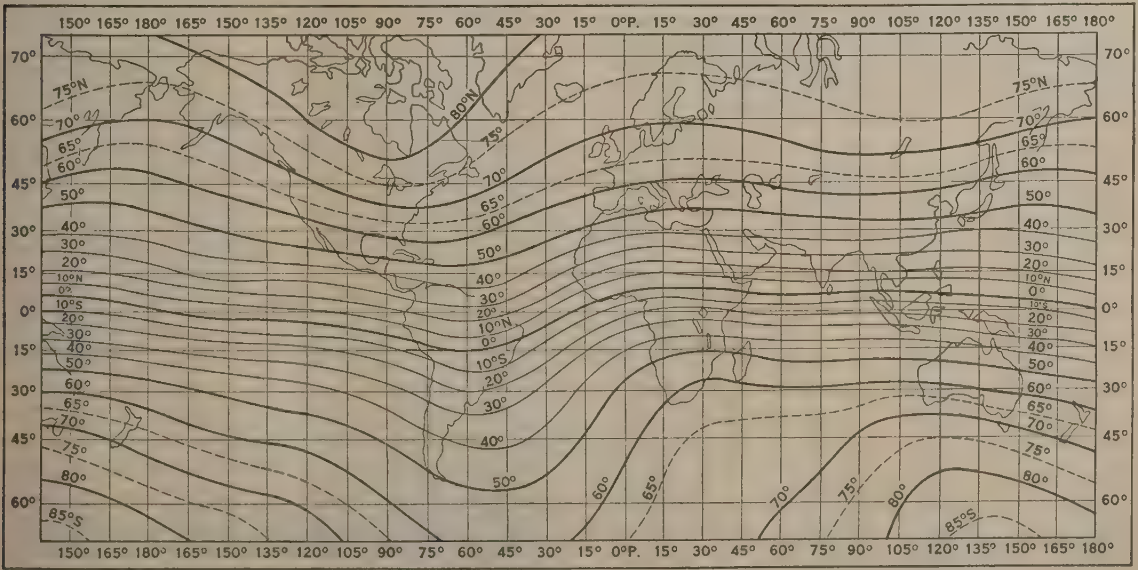
FIG. 1.—LINES OF EQUAL DECLINATION FOR 1922

TERRESTRIAL MAGNETISM, the science pertaining to the study of the magnetic phenomena of the earth.

It is probable that the directive property of loadstone was discovered independently in Europe and in China, but at a much earlier date in the latter than in the former. It is unlikely that the characteristic was known in Europe before the tenth century, but the Chinese were aware of it before the Christian era. Some go so far as to say that it was known in China as early as 2634 B.C., and there is evidence of the use, as early as 1110 B.C., of "south-pointing carts," *i.e.,* carts carrying a pivoted dummy with outstretched arm, and containing a magnet which caused the arm to point south. It has been claimed that, as early as the end of the eleventh century, the Chinese were aware of the fact that the compass needle does not point to the true north, but, as far as western civilization is concerned, Columbus is usually, although not universally[1]) (Note: the superior figures in the text refer to the latter part of the bibliography at the end of this article) credited with the discovery during his voyage to America in 1492.

The discovery of the "magnetic dip" is usually attributed to Robert Norman, an English instrument maker who describes it in *The Newe Attractive,* published in 1581, and who constructed a form of dip circle and found a rough value for the dip in London. The secular change in the orientation of the compass needle was discovered and recorded in 1635 by Henry Gellibrand as a result of the measurements which had been made at Limehouse by William Borough in 1581, by Edmund Gunter in 1622, and by himself in 1633. (*See* COMPASS.)

The fact that the orientation of the compass varied throughout the day was discovered by George Graham in 1722, and a more careful analysis of the phenomenon was made from 1756–


150° 165° 180° 165° 150° 135° 120° 105° 90° 75° 60° 45° 30° 15° 0°P. 15° 30° 45° 60° 75° 90° 105° 120° 135° 150° 165° 180°
70°
60°
45°
30°
15°
0°
15°
30°
45°
60°
75°N
70°
65°
60°
50°
40°
30°
20°
10°N
0°
10°S
20°
30°
40°
50°
60°
65°
70°
75°
80°
85°S
80°N
75°
70°
65°
60°
50°
40°
30°
20°
10°N
0°
10°S
20°
30°
40°
50°
60°
65°
70°
75°
80°
75°N
70°
65°
60°
50°
40°
30°
20°
10°N
0°
10°S
20°
30°
40°
50°
60°
65°
70°
75°
80°
85°S

SAME SOURCE AS FIG. 1

FIG. 2.—LINES OF EQUAL INCLINATION FOR 1922

1759 by J. Canton. About this time also a connection between magnetic disturbances and aurora was noticed by Canton and Peter Vilhelm Wargentin.

Not until the end of the eighteenth century was it known that the earth's total magnetic intensity varied over its surface. The first to observe the phenomenon was a Frenchman, Paul de Lamanon, but the first published results are those of the traveller Humboldt who made observations between 1798 and 1803, using measurements of the time of oscillation of a dipping needle as a means of comparison of the total intensities at different places. The diurnal variation in the dip and in the horizontal intensity of the earth's magnetism was discovered by Arago in 1827.

The foundations of absolute methods for measuring terrestrial magnetic quantities were laid by Gauss, who initiated regular observatory work in terrestrial magnetism at Göttingen in 1834. Magnetic observatories were established at St. Helena, Cape of Good Hope, Hobart, and Toronto by the middle of the 19th century, and since that time numerous observatories have sprung up in all parts of the world.

General Considerations.—The magnetic field of the earth is roughly that of a uniformly magnetized sphere, and the field of such a sphere at external points is the equivalent of that due to a magnetic doublet placed at its centre. According to an analysis of L. A. Bauer[2] the values M of the resultant moment, M_p of the axial component and M_e of the equatorial component for this doublet are as follows:

$M=8{\cdot}04\times10^{25}$ c.g.s.; $M_p=7{\cdot}88\times10^{25}$ c.g.s.; $M_e=1{\cdot}60\times10^{25}$ c.g.s.

The axis of the doublet intercepts the northern hemisphere in latitude 78° 32′ N. and longitude 69° 08′ W. The average intensity of magnetization, or moment per cubic centimetre of the earth is 0·074 c.g.s. unit.

The magnetic poles of the earth are defined as the places where the magnetic lines of force are vertical. Only very roughly may they be regarded as situated at the intersection of the prolongation of the axis of the doublet with the earth's surface. From observations taken between 1903 and 1906, R. Amundsen placed the north magnetic pole at 71° N. latitude and 96° W. longitude. The probable position of the south magnetic pole as calculated from data obtained on the "Discovery," 1902–4 is 72° 50′ S. latitude, and 156° 20′ E. longitude.

From a harmonic analysis of the earth's magnetic field, Gauss concluded that part was of external and part of internal origin. Analyses by A. D. Schmidt[3], and later by L. A. Bauer[2] lead the authors to the conclusion that part of the field was of a form which could not be attributed to any distribution of magnetization inside or outside of the earth. In the technical mode of expression this part is one which is not derivable from a potential, and is of a type requiring for its explanation in terms of classical electrodynamics the existence of electric currents flowing through the atmosphere in the regions where the magnetic observations are made. Bauer concludes that about 94 per cent of the earth's magnetic intensity is attributable to a potential arising from internal sources, about 3 per cent to a potential arising from external sources, and about 3 per cent is of non-potential origin.

The values of the average vertical current densities necessary to produce the non-potential part are given in Table I. for various ranges of latitude, according to Bauer's calculations[4] derived from the magnetic data available in 1920.

TABLE I.

Vertical Current Density i Corresponding to the Part of the Earth's Magnetic Field Not Derivable from a Potential

(a — sign corresponds to downward positive current)

Northern hemisphere		Southern hemisphere	
Latitude degrees N.	i (amp./km^2)$\times10^{-3}$	Latitude degrees S.	i (amp./km^2)$\times10^{-3}$
90–50 . .	21	90–50 . .	18
50–45 . .	45	50–45 . .	34
45–40 . .	— 6	45–40 . .	—47
40–35 . .	18	40–35 . .	—22
35–30 . .	8	35–30 . .	—31
30–25 . .	—29	30–25 . .	19
25–20 . .	—37	25–20 . .	58
20–15 . .	—19	20–15 . .	41
15–10 . .	—33	15–10 . .	—41
10– 5 . .	—53	10– 5 . .	14
5– 0 . .	—18	5– 0 . .	9

TABLE II.

Declination, Inclination, Horizontal Intensity and Vertical Intensity Recorded by Various Observatories Throughout the World

Observatory	Latitude	Longitude	Year	Decl'n (D)	Incl'n (I)	Hor. int. (H)	Ver. int. (V)
	° ′	° ′		° ′	° ′	c.g.s.	c.g.s.
Matochkin Shar .	73 15N	56 24E	1924	20 35·0E	80 03·0N	·0952	·5427
Sodankyla .	67 22N	26 39E	1922	1 22·6E	75 40·5N	·12561	·49187
Pavlovsk .	59 41N	30 29E	1924	3 16·1E	71 07·9N	·15818	·46970
Sitka . .	57 03N	135 20W	1922	30 29·1E	74 22·4N	·15560	·55631
Ekaterinburg	56 50N	60 38E	1924	11 00·8E	71 58·4N	·16578	·50942
Rude Skov.	55 51N	12 27E	1921	7 45·2W	69 01·2N	·17105	·44607
Kasan. .	55 50N	48 51E	1924	8 53·5E	70 07·6N	·17310	·47517
Eskdalemuir	55 19N	3 12W	1920	16 49·7W	69 39·5N	·16706	·45062
Meanook .	54 37N	113 20W	1924	27 17·7E	77 53·7N	·12866	·59984
Stonyhurst.	53 51N	2 28W	1924	15 05·3W	68 41·7N	·17276	·44281
Wilhelmshaven .	53 32N	8 09E	1911	11 28·2W	67 30·7N	·18110	·43747
Potsdam .	52 23N	13 04E	1923	6 56·9W	66 36·5N	·18565	·42920
Seddin .	52 17N	13 01E	1922	7 09·4W	66 32·8N	·18614	·42905
Irkutsk (Zuja) .	52 28N	104 02E	1920	1 02·3E	71 06·6N	·19277	·56337
De Bilt .	52 06N	5 11E	1924	10 38·0W	66 52·7N	·18372	·43024
Valencia .	51 56N	10 15W	1920	19 17·9W	68 05·3N	·17840	·44353
Bochum .	51 29N	7 14E	1921	10 10·4W	..	..	..
Kew . .	51 28N	0 19W	1920	14 31·0W	66 57·9N	·18410	·43297
Greenwich .	51 28N	..	1923	13 35·1W	66 51·9N	·18431	·43137
Uccle . .	50 48N	4 21E	1916	12 28·4W	66 02·8N	·18971	·42703
Hermsdorf .	50 46N	16 14E	1913	6 58·2W	..	..	..
Prague .	50 05N	14 25E	1921	6 24·2W	..	..	..
Val Joyeux.	48 49N	2 01E	1922	12 31·5W	64 39·6N	·19661	·41517
Munich .	48 09N	11 37E	1913	9 06·2W	63 04·6N	·20623	·40609
			1921	7 53·6W	..	..	..
O'Gyalla .	47 53N	18 12E	1918	5 21·9W	..	·20917	..
Nantes (Petit-Port)	47 15N	1 33W	..	..	..	..	..
Odessa .	46 26N	30 46E	1910	3 35·9W	62 26·9N	·21707	·41606
Pola . .	44 52N	13 51E	1922	6 28·0W	60 12·8N	·22090	·38591
Agincourt .	43 47N	79 16W	1924	7 05·8W	74 44·4N	·15752	·57733
Tiflis . .	41 43N	44 48E	1913	3 09·1E	56 51·1N	·25217	·37612
Capodimonte (Naples).	40 52N	14 15E	1914	..	..	·24166	..
Ebro (Tortosa)	40 49N	0 31E	1924	11 20·2W	57 30·5N	·23359	·36678
Coimbra .	40 12N	8 25W	1920	15 21·5W	58 22·8N	·23087	·37496
Cheltenham	38 44N	76 50W	1922	6 27·7W	70 57·6N	·19020	·55115
Athens .	37 59N	23 42E	1908	4 53·0W	52 11·7N	·26197	·33613
San Miguel	37 46N	25 39W	1920	19 24·9W	60 26·0N	·23123	·40759
San Fernando .	36 28N	6 12W	1924	13 23·5W	53 46·8N	·25016	..
Kakioka .	36 14N	140 11E	1916	5 17·6W	49 31·7N	·29743	·34859
Tsingtau .	36 04N	120 19E	1920	4 12·9W	52 07·0N	·30817	·39610
Tucson .	32 15N	110 50W	1922	13 47·5E	59 29·0N	·26839	·45533
Lukiapang .	31 19N	121 02E	1920	3 21·4W	45 30·7N	·33175	·33773
Dehra Dun	30 19N	78 03E	1922	1 43·2E	45 02·6N	·32927	·33091
Helwan .	29 52N	31 20E	1919	1 30·6W	41 09·6N	·29947	·26175
Hongkong .	22 18N	114 10E	1924	0 23·8W	30 42·8N	·37294	·22155
Honolulu .	21 19N	158 04W	1922	9 57·1E	39 24·5N	·28794	·23658
Teoloyucan	19 45N	99 11W	1922	9 09·9E	..	..	..
Toungoo .	18 56N	96 27E	1922	0 29·7W	23 07·2N	·39156	·16717
Alibag. .	18 38N	72 52E	1922	0 12·6E	25 05·0N	·36967	·17303
Vieques (Porto Rico)	18 09N	65 27W	1922	4 00·9W	51 33·1N	·27695	·34880
Antipolo .	14 36N	121 10E	1920	0 35·9E	16 11·7N	·38100	·11065
Kodaikanal	10 14N	77 28E	1922	1 58·7W	4 40·1N	·37878	·03093
Batavia-Buitenzorg	6 11S	106 49E	1924	0 52·9E	32 04·3S	·36821	·23072
St. Paul de Loanda .	8 48S	13 13E	1919	14 49·0W	..	..	..
Huancayo .	12 03S	75 20W	1924	8 01·7E	0 54·6N	·29755	·00395
Apia . .	13 48S	171 46W	1924	10 19·2E	30 07·5S	·35249	·20453
Tananarive	18 55S	47 32E	1914	8 25·2W	53 37·9S	·22484	·30532
Mauritius .	20 06S	57 33E	1923	10 49·2W	52 33·7S	·22982	·30018
LaQuiaca .	22 08S	65 43W	..	.	..	..	..
Vassouras .	22 24S	43 39W	1923	11 42·8W	15 53·7S	·24407	·06950
Watheroo .	30 19S	115 53E	1924	4 18·3W	64 05·2S	·24750	·50941
Pilar . .	31 40S	63 53W	1920	7·48·6E	25 41·2S	·25297	·12168
Toolangi .	37 32S	145 28E	1920	8 00·8E	67 55·1S	·22874	·56384
Christchurch	43 32S	172 37E	1923	17 11·7E	68 12·0S	·22209	·55526
Orcadas .	60 43S	44 47W	1912	4 46·5E	54 26·0S	·25343	·35442

TABLE III.

Secular Changes in Declination D at Various Places Over an Extended Period

Place	London, England	Eastport, Maine	Habana, Cuba	San Francisco, Calif.	Manila, P.I.	Callao, Peru	Rio de Janeiro, Brazil	Cape Town, S. Africa
Latitude Longitude	51°28′N 0°19′W	44°55′N 67°00′W	23°07′N 82°22′W	37°48′N 122°27′W	14°36′N 120°58′E	12°04′S 77°08′W	22°54′S 43°10′W	33°56′S 18°29′E
	°	°	°	°	°	°	°	°
1540 . .	7·2E	..	..	..	..	..	..	..
1560 . .	9·6E	..	..	..	..	..	..	..
1580 . .	10·9E	..	..	..	..	..	..	..
1600 . .	10·1E	..	..	..	..	..	..	1·0E
1620 . .	7·3E	19·0W	..	..	..	..	..	1·5W
1640 . .	3·3E	18·5W	..	..	..	..	..	4·0W
1660 . .	0·6W	17·5W	..	..	..	..	12·1E	6·4W
1680 . .	3·9W	16·0W	..	..	..	..	11·8E	8·9W
1700 . .	7·1W	14·5W	..	..	..	..	11·3E	11·5W
1720 . .	11·0W	13·1W	4·0E	..	..	6·7E	10·6E	14·0W
1740 . .	15·3W	12·4W	5·0E	..	..	7·7E	9·7E	16·8W
1760 . .	19·6W	12·2W	5·8E	..	0·1W	8·6E	8·5E	19·4W
1780 . .	22·7W	12·4W	6·3E	12·6E	..	9·4E	7·1E	22·2W
1800 . .	24·1W	13·2W	6·5E	13·6E	0·1E	10·0E	5·5E	25·0W
1820 . .	24·1W	14·7W	6·3E	14·6E	0·2E	10·4E	3·5E	27·1W
1840 . .	23·2W	16·3W	6·0E	15·4E	0·3E	10·6E	1·2E	29·0W
1860 . .	21·5W	18·0W	5·2E	16·1E	0·5E	10·5E	1·5W	30·0W
1880 . .	18·7W	18·8W	4·0E	16·5E	0·7E	10·3E	4·4W	29·8W
1900 . .	16·5W	19·3W	3·1E	16·9E	0·9E	9·9E	7·7W	28·6W
1910 .	15·7W	20·0W	3·0E	17·6E	0·8E	9·2E	9·5W	27·5W
1920 . .	14·1W	20·8W	3·4E	17·9E	0·7E	8·5E	11·2W	26·1W

The average value of the vertical current density taken regardless of sign is about 10,000 times the average atmospheric-electric current density (*see* ELECTRICITY: *Atmospheric*), so that if the former represents a reality the currents associated with it must be of a type produced, for example, by the influx or efflux of charged particles of high speed which derive their velocity from sources other than the atmospheric potential gradient.

According to the conclusions of Sir F. Dyson, and H. Furner⁵⁾, the non-potential part of the earth's magnetic field is not indicated with any certainty, although there is some evidence for it. Again, even as regards the part of the field depending upon a potential, different analyses have given different results depending on the data used. Thus the analyses made by Schmidt⁶⁾ on the basis of the data available in 1898 limits the surface field which can be of external origin to less than one per cent of the total; and the chief part of it is a uniform field of intensity 3×10^{-3} gauss.

The variable part of the earth's magnetic field corresponding to the diurnal variation has its main origin outside of the earth, and, according to S. Chapman⁷⁾, about 28 per cent of it owes its origin to sources inside the earth.

Gauss laid down the fundamental principle for the analysis of the earth's magnetic field corresponding to a case where the field was derivable from a potential.

It is well known that the potential Ω of any magnetic system can be expressed in polar co-ordinates, as a function of the distance r from the origin, the latitude l, and the east longitude λ in the form

$$\Omega=\sum_{n=0}^{n=\infty}\sum_{m=0}^{m=n}\left\{\frac{H_n^m(\sin l)}{r^{n+1}}(g_n^m\cos m\lambda+h_n^m\sin m\lambda)\right.$$
$$\left.+r^nH_n^m(\sin l)(g^m_{-n}\cos m\lambda+h^m_{-n}+\sin+m\lambda)\right\} \qquad (1)$$

where the g's and h's are constants known as Gaussian constants, and

$$H_n^m(\mu)=(1-\mu^2)^{\frac{1}{2}m}\left[\mu^{n-m}-\frac{(n-m)\,(n-m-1)}{2(2n-1)}\mu^{n-m-2}\right.$$
$$\left.+\frac{(n-m)(n-m-1)(n-m-2)(n-m-3)}{2\cdot 4(2n-1)(2n-3)}\mu^{n-m-4}\;.\;.\;.\right]$$

m and n being positive integers, with m not greater than n. Expressions for the components of the magnetic field may be obtained by differentiating the potential, and the various g's and h's may then be evaluated by determining them so as to cause the expression to fit the experimental data.

TABLE IV.

Secular Change in Total Intensity R, Declination D, and Inclination I, at Observatories

(The values of R are in units of γ, 10^{-5} c.g.s.)

Year		Greenwich, England	Vieques, P.R.	Cheltenham, Maryland	Toronto, Canada	Tucson, Arizona	Sitka, Alaska	Honolulu, Hawaii
1905	R .	47,274	44,795	59,878	61,730	..	58,797	38,168
	D .	16 09·9W	1 38·3W	5 17·8W	5 42·2W	..	29 59·1E	9 21·7E
	I .	66 55·9	49 17·0	70 25·4	74 34·3	..	74 43·2	40 05·0
1910	R .	47,240	44,734	59,596	61,421	53,669	58,426	37,910
	D .	15 41·2W	2 20·6W	5 41·4W	6 03·9W	13 25·8E	30 16·4E	9 29·7E
	I .	66 52·6	49 52·0	70 35·4	74 38·5	59 19·6	74 32·2	39 47·2
1915	R .	47,103	44,710	58,982	60,795	53,295	58,138	37,581
	D .	14 56·5W	3 10·1W	6 04·0W	6 28·5W	13 42·5E	30 23·2E	9 41·6E
	I .	66 51·8	50 45·9	70 46·8	74 42·9	59 24·7	74 26·5	39 29·1
1920	R .	47,022	44,582	58,498	60,291	52,057	57,800	37,341
	D .	14 08·6W	3 46·1W	6 18·5W	6 45·4W	13 48·0E	30 28·2E	9 53·2E
	I .	66 53·6	51 22·7	70 55·4	74 44·6	59 27·6	74 22·1	39 25·1
1925	R .	46,850	..	57,983	..	52,597	57,620	37,162
	D .	13 10·9W	..	6 39·2W	..	13 45·3E	30 27·2E	10 01·8E
	I .	66 51·5	..	71 00·5	..	59 30·6	74 22·2	39 25·9

If we should work out the magnetic potential due to a distribution of doublets inside and outside of the sphere of radius r, we should obtain an expression of the type of (1), and the part of (1) involving the g_n^m and the h_n^m would depend entirely on the doublets outside the sphere of radius r, while the part involving g_{-n}^m and h_{-n}^m would depend entirely on the doublets inside that sphere. For this reason, in the empirical analyses of the earth's field, we regard the part depending upon the g_n^m and the h_n^m as due to external causes and the part depending upon g_{-n}^m and h_{-n}^m as due to internal causes.

The determination of the Gaussian constants from the experimental data is by no means as simple a matter as it might seem; and slight errors in the data are apt to cause large errors in the constants, particularly in those of high order.

Magnitudes of the Magnetic Elements over the Earth's Surface.—The elements which enter into the discussion of terrestrial magnetism data are:

The *Declination, D,* the angle made with the geographic meridian by the vertical plane containing a freely suspended compass needle.

The *Dip,* or *Inclination, I,* the angle made with the horizontal by a freely suspended compass needle.

The *Horizontal Intensity, H,* the *Vertical Intensity V,* and the *Total Intensity, R* of the field.

Between the four quantities I, H, V and R there exist the relations

$$\frac{H}{V}=\tan I;\quad R^2=H^2+V^2$$

so that a determination of any two of them serves to yield the others.

Table II. gives, according to a compilation made in 1924[8], a list of values of the magnetic elements as recorded at various observatories throughout the world.

It is customary to represent the characteristics of the earth's magnetic field by means of charts, in which on a map of the world are drawn the lines of equal Declination, or Isogonics, the lines of equal Inclination, or Isoclinics, and the lines of equal Horizontal Intensity, or Isodynamics; figs. 1, 2 and 3, represent a set of such lines based on the British Admiralty Charts for 1922.

Variations in the Earth's Magnetic Field.—The magnetic elements are in a state of change, and the variations may be divided into three main classes, those which follow a regular periodicity, those which follow an orderly change which is in one direction at any rate for long intervals of time, and those which are of a more abnormal nature and which, in their more drastic forms, at any rate, are classed under the head of magnetic storms.

The variations of a regular nature comprise a *Secular Variation,* and a periodic variation comprising a part, the *Diurnal Variation,* based upon a fundamental period of a day, and a part, the *Annual Variation,* based upon the fundamental period of a year. It is probable that the periodicities of all the members of the solar system reflect themselves upon the periodicity of the magnetic elements although, in general, to an immeasurably small degree, except in the case of the moon, where the effect is well marked. Data for the discussion of the Secular Variation in declination extend back to about 1540, but naturally with reliability decreasing with the remoteness of the epoch. For the Dip the data are fewer, and there are no absolute intensity measurements prior to 1830. The general orders of magnitude involved will be gathered from the facts that, at London, the Declination was 11° E. in 1580. It reached its extreme westerly value at 24° W. in 1810, and since then it has been changing towards the east until in 1925 it reached the value 13° W. A value of 71° 50′ was recorded for the Dip in London in 1576, a value of 74° 30′ in 1700, and the present value is about 67°.

From an analysis of the available data, L. A. Bauer has concluded that, over the period 1843–1923, the average intensity of magnetization of the earth has been decreasing at the rate of about one part in 1,500 per year. A digest of the available data for the declination is given in Table III., for the period 1540–1920[9], and Table IV.[9] illustrates the variation of intensity, declination and inclination over a period of 20 years (1905–25).

A method which has been used for illustrating secular change is as follows: Radii are drawn from the centre of a sphere parallel to the direction of the freely dipping needle, and are produced to intersect the tangent plane drawn at a point which answers to the mean position of the needle during the epoch under consideration. The curve formed by the points of intersection shows the character of the secular change. Figure 4[10] represents such a curve for London. The direction of description of the curve is clockwise, although this conclusion does not hold, apparently, for all places on the earth's surface. The inference suggested is that the curve will eventually close, indicating a periodic phenomenon with a period of about 480 years.

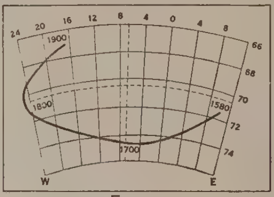
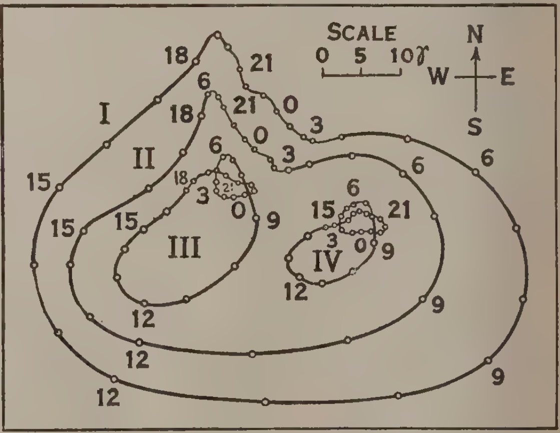


FIG. 3

All the magnetic elements at any ordinary station show a regular variation throughout the day. To separate this from the irregular changes, means of the hourly readings must be formed, making use of a number of days. The amplitude of the diurnal change usually varies considerably with the season of the year, and to an extent depending upon the geographical location. The curves in fig. 5 constructed by D. L. Hazard[9] illustrate the general nature of the phenomena. They are based on days selected because of their freedom from magnetic storms, and represent the average of a large number of days.

A convenient method of exhibiting the diurnal variations of terrestrial magnetism is through the agency of vector diagrams, which give rather more complete information than is given by such diagrams as fig. 4. In such a vector diagram, a vector representing in magnitude and direction the earth's total intensity is drawn from the point corresponding to the place of observation. The motion of the end of this vector then contains in three dimensions the story of the variations of all the elements. In particular, the projection of this vector on a horizontal plane contains the story of the variation in the horizontal intensity.

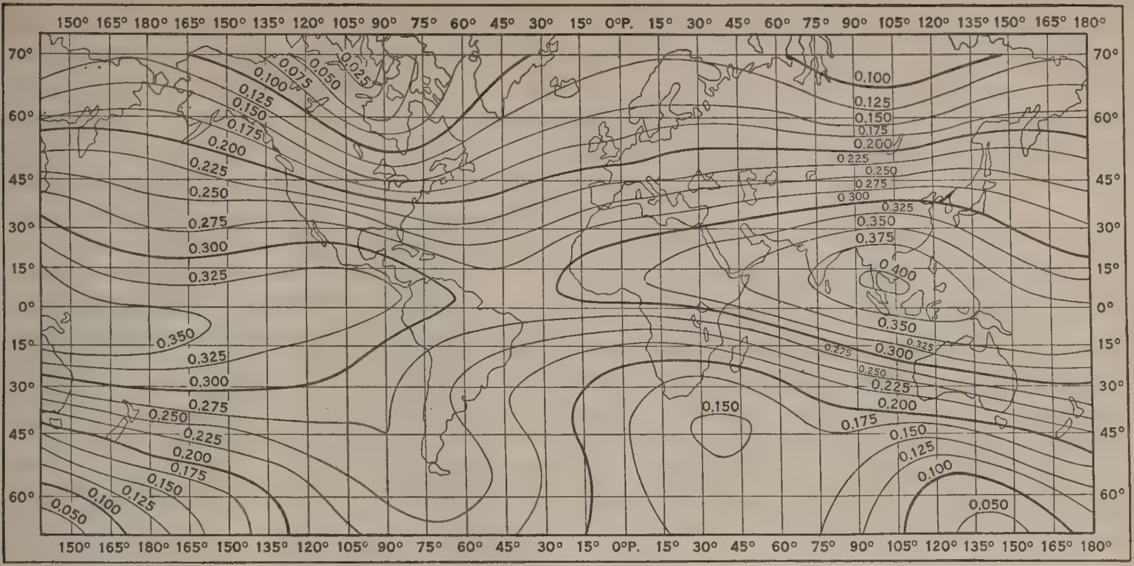


FROM GLAZEBROOK, "DICTIONARY OF APPLIED PHYSICS"

FIG. 4.—QUIET-DAY VECTOR DIAGRAMS OF THE DAILY VARIATION OF MAGNETIC FORCE IN THE HORIZONTAL PLANE AT GREENWICH, 1889–1914
I. June, sunspot maximum years; II. June, sunspot minimum years; III. December, sunspot maximum years; IV. December sunspot minimum years

By attaching to such a curve figures representing the time of day, the time variations of the element may be exhibited on the diagram. The sort of information representable in such a manner is indicated by the curves in fig. 4, which are drawn with particular reference to the influence of sunspot activity on the diurnal variation.

The more or less regular variations presented by the diurnal variation curves of fig. 4 are by no means characteristic of the individual days. On certain days the elements vary everywhere over the earth's surface, and to an extent large compared


150° 165° 180° 165° 150° 135° 120° 105° 90° 75° 60° 45° 30° 15° 0°P. 15° 30° 45° 60° 75° 90° 105° 120° 135° 150° 165° 180°
70°
60°
45°
30°
15°
0°
15°
30°
45°
60°
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.250
0.275
0.300
0.325
0.350
0.375
0.400

SAME SOURCE AS FIG. 1

FIG. 5.—LINES OF EQUAL HORIZONTAL INTENSITY FOR 1922

with the normal diurnal variation. The larger disturbances of this type are known as magnetic storms. Days particularly free from such disturbances are termed quiet days. As a rule the conditions lie somewhere between the two extremes. The more important disturbances occur almost simultaneously all over the earth and for this reason it is possible to speak of the magnetic character of a day regardless of the location, the day being measured in terms of Greenwich time. It is customary for magnetic observatories to assign "Character figures" 0, 1, or 2 to each successive day, 0 denoting a quiet day, 2 a disturbed day, and 1 a day of intermediate type.

Terrestrial Magnetic Measurements. *Non-electrical Methods of Measurement.*—Of the magnetic elements D, I, H, V, R, only the declination D, and two of the others need be measured independently, the remaining elements may then be calculated. Measurements may be divided into two classes, those in which isolated values of certain elements are measured, and those in which continuous records of the variations of the elements are obtained. The latter class of measurements is confined almost exclusively to fixed observatories, and the elements whose variations are recorded are usually the declination, the horizontal intensity and the vertical intensity. (*See* MAGNETOGRAPH.) The former class comprises field observations on land and sea, and also observatory observations. The elements usually measured are declination D, horizontal intensity H, and dip (or inclination) I. The declination is obtained by measuring the angle made by the axis of a freely suspended magnet with the geographical meridian. Absolute measurements of the horizontal intensity are usually obtained by determining for a magnet of moment M, the product MH by one series of experiments and the ratio M/H by another. H^2 may then be evaluated by dividing MH by M/H. For the determination of MH the time of swing T of the magnet freely suspended in a suitable holder is determined. If K is the moment of inertia of the suspended system,

$$T=2\pi\sqrt{\frac{K}{MH}} \tag{2}$$

The moment of inertia is then increased to $K+k$ by the addition of a non-magnetic cylinder of known moment of inertia k. The time of swing T_1 is then determined.

$$T_1=2\pi\sqrt{\frac{K+k}{MH}} \tag{3}$$

By the elimination of K between (2) and (3) we readily derive the expression

$$MH=\frac{4\pi^2k}{T_1^2-T^2}$$

for MH in terms of known quantities.

The ratio M/H is obtained by measuring the deflection θ from the magnetic meridian produced in a subsidiary suspended magnet when the magnet of moment M is placed with its axis horizontal, perpendicular to the deflected axis of the subsidiary magnet, and passing when prolonged through the axis of suspension. Under these conditions

$$H\sin\theta=\frac{2M}{r^3}\left(1+\frac{P}{r^2}+\frac{Q}{r^4}\cdots\right)$$

where r is the distance from the centre of the magnet of moment M to the point of suspension of the other magnet, $\frac{2M}{r^3}$ represents the field due to the former magnet at the centre of the latter under the approximation that the said former magnet may be treated as a simple doublet of moment M, while P and Q are constants which provide for a correction on account of this assumption. It is customary to neglect Q. Then, by taking deflections at two different values of r, two expressions may be obtained from which P may be eliminated and M/H determined in terms of measured quantities.

In practice, a rather elaborate series of observations is gone through for the purpose of elimination of various errors in both D and H. (*See* MAGNETOMETER.) The classical method of determining the inclination is by the use of the dip circle, in which a magnetic needle is mounted so that it can turn in a vertical plane which is adjusted to lie in the magnetic meridian. In order to obtain an accurate result from the instrument many sources of error must be recognized and eliminated by a systematic series of observations. For the standard procedure *see* INCLINOMETER.

Electrical Methods.—Within recent years, the principle of comparing the earth's horizontal intensity with that produced by a measured current in a coil of known dimensions has been occasionally employed in observatories in one or other of various possible forms. In an instrument designed by F. E. Smith, following the suggestion of Sir Arthur Schuster, the principle is [11]:

A coil of the Helmholtz-Gaugain type, designed so as to secure a field constant to one part in 100,000 within a sphere of 30 mm. diameter, is used to produce the magnetic field to be compared with that of the earth. At the centre of this coil a small magnet is suspended, and the principle of the method involves balancing the earth's horizontal intensity with the field produced by the coil, which field is given by Fi, where i is the current and F a constant calculable from the geometrical constants of the coil. One could secure the balance between Fi and H by adjusting i to secure an infinitely long period of vibration of the suspended magnet, but, a more practicable method, and the method followed, is one which invokes the fact that if the axis of the coil be set at an angle α to the magnetic meridian, it is possible to adjust i so that the magnet sets itself perpendicular to H in which case

$$Fi\cos\alpha = H.$$

The procedure, except for details is as follows: The axis of the coil is first set so that on starting or stopping the current, no deflection is obtained in the suspended magnet. The axis is then in the magnetic meridian, and the direction of the field of the coil is the same as that of H, the horizontal component of the earth's field. The axis is now turned through a slight angle α. The current in the coil is reversed and adjusted so that the axis of the magnet becomes perpendicular to the magnetic meridian. For convenience, the final adjustment of this condition is made by adjusting α rather than i. Next, keeping i constant, the axis of the coil is turned to approximately an equal angle β on the other side of the magnetic meridian, so that the magnet swings through 180°. The angle β is adjusted so that the angle through which the magnet swings is exactly 180° and the magnitude of the horizontal intensity is then given by

$$H = Fi(\cos\alpha + \cos\beta)/2.$$

The precision of the method is such as to permit of an accuracy of a few parts in 100,000 by measurements lasting only a few minutes, although in seeking this accuracy, attention must be given to many details not mentioned here[11].

A method to some extent analogous to the foregoing was also devised by W. M. Hicks[12] and submitted to experimental test by W. A. Jenkins. Yet another absolute instrument for the purpose takes the form of a sine galvanometer designed by S. J. Barnett[13].

For the determination of the dip, the dip circle has been superseded in many cases by the earth-inductor[14], in which a coil is rotated about an axis in its own plane, the axis being adjusted until no current is obtained in the coil. In this case the axis coincides with the direction of the earth's lines of force. The earth inductor must, of course, be provided with a commutator, and the galvanometer used must be situated sufficiently far from the apparatus to insure that its stray field shall not affect the measurements.

Field Terrestrial Magnetic Observations.—For land observation in the field it is customary to use the dip circle for inclination, and the magnetometer for declination and horizontal intensity determinations. However, the usual procedure is to determine at a fixed observatory the moment of inertia of the suspended system, used in the oscillation experiments, and then employ this value throughout for the field observations.

In sea observations[15], it is customary to use for declination a type of pivoted magnet system which is immersed in a liquid so as to remove much of the weight from the pivot and so reduce the friction. The geographical meridian is determined by observations on celestial bodies.

For inclination both the earth inductor and a specially mounted dipping needle have been employed.

Total intensity observations have been made at sea by a method devised by E. Lloyd. The method involves two operations, during both of which the dip circle is placed so that the suspended needle swings in the plane of the magnetic meridian. In north magnetic latitudes, for example, the inclination is measured with a needle having a weight added to its south end. Then the needle is used to deflect a second dip needle when placed at right angles to its undeflected direction and at a definite distance. The first measurement serves to give a relation between R, the weight, and the moment M of the loaded magnet. The second measurement gives a relation between M and R, so that from the two relations M may be eliminated, leaving an expression for R in terms of the loading weight.

Measurements of the horizontal intensity are made by measuring the angle of deflection produced in the liquid compass by a magnet placed above it with its center on the vertical axis through the pivot, and with its length horizontal and perpendicular to the deflected direction of the axis of the pivoted needle. Under this condition

$$H = mc/\sin u$$

where u is the angle of deflection, m is the moment of the deflecting magnet, and c is a constant depending upon the position of the deflecting magnet, etc. The constant quantity mc is evaluated by making measurements with the instrument at a fixed observatory where H is simultaneously measured by the usual methods.

THEORIES OF TERRESTRIAL MAGNETISM

Theories Involving Permanent Magnetization.—While it is true that a complete theory of terrestrial magnetism must take account of the variations of the earth's magnetism with time, and of the non-coincidence of the geographic and magnetic axes we should feel that we had made a reasonably satisfactory advance if we could see some way in which to account for any sort of a magnetic field of the right order of magnitude even though our theory should require that field to be symmetrical with respect to the axis of rotation and to show in its simplest form no secular variation.

The first idea which suggests itself is that the earth's interior may be of magnetizable substance, and that somehow or other, at some time or other it became magnetized. We cannot escape so easily the responsibilities of an explanation, however, for our ideas as to the temperature of the earth's interior place grave difficulties in the way of an assumption of a state of magnetization in the earth's interior; since, under ordinary conditions, iron, for example, would lose its capacity for magnetization at temperatures which would be reached at a depth of about 20 kilometers, and magnetite ceases to be magnetic at even lower temperatures than iron. Thus, unless we invoke some unknown effect of pressure to increase the temperature at which a substance loses its capacity for magnetization we must confine the possibilities as regards permanent magnetization to a relatively thin shell of the earth.

A uniformly magnetized sphere of radius a, magnetized to an intensity I, acts at external points like a doublet of moment $M = \frac{4}{3}\pi a^3 I$, and a shell of thickness δa acts like the difference of two such spheres of radii a and $a - \delta a$. It acts in fact like a doublet of moment $\delta M = 4\pi a^2 I \delta a$. In order that δM should correspond to the effective moment of the earth it is necessary to assume a value of about 50 for I if δa is to be as small as 15 or 20 kilometers. While this value of the intensity is not large beyond all reason its existence seems highly improbable.

Theories Involving Rotation of Charge Distributions.—It is difficult to resist the temptation to believe that the earth's magnetism may arise as a result of its rotation. As a guide in such considerations we have the experimental fact, as revealed by study of the Zeeman effect, that the sun possesses a magnetic field whose intensity at its pole is about 50 gauss. Further, the magnetic field which could arise from the rotation, at attainable speeds, of bodies of laboratory size must necessarily be small, as otherwise such magnetic fields would have revealed themselves long ago. Any theory which attempts to explain terrestrial magnetism as a result of rotation must lead to a formula consistent with the above facts.

The fact that a rotating charged body produces a magnetic field, leads one to inquire as to whether the earth's charge (*see* ELECTRICITY, ATMOSPHERIC) may, by its rotation with the earth, produce a magnetic field comparable with that of the earth. Calculation shows, however, that the field so produced would be a hundred million times too small. The magnetic potential Ω at a point with polar co-ordinates r and θ is given by

$$\Omega = \frac{Q\omega a^2}{3cr^2}\cos\theta$$

where Q is the total charge in electrostatic units, c the velocity of light, ω the angular velocity and a the radius of the sphere. The field outside the sphere is, in fact, similar to that of a doublet of moment $Q\,\omega\,a^2/3c$. Its general form would be approximately correct as corresponding to the part of the field symmetrical about the axis of rotation, but only as viewed by an observer who did not participate in the rotation. Whenever we have to deal with a magnetic field produced by the rotation of a system which also has an electric field, we are faced with a difference between the magnetic field as it appears to an observer stationed on the rotating body and to an observer who does not participate in the motion16) 17). In the case of the rotation of a charged earth cited above, the effect would, for an observer on the earth, cause a reversal of the horizontal intensity as seen by a stationary observer, while leaving the vertical intensity unchanged. The effect of this is to produce over the surface of the sphere a distribution of field quite inconsistent with the facts.

The easiest way to demonstrate the effect of the observer's motion is through the theory of relativity. Thus if H is the magnetic field as viewed from one system of axes, the magnetic field H' as viewed in a system of axes moving relatively to the first system with velocity v parallel to the axis of x is such that

$$H_x'=H_x,\ H_y'=\beta\left(H_y+\frac{v}{c}\,E_z\right),\ H_z'=\beta\left(H_z-\frac{v}{c}\,E_y\right)$$

when $\beta=\left(1-\frac{v^2}{c^2}\right)^{-\frac{1}{2}}$ c is the velocity of light, and where E is the electric field as measured in the first set of axes.

Thus, if the axis of x be taken to coincide instantaneously with the direction of motion of a point on the sphere at the place of observation, and if the axis of z be taken to correspond to the vertical, and the axis of y to the meridian, then for a case where $E_y=0$, we have

$$H_x'=H_x,\ H_y'=\left(H_y+\frac{v}{c}\,E_z\right),\ H_z'=H_z$$

where, in putting $\beta=1$ we have neglected only quantities of the second order in v/c. Thus, the only effect of the observer's motion is on the horizontal component H_y'.

The quantity of positive and negative electricity in the earth is enormous. Thus if all the positive and negative electricity in a cubic centimetre of the earth's substance were separated and concentrated at two points a centimetre apart, they would attract each other with a force of 10^{20} tons.

If we could annul the positive charge and leave only the negative, the rotation of the earth would produce a field about 5×10^{18} times that of the earth. Since two spheres of equal charge but different radii produce unequal magnetic fields at a point external to both it occurred to Sutherland that only a slight difference would be necessary in the radii of two superposed spheres of positive and negative, of which the earth may be regarded as being composed in order that, by the combined rotation of these spheres, a field comparable with that of the earth would result. As a matter of fact calculation shows that the radii need only differ by $2{\cdot}4\times10^{-10}$ cm., *i.e.,* about one hundredth of the diameter of a single atom in order to produce the desired effect. Moreover, since a symmetrical spherical distribution of charge produces at external points an electric field which is independent of the size of the sphere, the two equal and opposite charges would together produce no electric field at an external point. However, as regards regions just inside the surface the condition is different. Thus, at a point just inside the thin shell of thickness 10^{-10} cm., there would be a field of the order 6×10^{8} volts per centimetre tending to annul the separation which had taken place. This is demonstrated thus:

The magnetic potential Ω due to a sphere of radius a and uniformly distributed volume charge of total amount Q is, at an external point with co-ordinates r, Q, given by

$$\Omega=\frac{Q\omega a^2}{5cr^2}\cos\theta.$$

The potential $\delta\Omega$ due to two superposed spheres of equal charge, but of radii a and $a+\delta a$ respectively, is consequently

$$\delta\Omega=\frac{2}{5}\,\frac{Q\omega}{c}\,\frac{a\delta a}{r^2}\cos\theta.$$

The magnetic field H_z at the pole is

$$H_z=\frac{4}{5}\,\frac{Q\omega\delta a}{ca^2}.$$

At a point just inside the layer of thickness δa, the electric field due to the superposed spheres is

$$E=\frac{Q}{a^2}-\left(\frac{a}{a+\delta a}\right)^3\frac{Q}{a^2}=\frac{3\delta a}{a^3}\,Q.$$

Hence,

$$\frac{E}{H_z}=\frac{15}{4}\,\frac{c}{\omega a}$$

Inserting appropriate values for H_z, c, ω and a, we readily find $E=2\times10^{6}$ e.s.u., *i.e.,* 6×10^{8} volts per cm.

A solid sphere of negative electricity would, by its rotation give a magnetic field roughly similar to that of the earth, as viewed by an observer who did not participate in the motion. As viewed by an observer on the sphere, however, the considerations referred to above cause a reversal of the apparent horizontal component while leaving the vertical component unchanged. The latter consideration may be avoided by coating the surface of the sphere with a uniform charge of sign opposite to but of total amount equal to that of the volume distribution, so as to annul the external field17). The magnetic potentials due to the combined distribution is then

$$\Omega=\frac{Q\omega a^2}{5cr^2}\cos\theta-\frac{Q\omega a^2}{3cr^2}\cos\theta.$$

The first term on the right hand side corresponds to the volume charge and the second to the surface charge. The effect of the surface charge is thus to reverse the sign of Ω from that given by the volume charge. In other words, in order to produce a magnetic field corresponding to that of the earth we should have to postulate a positive volume charge, and a negative surface charge. Here again, however, the electrostatic pull on the negative surface charge as a result of the volume charge would be enormous, the field just inside the surface layer being of the order 10^{8} volts per centimeter. There is consequently no obvious way in which the separation of charges could be maintained.

A modification of the foregoing possibilities is to be found in supposing that the rotation brings about a radial polarization in the atoms. The rotation of such a polarized system gives rise to a magnetic field, and also, of course, to an electric field. The latter may be compensated at external points by a suitable distribution of charge over the surface, and the rotation of the combined electrostatic distribution would produce a magnetic field17). On submitting the matter to calculation, we find that the polarization necessary to give rise to a magnetic field comparable with that of the earth is such as would correspond to each having the moment which it would acquire by the separation of a proton and electron to the extent of an atomic diameter. (*See* ATOM.) While the distribution of charge over the surface would come about automatically in the case of conducting atmosphere, it would, however, not remain on the surface since the polarized distribution of the interior would give rise to an enormous field of the order of 10^{6} volts per centimetre tending to draw it inwards. A possibility closely resembling the foregoing is one suggested by Sir Joseph Larmor18), who examines the consequences of supposing that the earth may be regarded as a rotating polarized crystal.

The complete inadequacy of non-electrical forces of ordinary type to maintain against the electrostatic forces such charge distributations as would be necessary to produce, by their rotation, a magnetic field comparable with that of the earth may be illustrated by one or two examples. Thus, the centrifugal force of the earth's rotation would, in a conducting earth cause a flow of electrons to the exterior until compensation was attained by the electrostatic forces. On submitting the matter to calculation19) we find that the magnetic field which results is only about 10^{-23} of the earth's field. Moreover, for an observer situated on the sphere, the horizontal component H would be of the same sign as that of the earth for latitudes 0° to 26·6°, and of opposite sign for other latitudes, while the vertical component would be of the same sign as that of the earth for latitudes 0° to 51° and of opposite sign elsewhere.

The effect of centrifugal force is to produce (a) a uniform volume distribution giving rise at external points to a magnetic potential

$$\Omega_1 = 2m\omega^3a^5\cos\theta/15c^2er^2$$

where e and m are the electronic charge and mass. (b) A uniformly distributed surface charge of total amount equal and opposite to the volume charge, and giving rise to a magnetic potential

$$\Omega_2 = -2m\omega^3a^5\cos\theta/9c^2er^2$$

(c) A non-uniformly distributed surface charge of total amount zero, giving rise to a magnetic potential

$$\Omega_3 = \frac{-m\omega^3a^3}{3c^2e}\left\{\frac{a^2}{3r^2}\cos\theta - \frac{3a^4}{14r^4}\left(5\cos^3\theta - 3\cos\theta\right)\right\}.$$

The external electrostatic potential arises only from the non-uniformly distributed charge, and is given by

$$V = \frac{m\omega^2a^5}{3er^3}\left(1 - \tfrac{3}{2}\sin^2\theta\right).$$

If the free electrons in the substance of the earth are affected by gravity, we should expect them to tend to congregate towards the centre until equilibrium was established on account of their pressure and electrostatic repulsion, the latter equilibrating influence being the all important one. On submitting the matter to calculation[19], we find that the magnetic field which results is of the order 10^{-21} of the earth's field, and is moreover opposite in sign to that of the earth.

The solution for the foregoing case gives (a) a uniform negative volume charge of such amount as to give rise to a magnetic potential

$$\Omega_1 = -4\pi DGm\omega a^5\cos\theta/15c^2er^2$$

D being the density of the earth's substance, and G the gravitational constant. (b) A uniformly distributed positive surface charge of total amount equal to that of the volume charge, and giving rise to a magnetic potential

$$\Omega_2 = 4\pi DGm\omega a^5\cos\theta/9c^2er^2$$

There is of course no external electrostatic field.

Owing to the fact that the inside of the earth is hot, the pressure of the free electrons in the earth's interior will exceed that in the cooler parts, and there will be a flow of electrons until the remaining difference in pressure is balanced by the difference of potential set up. The potential difference which arises in this manner is none other than that corresponding to the well-known Thomson effect. The rotation of the charge distribution set up by this process gives rise to a magnetic field. If we submit the matter to calculation[19] on the classical theory of electron equilibrium, we find that the results depend upon the type of the radial temperature and are greatest for the case where the gradient takes place entirely in a shell near the surface. In this case, assigning a total temperature change of 5,000° C, we find that the resulting magnetic field produced is of the order of 10^{-17} of the earth's field. The sign of the field corresponds to that of the earth.

The analysis for this case shows a volume distribution of positive charge and a surface distribution of negative charge. Since both are symmetrically distributed (although the volume charge is not uniformly distributed), there is no external electric field.

If, in accordance with the customary assumption in electron theory of thermionic effects we assume the number n of free electrons per c.c. to be proportional to the 1·5 power of the absolute temperature T, we find for the magnetic potential due to the combined system of charges

$$\Omega = \frac{-16}{9}\,\frac{a\omega\cos\theta}{c^2er^2}\int_{T_s}^{T_c} R^3dT$$

when R is the distance from the centre of the sphere to a place where the temperature is T, and T_s and T_c are the temperatures of the surface and centre of the sphere respectively. For the case where the whole temperature drop occurs in a thin shell, near the surface the integral assumes the form $a^3(T_c\text{-}T_s)$.

The foregoing considerations will serve to emphasize the general principle that, at any rate, unless we are willing to alter our fundamental laws, it is impracticable to attempt any explanation of the earth's magnetism as a result of the rotation of charges which have been separated against electrostatic attraction, since the mechanical forces necessary to produce the required separation must be, in all cases, enormous and far beyond the limits of such forces as are available.

Possibilities of Modification of Laws.—Many years ago, Lorentz suggested a modification of the laws of electrical attraction and repulsion with the object of accounting for gravitation. He assumed that unlike units of charge attracted each other with a force slightly greater than that with which like units repelled each other. It would result from this that two pieces of neutral matter would exhibit an attraction, and this attraction he associated with gravitation.

If, assuming that unit charges of either sign are defined so that the repulsive force between like charges, e_1, e_2 is $\frac{e_1e_2}{r^2}$, we also assume that the force exerted by a positive charge e_+ on a negative charge e_- is $(1+\alpha)\,\frac{e_+e_-}{r^2}$ and the force exerted by a negative charge e_- on a positive charge e_+ is $(1-\beta)\,\frac{e_-e_+}{r^2}$, where α and β are small positive quantities, we obtain a wider range of possibility[20].

It would, on this hypothesis, result that a free electron in a neutral sphere would not be in equilibrium since the attraction on it due to the positive charges within would outweigh the repulsion due to the negative. It would be necessary for the sphere to acquire a negative charge in order that equilibrium should be established, and it is possible to determine α so that this negative charge would be such as to give rise by its rotation to a magnetic field comparable with that of the earth. While β plays no part in determining the equilibrium of a free electron, it does play a part in determining the total force which would be exerted on the element of matter composed as it is of both positive and negative electrons; and, it is possible to determine β so that the net force on the element of matter is just such as to correspond to gravitation. In order to account on these lines for both terrestrial magnetism and gravitation, it is necessary to have

$1+\alpha = 1+1{\cdot}9\times10^{-19}$, and $1-\beta = 1-(1{\cdot}9\times10^{-19})+(0{\cdot}78\times10^{-36})$

so that both α and β are zero to within all limits of detection by laboratory experiments. We obtain by our hypothesis a volume charge sufficient to give by its rotation the earth's magnetic field; but, our modification of the law of attraction has saved us from the consequences of a very large electric field such as we should encounter on classical lines; and, indeed, the residual electrical forces have been adjusted so as to no more than satisfy the demands of gravitation.

The details of the calculation are as follows: let ρ_+ and ρ_- be the densities of positive and negative electricity, respectively.

The condition that a free electron in the matter shall be in equilibrium is

$$\text{grad}\,(1+\alpha)\iiint\frac{\rho_+}{r}d\tau + \text{grad}\iiint\frac{\rho_-}{r}\,d\tau = 0 \tag{4}$$

where the integrals are taken throughout the regions comprised by the matter.

The force on all the electricity in an element of volume dV is

$$\begin{aligned}&\left[\text{grad}\,(1+\alpha)\iiint\frac{\rho_+}{r}\,d\tau + \text{grad}\iiint\frac{\rho_-}{r}\,d\tau\right]\rho_-dV\\ &+\left[\text{grad}\,(1-\beta)\iiint\frac{\rho_-}{r}\,d\tau + \text{grad}\iiint\frac{\rho_+}{r}\,d\tau\right]\rho_+dV\end{aligned} \tag{5}$$

where, in the general case, the ρ's might be functions of the coordinates. This is the quantity which the theory makes equal to the gravitational force on the element of volume dV. Thus, using (4) and (5), we have

$$\left[\text{grad}\,(1-\beta)\iiint\frac{\rho_-}{r}\,d\tau+\text{grad}\iiint\frac{\rho_+}{r}\,d\tau\right]\rho_+dV$$
$$=\left[\text{grad}\,G\iiint\frac{D}{r}\,d\tau\right]DdV \tag{6}$$

where D is the density of the matter. Now, if m_+ and m_- are the masses of a proton and an electron, respectively, and N_+ and N_- the corresponding numbers of these entities per c.c.,

$$D=N_+m_++N_-m_-.$$

For a body which is sensibly neutral, or for which N_+-N_- is small compared with N_+, we consequently have

$$D=N_+(m_++m_-)=\frac{\rho_+}{e}(m_++m_-) \tag{7}$$

where e is the electronic charge, so that, from (6),

$$\text{grad}\,(1-\beta)\iiint\frac{\rho_-}{r}\,d\tau+\text{grad}\iiint\frac{\rho_+}{r}\,d\tau$$
$$=\left(\frac{m_++m_-}{e}\right)G\,\text{grad}\iiint\frac{D}{r}\,d\tau. \tag{8}$$

For (4) and (8) to be true, it is sufficient that

$$(1+\alpha)\rho_++\rho_-=0 \tag{9}$$

and

$$(1-\beta)\rho_-+\rho_+=\left(\frac{m_++m_-}{e}\right)GD \tag{10}$$

and these conditions are also *necessary* if (4) and (8) are to be true for bodies of all shapes.

From (10) and (7),

$$(1-\beta)=-\frac{\rho_+}{\rho_-}\left[1-\left(\frac{m_++m_-}{e}\right)^2G\right]. \tag{11}$$

The net quantity of electricity ρ per unit of volume is,

$$\rho=\rho_++\rho_-. \tag{12}$$

Hence, from (11) and (12),

$$1-\beta=\left[\frac{1}{1-\frac{\rho}{\rho_+}}\right]\left[1-\left(\frac{m_++m_-}{e}\right)^2G\right] \tag{13}$$

i.e., approximately

$$\beta=-\frac{\rho}{\rho_+}+\left(\frac{m_++m_-}{e}\right)^2G \tag{14}$$

and from (9) and (12)

$$\alpha=-\frac{\rho}{\rho_+}. \tag{15}$$

Since ρ_+ is given in terms of D by (7), equations (14) and (15) serve to determine α and β in terms of $(m_++m_-)/e$, G and ρ. The last named quantity becomes determined as the value necessary to give rise to the earth's magnetic field as a result of its rotation. The necessary value of ρ is

$$\rho=-3{\cdot}0\times10^{-4}\text{e.s.u.}$$

Putting $G=6{\cdot}6\times10^{-8}$, $D=5{\cdot}5$, and $\frac{m_++m_-}{c}=0{\cdot}345\times10^{-14}$, we readily find

$$\alpha=1{\cdot}9\times10^{-19};\quad\beta=1{\cdot}9\times10^{-19}+0{\cdot}78\times10^{-36}.$$

Tempting as the foregoing view may seem, it is not without its difficulties. For, it turns out that if we desire to formulate a complete scheme of electrodynamics in such a manner as to conform to the requirements of the theory of relativity, we must not allow ourselves to modify the law of force between statical charges without modifying that between moving charges as well, and in the same ratio. Now the effect of motion of a charge on the force exerted on that charge by other charges is precisely the effect which we recognized as that of the magnetic field caused by those other charges; and, when everything is taken into account, it turns out that the magnetic field caused by the rotation of the positive electricity is different in magnitude as well as in sign from that caused by the rotation of an equal distribution of negative electricity, and the difference is just such as to cancel the magnetic field resulting from the excess of one kind of charge over the other[20]. Thus, the net result is that no magnetic field is obtained as a result of the rotation of the system; and, the only way in which to secure a magnetic field on these lines is to sacrifice conformity with the requirements of the restricted theory of relativity.

Possibilities in Circulation of Currents.—If currents flowed in circles with planes perpendicular to the earth's axis, they would generate at external points a field roughly similar to the earth's field. If the current density were uniform throughout the earth its magnitude would have to be of the order of 10^{-8} ampere in order to provide for the facts, and the general order of magnitude would not be materially altered if the current density varied throughout the earth in any manner which preserved the same order of magnitude for the greater part of the earth's volume. One's first thought concerns the question of where the electromotive forces necessary to maintain such currents could come from, and here we encounter a rather curious phenomenon. The electrical inertial considerations (self induction) in the case of a body of the earth's size become of enormous importance, so that currents once generated take a long time to die down after the source of electromotive force which caused their generation has been removed. Thus H. Lamb[21] has shown that currents generated in a copper sphere of the size of the earth would take about 3 million years to die to one-third of their value after the source of electromotive force was removed. A somewhat similar situation exists in relation to a sudden destruction of an initial state of permanent magnetization. Thus if a sphere of the size of the earth were originally magnetized and the state of magnetization were destroyed, for example, by a sudden rise of temperature, the change of magnetic flux attending the destruction of the magnetization would set up induced currents which would tend to perpetuate the field to such an extent that in the case of a conductivity comparable with copper, about 3 million years would elapse before the field due to the sphere at a point had sunk to a value comparable with one-third of its original value[22]. Suggestive as are these considerations in tempting us to see in them the origin of currents which would account for the earth's magnetism we have to realize the great improbability of a conductivity of the earth's interior sufficient to provide for the necessary requirements. Data as to the conductivity of the earth's interior drawn from considerations based on the theory of the diurnal variation suggest a value so small as to insure that such current as the above would fall to one-third of their original values in two or three days.

A possible source of maintenance of internal currents has been suggested by Lamor[18], chiefly in reference to an explanation of the magnetic field of the sun. If there is any internal circulation of matter in meridional planes and if we start with an initial magnetic flux parallel to the polar axis, the flow will set up induced currents in circles parallel to the equator. If the initial magnetic flux is in the right direction in relation to the circulation, the induced currents set up will increase the original field, so that a finite field may become produced in this manner from infinitesimal beginnings, as in the case of a self exciting dynamo, the energy coming, of course, from the internal circulation. On such a view, the secular variation would have to seek its origin in a secular periodicity in the internal circulatory motion.

The enormous amount of positive and negative electricity in the earth tempts us to seek in strange places for possibilities as regards a residual current which might result from a slight difference in their velocities. Thus, if the free electrons in the earth were *absolutely* free, and if the remainder of the substance of the earth were dying down in velocity, for example as a result of total friction, and if the causes responsible for the decay of motion operated only on the part of the matter other than the free electrons, the latter would continue to revolve with undiminishing velocity, and as time went on a large current would result from the relative motion of these electrons and the remainder of the earth's substance. In practice, the relative motion would only grow until the drag due to friction—in this case, electrical resistance—which resulted from the relative velocity was sufficient to bring about the continual destruction of momentum of the electrons as a result of their continual loss of velocity. On submitting the matter to calculation we find that, for the specific resistance of the earth's core as calculated from diurnal variation considerations, it would be necessary for the earth to lose practically the whole of its angular velocity in a very small fraction of a second in order that the electric current set up as a result of the drag should be sufficient to account for the earth's field.

The argument for the foregoing consideration is as follows: Suppose σ is the specific resistance of the material of the earth, e the electronic charge, and m the mass. Then, if i is the electric current density sought, and if v is the tangential velocity of the earth at the point in question

$$\sigma ie=-m\frac{dv}{dt}$$

$$\frac{1}{v}\frac{dv}{dt}=\frac{\sigma ie}{mv}.$$

Putting $\sigma=0{\cdot}3\times10^{18}$ e.m.u.11), $i=4\times10^{-10}$ e.m.u., $e/m=1{\cdot}7\times10^{7}$, and $v=5\times10^{4}$, we find

$$-\frac{1}{v}\frac{dv}{dt}=4\times10^{5}\text{ nearly.}$$

Even had the specific resistance been as low as that of copper, viz. $0{\cdot}7\times10^{3}$, we should have found

$$-\frac{1}{v}\frac{dv}{dt}=8\times10^{-5},$$

and it would have been necessary for the earth to lose practically the whole of its velocity in less than a day in order to give rise to a magnetic field comparable with that of the earth.

Quite apart from considerations invoking a finite rate of decay in the earth's rotation, it is not out of the realm of possibility that the mere rotation itself may bring about a condition in which there is a relative motion between the free electrons and the remainder of the matter. It may not even be necessary to provide a source of power to maintain the relative motion in opposition to electrical resistance; for, such a state of relative motion may be the state of equilibrium which must be attained in order that there shall be no dissipation of energy. The elements which enter in this connection are those associated with the mechanism by which electrical conductivity arises in a metal and there are certain not unreasonable hypotheses which would provide for conditions of this kind17). However, any attempt to account for the earth's magnetism along these lines must necessarily be highly speculative.

Magnetization of Rotation.—If we believe that the atoms of which the substance of the earth is composed are magnetic, and that this magnetic condition arises from the rotation of electrons in the atom, we should expect the atoms to act like gyroscopes and tend to turn with their axes parallel to the axis of the earth's rotation, this effect in favour of organized orientation being opposed by the temperature agitation of the molecules. However, a phenomenon of this kind makes the intensity of magnetization independent of the size of the sphere for a given angular velocity17), so that if it were a potent factor in the case of the earth's magnetism, the effect would be very readily observable in the case of small bodies set into rotation in the laboratory. The magnetization produced by rotation has been experimentally measured by S. J. Barnett, and both calculation and experiment alike show that even in the most favourable case, that of an earth with an iron core, we could not expect to realize a magnetic field more than about 10^{-10} for the earth's magnetic field.

It has sometimes been suggested that a very weak magnetizing intensity, either of the nature of a magnetic field of unknown origin or of a dynamical nature such as the gyroscopic action just discussed might, in the presence of an abnormally large permeability, result in an intensity of magnetization comparable with that of the earth. Such might indeed be the case for a long cylindrical body; but, in the case of a sphere magnetized to an intensity I, there is within the sphere a demagnetizing field equal to $I/3$, resulting from the so-called fictitious distribution of positive and negative magnetism on the two hemispheres (this fictitious distribution being of course, as regards its action, the representative of all the molecular magnets of which the sphere is composed). Thus, to be effective, any magnetizing influence, magnetic or otherwise, must be such as to exert on the molecule a couple equal to that exerted by a magnetic field equal to one-third of the resultant magnetic intensity to be produced in the sphere.

Possibilities of Modifications in Classical Electrodynamics.—The fact that the positive electricity and the negative electricity in the earth, taken by themselves, produce by their rotations such enormous magnetic fields tempts us to inquire whether some slight modification in classical electrodynamics may be made which would permit a lack of complete compensation between the effects of the electricity of opposite sign and leave the observed magnetic field as a residual. We have already discussed one such possibility under *Possibilities of a modification of laws of force between electric charges;* but although the idea there involved was comparatively simple, the result was secured at the expense of conformity with the theory of relativity. By adopting a rather more radical modification of the electrodynamic laws23), but one consistent with the theory of relativity, it has been found possible to provide for a situation in which, while the laws for the fields due to negative electricity are unaltered, the modified equations demand a contribution to the magnetic field produced by the positive electricity as a result of the acceleration, rate of change of acceleration, etc., which it experiences in its rotation, a contribution non-existent in the case of the negative electricity. The superposed distributions no longer cancel as regards magnetic field and a residual is provided for. Moreover, the modification of the laws demanded for the positive electricity is a violation of the equation of continuity, so that positive electricity is gradually destroyed as a result of the rotation, with a result that the surplus negative electricity piles up until it has created a potential gradient in the atmosphere sufficient to insure its departure into space at a rate which balances its accumulation. (*See* ELECTRICITY: *Atmospheric.*) Finally, the modification contains a provision for a difference between the force between like and unlike charges which provides for gravitation in a manner roughly analogous to that described in section *Possibilities of a modification of the laws of force between electric charges.*

The modifications necessary in the fundamental laws are extremely small in magnitude for such accelerations, etc., as are concerned in the earth's rotation. Thus, for example, the modification in the equation of continuity corresponds to a disappearance of only 0·5 per cent of the earth's mass in 10^{20} years, and the difference between the force of attraction between like units of electricity and the force of repulsion between unlike units amounts to less than one part in 10^{36}.

The form of the modification is adjusted so as to secure the correct ratio of the magnetic field of the earth to that of the sun and to predict an almost negligibly small magnetic field for a body of laboratory dimensions rotating at the highest attainable speed. It must be remarked, however, that the value of comparison with the sun is largely diminished on account of entirely different conditions and nature of the magnetic field to be found on that body. In one form of the theory, the expression for the magnetic field as a function of the angular velocity and size of the rotating body leads to the conclusion that magnetic fields of the known order 2,000 gauss may be expected in sunspots provided that in the spots, the solar gases may be supposed in rotation with the not unreasonable peripheral speed of 80 kilometers per second.

A brief outline of the details of the theory is as follows: The electromagnetic equations,

$$(A)\ \frac{\rho\mathbf{u}}{c}=\frac{1}{c}\frac{\partial\mathbf{E}}{\partial t}+\operatorname{curl}\mathbf{H},\quad (C)\ 0=\frac{1}{c}\frac{\partial\mathbf{H}}{\partial t}+\operatorname{curl}\mathbf{E}.$$

$$(B)\ \rho=\operatorname{div}\mathbf{E},\qquad (D)\ 0=\operatorname{div}\mathbf{H},$$

together with a force equation of the form

$$(H)\ \left(\mathbf{E}+\frac{[\mathbf{w}\cdot\mathbf{H}]}{c}\right)e=\frac{d}{dt}(m_o k\mathbf{w}),$$

with $k=\left(1-\frac{\mathbf{w}^2}{c^2}\right)^{-\frac{1}{2}}$ are taken as a basis from which to generalize.

The equations corresponding to $(A)-(D)$ are left unchanged for the fields due to negative electricity; but for the fields due to positive electricity they are generalized in the following way:—The 4-vector $\rho\mathbf{u}$, ρic associated with (A) and (B) is replaced by a more general 4-vector $\mathbf{S}$, $ic\mathbf{S}_t$, given by

$$(I)\ \mathbf{S}=\rho_+\mathbf{u}_+ +\alpha k_+ d\frac{(\rho_+\mathbf{u}_+)}{dt}+\beta k_+\frac{d}{dt}k_+\frac{d}{dt}(\rho_+\mathbf{u}_+)=\rho_+\mathbf{u}_+ +\alpha\mathbf{P}+\beta\mathbf{Q},$$

$$(J)\ \mathbf{S}_t=\rho_+ +\alpha k_+\frac{d\rho_+}{dt}+\beta k_+\frac{d}{dt}k_+\frac{d\rho_+}{dt}=\rho_+ +\alpha\mathbf{P}_t+\beta\mathbf{Q}_t$$

where α and β are invariants of the Lorentzian transformation, and the $\mathbf{P}$'s and $\mathbf{Q}$'s have the values defined in (I) and (J). The additional terms in (I) and (J) destroy the equation of continuity, the only one appreciably operative in this respect for uniform rotation being $\alpha\mathbf{P}$. By an appropriate choice of α we can make this term give rise to a slow death of positive electricity (amounting to a loss of 0·5 per cent of the earth's mass in 10^{20} years) such as to leave a continually increasing surplus of negative which, after building up the necessary electric field, passes off continually, as the atmospheric electric current, by conduction through the atmosphere.

The generalized equations lead, very approximately, to the same expressions for the fields as are given by the classical theory, except that the $\rho_+\mathbf{u}_+$ and ρ_+ of classical theory are replaced by $\mathbf{S}$ and $\mathbf{S}_t$. Thus, in the case of a rotating neutral earth there is a fictitious current density $\alpha\mathbf{P}+\beta\mathbf{Q}$ and a fictitious charge density $\alpha\mathbf{P}_t+\beta\mathbf{Q}_t$. The value of α chosen as above is too small to make appreciable contribution to the fictitious current density. The fictitious current density is provided for by $\beta\mathbf{Q}$, and the choice of β necessary to result in a magnetic field equal to that of the earth is such that, as regards any fictitious charge density of importance in its power to give rise to the earth's electric field, the term $\beta\mathbf{Q}_t$ is negligible, as is also the term $\alpha\mathbf{P}_t$. The electric field is provided for otherwise, as outlined above.

The forms of the invariants α and β are chosen so that the theory gives the correct ratio for the magnetic field of the earth to that of the sun, and predicts for a small sphere of laboratory size, rotating at the highest attainable speed, a magnetic field and a rate of death of charge which would be immeasurable, or measurable only with considerable difficulty.

Gravitation is provided for by a replacement of the force equation by two equations, for the motions of positive and negative electrons respectively, the modification implying, primarily, a difference in the forces between equal like charges and equal unlike charges.

Magnetic Field of the Sun.—The magnetic field of the sun is of particular interest in relation to theories of terrestrial magnetism; for, in the sun and earth we are presented with bodies of entirely different size, angular velocity, and physical condition. In addition to strong magnetic fields of the order of 2,000 gauss which are to be found in sunspots, the sun possesses a general magnetic field similar in some respects to that of the earth, but with very important differences.

The Zeeman effect affords a means of measuring the magnetic intensity at different levels in the sun's atmosphere. Measurements extend from altitudes of 250 kilometres to 450 kilometres above the sun's disc, and show a remarkably sharp decline in value from 50 gauss for the former altitude to 10 gauss for the latter. If the magnetic field of the sun were anything like that of a uniformly magnetized sphere, the field would vary as the inverse cube of the distance from the sun's centre, and would change by only about 0·1 per cent between the altitudes cited.

The direction of the sun's magnetic field at a point bears the same relation to the direction of rotation as in the case of the earth, and the magnetic axis of the sun is inclined at an angle of about 5° to the axis of rotation. The magnetic axis, moreover, exhibits a rapid "secular" variation consisting of a rotation in the opposite direction to the rotation of the sun, with a period of about eight months.

THEORIES OF MAGNETIC IRREGULARITIES AND VARIATION

Magnetic Irregularities.—The difficulties of accounting for the larger irregularities of the earth's field are bound up with our lack of knowledge of the composition of the earth's crust to any considerable depth. Local irregularities can in most cases be assigned to local deposits of magnetic material. An ingenious attempt to ascertain the general nature of the conditions necessary to provide for the main features of the earth's magnetic abnormalities was made by Wilde24), who constructed a "magnetarium" designed to reproduce the main features of the earth's field and also its secular variation. Wilde's magnetarium consisted of a globe 18 inches in diameter provided with plates of iron attached to its under side beneath the oceans, and in one or two other locations. Within the sphere, and fastened to it, was a spherical shell of wire gauze supporting a current winding with its planes parallel to the equator. Within the gauze shell was mounted a smaller sphere which could be made to revolve about an axis inclined at 23·5° to the axis of the first sphere, and which was wound with wire in planes perpendicular to its axis of rotation. Wilde's views have not passed without criticism. However, a consideration of the depth to which the probable temperatures conditions within the earth would permit iron to exist in magnetizable form, combined with the effect of the ocean areas in modifying the temperature gradient, and the requirements imposed by the hypothesis of isostasy lend support to reasonableness of the condition suggested by the magnetarium, as regards their application to the larger irregularities11). The part of Wilde's conclusions having to do with currents circulating within the earth, and with the secular variation must necessarily remain more speculative.

Theory of the Diurnal Variation.—The fundamental idea underlying the cause of the diurnal variation is undoubtedly that originated by Balfour Stewart. According to this view, the motion of the earth's upper atmosphere under the influences of the tides sets up electromotive forces on account of the cutting of the earth lines of force by the moving air. These electromotive forces set up currents in the atmosphere in regions where the conductivity is sufficient and these currents, varying as they must with the tides, produce magnetic fields which also partake of the tidal periods. In addition to the direct effect of the atmospheric currents, induced in the above manner, there is a secondary effect caused by the induced currents which the time rates of change of the atmospheric currents set up in the substance of the earth. According to S. Chapman7), these currents induced in the earth contribute about 28 per cent of the total diurnal variation.

The two bodies chiefly concerned in producing the atmospheric motions which are the origin of the diurnal variation are the sun and the moon. If we first confine our attention to the variation of the magnetic elements throughout the lunar day, averaging the results for any (lunar) time of day throughout one or more months, and if we plot the results so obtained against the time, we find that the curves are symmetrical in horizontal intensity north and south of the equator, and anti-symmetrical in declination and (outward) vertical intensity. All the curves are purely semi-diurnal in type. These features are accounted for by the assumption that the atmospheric motions are of the lunar tidal type. The barometer indicates semi-diurnal variations in atmospheric pressure indicating the existence of an atmospheric lunar tide, and this must involve a circulation of the air, the flow being mainly horizontal11). It is consequently the earth's vertical component of magnetic intensity which is mainly concerned in the production of the electric currents in the conducting regions of the atmosphere. An element of lack of harmony between theory and observations appears, however, in a numerical comparison of the phase of the magnetic diurnal variation and that of the oscillations in barometric pressure[11].

If, instead of plotting the means for one or more lunar months, we plot the data for the individual lunar days, the curves obtained are more complicated than those constructed from the monthly means. In a general way the complication is in the direction of a magnification of the magnetic variations during the daytime. On plotting the magnetic elements throughout the solar day, using for this purpose a number of the quietest days for the month, we obtain curves which have many features in common with those obtained by plotting against time for the lunar day, but the amplitudes are about eleven times those for the lunar day. This is in harmony with the expectations arising from the barometric variation, which, for observations plotted throughout the solar day, indicate amplitudes of tidal motion fifteen times those obtained by plotting the monthly averages throughout the lunar day. It is probable that the atmospheric motions associated with the sun have their origin in temperature differences rather than in ordinary tidal forces; for, if this were not the case, the lunar variation of barometric pressure should be greater than the solar variation, since the purely tidal influence of the moon is about twice that of the sun.

The inferences to be drawn from terrestrial magnetism as regards the conductivity of the upper atmosphere have been summarized under ELECTRICITY: *Atmospheric.*

Magnetic Storms.—One of the first attempts to explain magnetic storms attributed them to the magnetic fields produced by streams of charged particles emanating from the sun; but, as pointed out by Schuster, such theories are untenable because the natural repulsion of the parts of such a stream would prevent its arriving at the earth in sufficiently concentrated form. S. Chapman[25] has shown that the most characteristic features of magnetic storms may be explained by supposing that they are produced by atmospheric currents set up as a result of the cutting of the earth's horizontal component by a radial motion of an atmospheric conducting layer. The magnetic phenomena suggest a radial motion inwards at the commencement of the storm, followed by an outward radial motion. In the original form of Chapman's theory the primary agency responsible for the storm was a stream of alpha particles from the sun, the outward radial motion resulting from the subsequent mutual repulsion of the positive charges. Lindemann[26] has criticized the theory in this form on the grounds that a stream of alpha particles of the necessary strength would imply an unwarrantedly large radioactivity in the sun, and that further, a stream of the necessary intensity could not hold itself together against self-repulsion in its journey from sun to earth. Lindemann himself has suggested as the origin of these storms, groups of positive and negative particles shot out from the solar prominences under the influence of the pressure of light. As a matter of fact, actual observations of the rate of growth of solar prominences indicate that the gases in these cases attain velocities of the order of 10^8 cms. per second, and this velocity is sufficient to make reasonable the assumption of their journey from sun to earth without serious recombination. The neutrality of the stream as a whole would provide an escape from the difficulties inherent in self-repulsion. Lindemann supposes that the negative ions may be lighter than the positive, so that the former are stopped in the outermost regions of the atmosphere, while the positive ions penetrate deeper down and are responsible for auroral phenomena.

If, as is likely to be the case, the positive ions were hydrogen atoms or molecules, they would be lighter than the molecules to which the electrons attach themselves on their impact with the outer atmosphere. The subsequent attraction of the positive and negative ions would consequently result in an outward motion of the negative ions which would be more rapid than the inward motion of the positive ions. The net result would be that, following the initial effects due to the influx of the stream, there would be the equivalent of an outward flow of gas, and this gas cutting across the horizontal component of the earth's field would give rise to the type of atmospheric currents necessary to account for the most characteristic features of magnetic storms[11].

Of course, the earth's magnetic field would act independently on the two oppositely charged portions of the neutral stream of particles, tending to separate them, but with a sufficiently intense beam this tendency to separate would become almost immediately compensated by the electrostatic field resulting from the separation, so that the beam as a whole would travel practically uninfluenced by the earth's magnetic field. The facts associated with the aurora do demand a concentration of ionizing towards high latitudes, however, so that it would seem difficult to avoid the conclusion that there is an excess charge of one sign in the material radiations from the sun, unless, indeed, it is possible to formulate a condition, satisfying the mathematical requirements and in which the magnetic field of the earth bends the paths of both the positive and negative particles in such a manner as to result in a concentration in the auroral zones without there being necessarily a large excess density of one sign anywhere. In this connection it must be remembered that the path of a charged particle may be bent completely around the earth, so that it is not out of the realm of possibility that in spite of the fact that the positive particles are bent in opposite directions to the negative by the magnetic field, there may exist a general intermixing and intersection of orbits of oppositely charged particles such as to reduce greatly the electrostatic fields which would otherwise be set up in the absence of such conditions.

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(W. F. G. S.)

TERRISS, WILLIAM (1847–1897), English actor, whose real name was William Charles James Lewin, was born in London on Feb. 20, 1847. After trying the merchant service, medicine, sheep-farming in the Falkland isles, and tea-planting in Bengal, in 1867 he took to the stage. He quickly came into favour, and appeared at the principal London theatres from 1868 onwards. In 1880 he joined Irving's company at the Lyceum, playing such parts as Cassio and Mercutio. He was then engaged to take the leading parts in Adelphi melodrama. His last appearance was in *Secret Service.* On Dec. 16, 1897, as he was entering the Adelphi theatre, he was stabbed to death by a madman, Richard Prince. Terriss married Miss Isabel Lewis, and his daughter Ellaline Terriss became a well-known actress in association with her husband Edward Seymour Hicks (b. 1871).

See Arthur J. Smythe, *The Life of William Terriss* (1898).

TERRITORIAL ARMY. The end of the nineteenth century saw a situation very similar to that at the end of the eighteenth century. The possibility of this country's being engaged in a major war, and fear that an enemy would attempt an invasion of the British Isles. Like so many British institutions, the army grew with its own momentum, encouraged in differing degrees, its organization not proceeding with its growth. The Royal Commission of 1904 laid stress on the fact that organization for war was almost non-existent, and concluded with the unanimous opinion that from these and other defects of education and training, the force was not qualified to take the field against the troops of a Continental army (Report of Royal Commission on the Militia and Volunteers, 1904, paragraphs 35–49, 57, 58).

The military forces of the Crown in 1906 comprised the first line, or regular army; the second line was provided by the Militia; the third line consisted of the volunteers and yeomanry. The third line was separately organized from the other two, and owing to a disbelief in its value was given no permanent place in any scheme for using the available military resources of the nation in the event of war.

Such was the situation which faced Lord Haldane and his advisers in 1907; how well the reorganization was done may be shown by the words written by Earl Haig on the fly-leaf of a copy of War Despatches given by him to Lord Haldane on Peace Day:—

> "In grateful remembrance of his successful efforts in organizing our Military Forces for a war on the Continent."

The reorganization of the Army of 1908 retained the regular army, reorganized into six Divisions and four cavalry brigades and the necessary army troops as the first line; changed the militia into the "special reserve" with the duty of finding and training drafts for the first line, the territorial force becoming the second line.

The Territorial Force was for home defence, but within itself contained a "special service section," men of which volunteered to occupy posts outside the United Kingdom vacated by the regular army, or to serve within the United Kingdom for purposes of defence whether the territorial force be embodied or not. The T.F. was organised on a county basis, and of necessity additional units were raised to complete the new arms or services, whilst redundant units, particularly infantry, were either disbanded or reconstituted into units of a different arm.

Before 1908, the universities and many public schools had volunteer corps attached to the local volunteer unit. These were transformed into an "officers' training corps" administered direct by the War Office, a far reaching change, as the World War proved.

Administration and Training of the territorial force were separated, officers commanding units being no longer personally responsible for the finances of their units. County territorial force associations for each county were formed under the presidency of the Lord Lieutenant, consisting of representatives of the county and borough Councils, the territorial units of the county and certain co-opted members. The duty of these associations was to raise and equip the men, provide accommodation, and generally relieve the units of all details and other responsibilities outside training. The Under Secretary of State for War was given the direct responsibility for this side of the work, and a territorial directorate was established at the War Office under his direction. The training remained the responsibility of the military authorities.

The Fear of Invasion.—Six months of training were considered necessary after mobilization before the force could take the field overseas, and liability for service overseas was not insisted upon. The possibility of an invasion of the British Isles was always in the mind of the nation; the functions of the territorial force were therefore to supply garrisons for naval and other fortresses; to repel raids; and, by voluntary agreement to furnish units for the expansion of the Expeditionary Force.

The World War.—So 1914 found the Territorial Force. On the outbreak of the World War, Lord Kitchener, who assumed control at the War Office, realized that the existing military forces would not be sufficient, the territorial force being without reserves, and in his scheme of expansion discarded the county system that had been built up, and raised and trained the New Armies.

Soon after the outbreak of the war there were urgent demands for reinforcements in France, and territorial units volunteered readily for overseas service. In his dispatch dated Nov. 20, 1914, which covered the period Oct. 8 to Nov. 20, 1914, Field Marshal Sir John French reported:—

> "In the period covered by this despatch territorial troops have been used for the first time in the army under my command. The units actually engaged have been the Northumberland, Northamptonshire, North Somerset, Leicestershire and Oxfordshire Regiments of Yeomanry cavalry; and the London Scottish, Hertfordshire, Honourable Artillery Company and the Queen's Westminster battalions of Territorial Infantry.
>
> "The conduct and bearing of these units under fire, and the efficient manner in which they carried out the various duties assigned to them, have imbued me with the highest hope as to the value and help of Territorial Troops generally."

By Dec. 1 2,413 officers and 66,805 other ranks of the territorial army had gone overseas (the 42nd division had proceeded to Egypt and the 43rd and 44th divisions to India, to take over garrison duties, and so permit the regular units to be relieved for active service).

As a complete territorial division, the 46th (North Midland) division was the first to proceed overseas to a theatre of war; by August 1915 the whole of the original fourteen territorial divisions were overseas, and towards the end of the war there were 21 territorial divisions in the various theatres of war, whilst to the end, one mounted and four infantry territorial divisions were maintained in this country for its defence against invasion.

There has been much controversy over the question whether it was wise that expansion of the military forces of Great Britain should be made through the medium of the "new armies" instead of through the existing organization of the territorial force, but there was a difficulty in the fact that the territorial soldier, unless he voluntarily offered, was not available for service overseas. Time showed that the territorial soldier was willing and eager to pull his full weight, but the decision had to be made before such knowledge was available.

In France, Flanders, Salonika, Gallipoli, Palestine and Mesopotamia territorial divisions served, whilst in India, Egypt, Malta and Gibraltar garrison duty was done, thus relieving regular units. The fourteen first line divisions served as complete divisions overseas in war areas—they were numbered consecutively from 42nd to 56th (except the 45th, a second line division) inclusive, and in addition eight, the 45th, 57th to 62nd, and 66th, second line territorial divisions served overseas. As the war went on, yeomanry units were amalgamated and formed the 74th division which also served overseas.

Reconstruction in 1920.—Demobilization saw the Territorial Force dispersed; all that remained were rolls of officers in the Army List. But the territorial force had proved its value, and the principle was accepted that in the event of any future war on a national scale, the territorial army would be the basis of expansion —the word "force" being dropped in the new scheme, and "army" substituted. In February 1920, the territorial army was reconstructed. The fourteen divisions were maintained, and as time went on various alterations from its pre-war constitution were made. One important truth was accepted, that the defence of these islands is overseas, and to-day, every man joining the territorial army signs up for overseas service. It is now organized on almost identical lines with the regular army, new units such as signal and armoured car companies being introduced by conversion from the yeomanry, which has been reduced from 14 Brigades to 2 Brigades. As the air is now so important a factor, territorial air squadrons, and their opposite numbers, air defence brigades, have been formed.

The territorial army to-day can truly be said to be a basic part of the military forces of the country. The training, too, has reached a far higher standard than before the war. At the army manoeuvres of 1925, the 162nd Infantry Brigade (T.A.) was selected to represent the territorial army, and met with the commendation of the Secretary of State for War who stated that the territorial soldier had proved himself indistinguishable from his comrade of the regular army.

Plans for Co-ordination.—It has been stated in Parliament that the territorial army is to be the basis of expansion of the British fighting forces in the event of a national war, although the exact method of such expansion has not yet been definitely announced. There is a handicap in the fact that the unit of organisation of the army is the division while the existing organisation of territorial army associations does not coincide with this.

Associations to-day are formed on the basis of local administrative areas with the county as the unit, but this is hardly ideal from the military point of view. The territorial army is actually made up of individual citizens recruited in the main from the larger centres of population. The main centres of population in many cases do not coincide with the county boundaries and communications whether by road or rail give a community of interest between towns which in many cases are situated in different counties. The old pride of "county" even has largely given place to the pride of town.

In view of the impending changes in military organisation, it may well be asked whether this would not be an opportune time to consider the question of the redistribution of the responsibilities of associations to make them coincide with the military distribution. Such a change would undoubtedly be a great advantage in the event of a general mobilization and the expansion that would be necessary. The division might be the main area, with, in widely extended areas, a brigade area as the minimum unit of administration. This would permit, by the amalgamation of offices, the payment of salaries adequate to ensure only first class men being appointed, and would tend to prevent the confusion and duplication that frequently occurred at the outbreak of the World War.

Territorial Associations consist of representatives of local authorities, co-opted members, and military members. The latter form the majority and must be serving or have served with the territorial army or its predecessor. To ensure a full appreciation of current problems the military members should be nominated by the units through the ordinary military channels, the representative members already being nominated by the units they represent.

Mechanism.—No study of the territorial army to-day can be complete without considering the influence that the advent of mechanization is likely to exert. The territorial army would benefit by mechanization and would improve in efficiency in a greater degree than even the regular. Life to-day is centred round industry and at their daily work men are brought into continual contact with machines, whilst in their leisure the car and motor bicycle are almost universally used; this means that a portion of the training required is already in the possession of the potential recruit and experience has shown that mechanical units attract a high class of recruit.

Training.—Although during the war and since the value of the territorial army has been acknowledged, in some quarters the view still lingers that the territorial army is not equal to the task required and that the territorial soldier cannot rise to the higher commands. This view is contradicted by history with its numerous examples of the success of armies composed of and commanded by citizen soldiers. There is no race in which the individual takes more quickly to the work of war than the people of the British Empire, and if the mistakes, under-valuation, and friction of the past are not to be repeated it is essential that the liaison between the regular and territorial armies should become more complete.

Liaison will not be complete until the two are in reality, not merely in name, branches of one army. To this end all avenues must be explored.

Distinction in Character.—With a sympathetic co-operation between the professional and amateur soldier the territorial army can undoubtedly attain and maintain such a state of efficiency that in the event of a fresh national emergency, the country will have a second line on which full military reliance can be placed. But it is well to emphasize that the only territorial soldier who is of value is the one who joins because soldiering appeals to him.

Much of the regular army's life is devoted to duties and ceremonial which have no place on the battlefield; all such work is unnecessary and even irritating to the territorial soldier who has joined for the "pure" soldiering life, and is anxious to learn. And as, at the same time, the annual training is usually his annual holiday, he does not view with satisfaction unnecessary restrictions such as evening passes out of camp, the surveillance of pickets and regimental police, and curfew—like "lights out" at an hour reminiscent of a schoolboy's bedtime. Experience, indeed, has shown that with the citizen soldier discipline is improved by the removal of restrictions which impair his self-respect and serve no practical purpose. (J. Br.)

TERRY, EDWARD O'CONNOR (1844–1912), English actor, was born in London, and began his stage career in the provinces. Between 1868 and 1875 he was the leading comedian at the Strand theatre, London. He joined Hollingshead's company at the Gaiety in 1876 and became a public favourite in the burlesques produced there during the next eight years, his eccentric acting and singing having many imitators. In 1887 he went into management, opening Terry's theatre, where his production of Pinero's *Sweet Lavender* was a notable success. Subsequently he was best known on many tours in the provinces and in Australia, America and South Africa. Off the stage he was well known as an ardent Free-mason, and an indefatigable member of the councils of many charities and of public bodies.

TERRY, ELLEN ALICIA (1848–1928), English actress, was born at Coventry on Feb. 27, 1848. Her parents were well-known provincial actors and close friends of the Keans. Her sisters Kate, Marion and Florence, and her brother Fred, all joined the theatrical profession. Her own first appearance on the stage was made on April 28, 1856, under the Keans' management, as the boy Mamilius in *The Winter's Tale,* at the Princess's theatre, London. Two years later she played Prince Arthur in *King John* and won high praise. From 1860 to 1863 and again from 1867 to 1868 she acted with various stock companies. On Dec. 26, 1867 she played for the first time with Henry Irving, being cast as Katharine to his Petruchio in Garrick's version of *The Taming of the Shrew* at the Queen's theatre. When quite a girl she married G. F. Watts the painter, but the marriage was soon dissolved. Between 1868 and 1874, having married E. A. Wardell, an actor whose professional name was Charles Kelly, she was again absent from the stage, but reappeared at the Queen's theatre under Charles Reade's management. On April 17, 1875, she played Portia in a revival of *The Merchant of Venice* under the Bancrofts' management at the old Prince of Wales's theatre. A succession of smaller triumphs at the Court theatre culminated in her beautiful impersonation of Olivia in W. G. Wills's dramatic version of Goldsmith's *Vicar of Wakefield,* in 1878, the result of which was her engagement by Henry Irving as his leading lady for the Lyceum and the beginning of a long artistic partnership, in the success of which Ellen Terry's enchanting personality and fine aesthetic sense played a large part. Her Shakespearean impersonations at the Lyceum were Ophelia in 1878, Portia in 1879, Desdemona in 1881, Juliet and Beatrice in 1882, Viola in 1884, Lady Macbeth in 1888, Katherine, in *Henry VIII.,* and Cordelia in 1892, Imogen in 1896, and Volumnia, in *Coriolanus,* in 1901. Other notable performances were those of the Queen in Wills's *Charles I.* in 1879, Camma in Tennyson's *The Cup* in 1881, Margaret in Wills's *Faust* in 1885, and the title-part in Charles Reade's one-act play *Nance Oldfield* (1893), Rosamund in Tennyson's *Becket* (1893), Madame Sans-Gêne in Sardou's play (1897), and Clarisse in *Robespierre* (1899). With the Lyceum company she several times visited the United States. In 1902, while still acting with Sir Henry Irving, she appeared with Mrs. Kendal in Beerbohm Tree's revival of *The Merry Wives of Windsor,* at His Majesty's theatre, and she continued, after Sir Henry Irving's death, to act at different theatres, notably at the Court theatre (1905) in some of Bernard Shaw's plays. In 1906 her stage-jubilee was celebrated in London with much enthusiasm, a popular subscription in England and America resulting in some £8,000 being raised. In 1907 Miss Terry married James Carew, an American actor.

In 1922 she was granted the honorary degree of LL.D (St. Andrews); and in 1925 she received the Grand Cross of the Order of the British Empire. Dame Ellen Terry's 80th birthday was celebrated in February 1928, when an interesting reminiscent correspondence appeared in the *Times.* On the following July 21 she died, after a short illness, at Small Hythe, near Tenterden, Kent. Sir Johnston Forbes Robertson has said of her: "Everything she did was invested with great charm. I do not suppose there ever was such an Ophelia. Nor do I think there ever will be again. In the theatre she was adored. In the public estimation she became a fetish. Take her for all in all she is one of the most remarkable figures in the history of the stage." In 1908 she published her only book, *The Story of My Life*.

See Charles Hiatt, Ellen Terry and her Impersonations (1898); Clement Scott, *Ellen Terry* (1900).

TERRY, SIR RICHARD RUNCIMAN (1865–), knighted 1922, British organist and choir-director, was born at Ellington, Northumberland, the son of Thomas Terry of Newcastle-on-Tyne, and obtained a choral scholarship at King's College, Cambridge. After acting as organist and choirmaster at Elstow School (1890); St. John's Cathedral, Antigua, West Indies (1892); and at Downside Abbey near Bath (1896), he became organist and director of the Roman Catholic Cathedral, Westminster, London (1901–24). His great service to English music is twofold: he studied and revived the beautiful church music of the English composers of the 17th century, and by the finished performances at Westminster of the works of these and the Italian composers brought about a revolution in church services in England, even outside his own communion. He was the composer of five Masses and other music, and the author of *Our Church Music* (1901); *Catholic Church Music* (1907); *Tudor Church Music* (1922); *On Music's Borders* (1927); etc. He also compiled the *Westminster Hymnal* and published a collection of shanties in *The Shanty Book* (pt. I. 1921, pt. II. 1926).

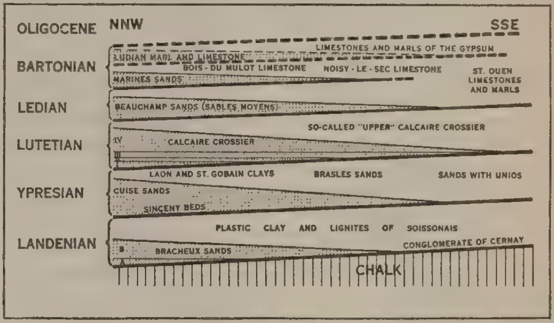
TERTIARIES, associations of lay folk in connection with the Mendicant Orders. The old monastic orders had had attached to their abbeys confraternities of lay men and women, who were made partakers in all the religious exercises and other good works of the community to which they were affiliated, and they were expected in return to protect and forward its interests; but they were not called upon to follow any special rule of life. The institution of Tertiaries arose out of the Franciscan movement. It seems to be certain that St. Francis at the beginning had no intention of forming his disciples into an Order, but only of making a great brotherhood of all those who were prepared to carry out in their lives certain of the greater and more arduous of the maxims of the Gospel. The formation of the Franciscan Order was necessitated by the success of the movement and the wonderful rapidity with which it spread. When the immediate disciples of the saint had become an order bound by the religious vows, it became necessary to provide for the great body of laity, married men and women, who could not leave the world or abandon their avocations, but still were part of the Franciscan movement and desired to carry out in their lives its spirit and teaching. And so, probably in 1221, St. Francis drew up a Rule for those of his followers who were debarred from being members of the order of Friars Minor. At first they were called "Brothers and Sisters of the Order of Penance"; but later on, when the Friars were called the "First Order" and the nuns the "Second Order," the Order of Penance became the "Third Order of St. Francis"—whence the name Tertiaries. Immediately on its establishment in 1221 the Third Order spread with incredible rapidity. Everywhere it was connected closely with the First Order, and was under the control of the Friars Minor.

In time a tendency set in for members of the Third Order to live together in community, and in this way congregations were formed who took the usual religious vows and lived a fully organized religious life based on the Rule of the Third Order with supplementary regulations. These congregations are the "Regular Tertiaries" as distinguished from the "Secular Tertiaries," who live in the world, according to the original idea. The Regular Tertiaries are in the full technical sense "religious," and there have been, and are, many congregations of them, both of men and of women. In 1883 Leo XIII. caused the rule to be recast and made more suitable for the present day.

There can be little doubt, whatever counter-claims may be set up, that the Third Order was one of St. Francis' creations, and that his Third Order was the exemplar after which the others were fashioned; but at an early date the other Mendicant Orders formed Third Orders on the same lines, and so there came into being Dominican Tertiaries, and Carmelite, and Augustinian, and Servite, and also Premonstratensian, together with a large number of others.

BIBLIOGRAPHY.—The most serviceable authority on the Franciscan Tertiaries is probably Max Heimbucher, *Orden und Kongregationen* (1907), ii. §§ 103, 104, 105, where an ample bibliography is supplied. The same work gives information on the other Tertiaries at the end of the sections on the various Orders. *See* also the *Catholic Encyclopaedia*, art. "Tertiaries"; Adderley and Marson, *Third Orders* (1902); Tachy, *Les tiers Ordres* (1897).

TERTIARY, in geology, the third of the great time divisions or eras distinguished since the appearance of clearly recognisable forms of life on the globe. It succeeds the Secondary or Mesozoic era and is followed by the Quaternary era in which we are now living. Some geologists, however, do not recognize the Quaternary and consider that the Tertiary or Kainozoic extends up to the historic period.


OLIGOCENE
NNW
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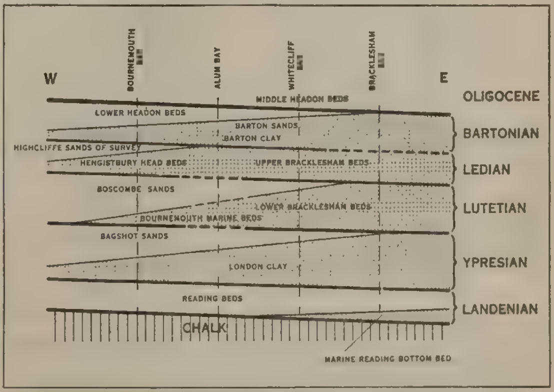
BARTONIAN
LIMESTONES AND MARLS OF THE GYPSUM
LUDIAN MARL AND LIMESTONE
BOIS-DU MULOT LIMESTONE
NOISY-LE-SEC LIMESTONE
ST. OUEN LIMESTONES AND MARLS
MARINES SANDS
LEDIAN
BEAUCHAMP SANDS (SABLES MOYENS)
LUTETIAN
SO-CALLED "UPPER" CALCAIRE CROSSIER
IV
CALCAIRE CROSSIER
III
YPRESIAN
LAON AND ST. GOBAIN CLAYS
BRASLES SANDS
SANDS WITH UNIOS
CUISE SANDS
SINCENY BEDS
LANDENIAN
PLASTIC CLAY AND LIGNITES OF SOISSONAIS
CONGLOMERATE OF CERNAY
B
BRACHEUX SANDS
CHALK

FROM "GEOLOGICAL MAGAZINE" (DUNLAU & CO.)

FIG. 1.—CYCLES OF SEDIMENTATION IN THE PARIS BASIN

The name was introduced by G. Cuvier and H. Brongniart in 1810 (*Essai sur la géographie minéralogique des Environs de Paris 1810–1811*, 1st ed.) and Deshayes studied the rich assemblages of fossils found in the beds of this age in the Paris Basin. The Tertiary faunas there consist very largely of mollusca of modern aspect and Deshayes (1830) worked out the percentages of recent species found at several horizons. Upon this basis Sir Charles Lyell (1852) founded the main periods, viz., the Eocene with 3½ per cent of recent forms, Miocene, 17 per cent, Pliocene 35–50 per cent. Later Beyrich introduced the Oligocene period between the Eocene and Miocene and some geologists distinguish a Palaeocene below the Eocene. Although later studies have shown that it is very doubtful whether *any* existing species are found in the earlier Tertiary periods, the order and nomenclature of the periods have been retained.


BOURNEMOUTH BAY
ALUM BAY
WHITECLIFF BAY
BRACKLESHAM BAY
W
E
OLIGOCENE
MIDDLE HEADON BEDS
LOWER HEADON BEDS
BARTON SANDS
BARTON CLAY
BARTONIAN
HIGHCLIFFE SANDS OF SURVEY
HENGISTBURY HEAD BEDS
UPPER BRACKLESHAM BEDS
LEDIAN
BOSCOMBE SANDS
LOWER BRACKLESHAM BEDS
BOURNEMOUTH MARINE BEDS
LUTETIAN
BAGSHOT SANDS
LONDON CLAY
YPRESIAN
READING BEDS
LANDENIAN
CHALK
MARINE READING BOTTOM BED

FROM "GEOLOGICAL MAGAZ.NE" (DUNLAU & CO.)

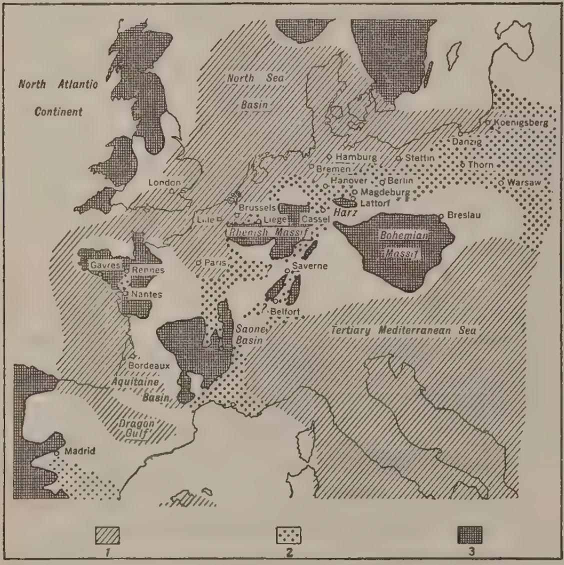
FIG. 2.—CYCLES OF SEDIMENTATION IN THE HAMPSHIRE BASIN

It has been found, however, that the Tertiary era falls naturally into two primary divisions so that the grouping now generally adopted is:—

The Newer Tertiary or Neogene { Pliocene
Miocene
The Older Tertiary or Palaeogene { Oligocene
Eocene
Palaeocene

The Palaeogene is characterized by an abundance of nummulites, hence the alternative name "Nummulitic."

Conditions During the Tertiary Era.—Very roughly the Palaeogene and the Neogene periods represent respectively the time before and after the great Tertiary or Alpine earth-movements which resulted in the elevation of most of the major mountain chains of the world, such as the Alps, Himalayas, Rockies and Andes. The mountain-building movements commenced in the Eocene and increased in intensity, "the Alpine storm" reaching its height in the Oligocene-Miocene. Thus, whereas the geography of the Older Tertiary period was fundamentally different from that of the present day in that oceanic troughs occupied the emplacements of the great mountains of to-day, the geography of the Newer Tertiary period shows the foundation of the configuration of the present day. This aspect is dealt with more fully under the separate articles Eocene, etc., and is illustrated in the accompanying figures. The end of the Cretaceous was marked in most areas, notably in Europe, by a great regression of the sea. The Eocene is characterized by a new marine invasion which proceeded spasmodically and is marked by local regressions, but which generally reached its height in the Lutetian or Middle Eocene. The minor cycles are illustrated in the accompanying diagrams. Then followed a slow and irregular regression in most areas and there is little or no break between the Eocene and Oligocene; elsewhere, especially in northern Germany, the Oligocene sea invaded areas not previously occupied by the Eocene sea. The end of the Palaeogene is marked by a general regression.



FROM GIGOUX, "GEOLOGIE STRATIGRAPHIQUE" (MASSON ET CIE)

FIG. 4.—MAP OF WESTERN EUROPE SHOWING CHANGES DURING THE OLIGOCENE PERIOD

(1) Maximum extension of the Eocene seas. (2) The central European continental area invaded only in Post Eocene (Oligocene) times by arms of the sea on lagoons. (3) Ancient massifs

The beginning of the Neogene is marked by the Miocene transgression; then came a new general regression, itself followed by a transgression much less important, that of the Pliocene; finally a last regression which marks the beginning of the Quaternary. It was in the Miocene period that the geography of Europe began definitely to assume its present day form.

Life in the Tertiary.—The faunal aspect of the Tertiary periods differs strikingly from that of the preceding Secondary or Mesozoic; in place of the great reptiles we find the rapid development and finally the maximum expansion of mammals. The Tertiary is often called the Age of Mammals and it is the mammals which furnish the means of distinguishing the subdivisions of the periods and correlating them over wide areas. Snakes and birds advanced rapidly towards their modern position; in the seas bony fish and crab-like decapods increased in number and variety. The ammonites and belemnites so abundant in, and so characteristic of, the Mesozoic periods entirely disappear and give place to lamellibranchs and gastropods of modern aspect—leaving behind such forms as *Rudistes, Inoceramus,* etc. Still more remarkable is the development and abundance in the Early Tertiary period of large foraminifera—the nummulites and orthophragminas. They are excellent zonal fossils if one bears in mind that, for Europe, the "Tethys" or Mediterranean formed their area of evolution and dispersal. In the plant world dicotyledons gradually assumed the leading place which they occupy to-day.

(L. D. S.)

TERTULLIAN (*c.* 155–*c.* 222), whose full name was Quintus Septimius Florens Tertullianus, is the earliest and after Augustine the greatest of the ancient church writers of the West. Before him the whole Christian literature in the Latin language consisted of a translation of the Bible, the *Octavius* of Minucius Felix (*q.v.*)—an apologetic treatise written in the Ciceronian style for the higher circles of society, and with no evident effect for the church as a whole, the brief Acts of the Scillitan martyrs, and a list of the books recognized as canonical (the so-called Muratorian fragment). Whether Victor the Roman bishop and Apollonius the Roman senator ever really made an appearance as Latin authors is quite uncertain. Tertullian in fact created Christian Latin literature; one might almost say that that literature sprang from him full-grown, alike in form and substance, as Athena from the head of Zeus. Cyprian polished the language that Tertullian had made, sifted the thoughts he had given out, rounded them off, and turned them into current coin, but he never ceased to be aware of his dependence on Tertullian, whom he designated as *κατ' ἐξοχήν*, his master (Jer., *De vir. ill.* 53).

Life.—Born at Carthage about 150 of good family—his father was a "centurio pro consularis"—he received a first-rate education both in Latin and in Greek. He was able to speak and write Greek, and gives evidence of familiarity alike with its prose and with its poetry; and his excellent memory—though he himself complains about it—enabled him always to bring in at the right place an appropriate, often brilliant, quotation or some historical allusion. The old historians, from Herodotus to Tacitus, were familiar to him, and the accuracy of his historical knowledge is astonishing. He studied with earnest zeal the Greek philosophers; Plato in particular, and the writings of the Stoics he had fully at command, and his treatise *De Anima* shows that he himself was able to investigate and discuss philosophical problems. From the philosophers he had been led to the medical writers, whose treatises plainly had a place in his working library. But no portion of this rich store of miscellaneous knowledge has left its characteristic impress on his writings; this influence was reserved for his legal training.

His father, whose military spirit reveals itself in the whole bearing of Tertullian, to whom Christianity was above everything a "militia," had intended him for the law. He studied in Carthage, probably also in Rome, where, according to Eusebius, he enjoyed the reputation of being one of the most eminent jurists. This statement derives confirmation from the *Digest*, where references are made to two works, *De Castrensi Peculio* and *Quaestionum Libri VIII.*, of a Roman jurist named Tertullian, who must have flourished about A.D. 180. In point of fact the quondam advocate never disappeared in the Christian presbyter. This was at once his strength and his weakness: his strength, for as a professional pleader he had learned how to deal with an adversary according to the rules of the art, and was specially qualified to expose the irregularities in the proceedings taken by the state against the Christians; but it was also his weakness, for it was responsible for his litigiousness, his often doubtful shifts and artifices.

At Rome in mature manhood (*c.* 190–195) Tertullian became a Christian, under what circumstances we do not know, and forthwith he bent himself with all his energy to the study of Scripture and of Christian literature. Not only was he master of the contents of the Bible: he also read carefully the works of Hermas, Justin, Tatian, Miltiades, Melito, Irenaeus, Proculus, Clement, as well as many Gnostic treatises, the writings of Marcion in particular. In apologetics his principal master was Justin, and in theology proper and in the controversy with the Gnostics, Irenaeus. As a thinker he was not original, and even as a theologian he has produced but few schemes of doctrine, except his doctrine of sin. His special gift lay in the power to make what had been traditionally received impressive, to give to it its proper form, and to gain for it new currency. From Rome Tertullian visited Greece and perhaps also Asia Minor; at any rate we know that he had temporary relations with the churches there. He was consequently placed in a position in which he could check the doctrine and practice of the Roman church.

Thus equipped with knowledge and experience, he returned to Carthage in 197 and there laid the foundation of Latin Christian literature. At Carthage he became a presbyter, and married. At first, after his conversion, he wrote Greek, but by and by Latin almost exclusively. The elements of this Christian Latin language may be enumerated as follows:—(i.) it had its origin, not in the literary language of Rome as developed by Cicero, but in the language of the people as we find it in Plautus and Terence; (ii.) it has an African complexion; (iii.) it is strongly influenced by Greek, particularly through the Latin translation of the Septuagint and of the New Testament, besides being sprinkled with a large number of Greek words derived from the Scriptures or from the Greek liturgies; (iv.) it bears the stamp of the Gnostic style and contains also some military expressions; (v.) it owes something to the original creative power of Tertullian.

Theology.—As for his theology, its leading factors were:—(i.) the teachings of the apologists; (ii.) the philosophy of the Stoics; (iii.) the rule of faith, interpreted in an anti-Gnostic sense, as he had received it from the Church of Rome; (iv.) the Soteriological theology of Melito and Irenaeus; (v.) the substance of the utterances of the Montanist prophets (which he recognized as a work of God in 202–3). This analysis does not disclose, nor indeed is it possible to discover, what was the determining element for Tertullian; in fact he was under the dominion of more than one ruling principle, and he felt himself bound by several mutually opposing authorities. It was his desire to unite the enthusiasm of primitive Christianity with intelligent thought, the original demands of the Gospel with every letter of the Scriptures and with the practice of the Roman church, the sayings of the Paraclete with the authority of the bishops, the law of the churches with the freedom of the inspired, the rigid discipline of the Montanist with all the utterances of the New Testament and with the arrangements of a church seeking to set itself up within the world.

At this task he toiled for years, involved in contradictions which taxed all the finished skill of the jurist to conceal from him for a time. His efforts to secure the triumph of Montanism within the Church involved him in bitter controversy with the clergy at Carthage, who had the support of Rome. At last (*c.* 207–08) he felt compelled to break off from the church for which he had lived and fought and he became the head of the small Montanist community in Carthage; but the breach could not clear him from the contradictions in which he found himself entangled. Not only did the great chasm between the old Christianity, to which his soul clung, and the Christianity of the Scriptures as juristically and philosophically interpreted remain unbridged; he also clung fast, in spite of his separation from the Catholic church, to his position that the church possesses the true doctrine, that the bishops *per successionem* are the repositories of the grace of the teaching office, and so forth. The growing violence of his latest works is to be accounted for, not only by his burning indignation against the ever-advancing secularization of the Catholic church, but also by the incompatibility between the authorities which he recognized and yet was not able to reconcile. After having done battle with heathens, Jews, Marcionites, Gnostics, Monarchians, and the Catholics, he died at a great age.

What has just been said brings out very clearly how important in their bearing on Tertullian's development were the circumstances of the age in which he laboured. His activity as a Christian falls between 190 and 220, a period of very great moment in the history of the Catholic church; for within it the struggle with Gnosticism was brought to a victorious close, the New Testament established a firm footing within the churches, the "apostolic" rules which thenceforward regulated all the affairs of the church were called into existence, and the ecclesiastical priesthood came to be developed. Within this period also falls that evangelical and legal reaction against the political and secular tendencies of the church which is known as Montanism. The same Tertullian who had fortified the Catholic church against Gnosticism was none the less anxious to protect it from becoming a political organization. Being unable to reconcile incompatibles, he broke with the church and became the most powerful representative of Montanism in the West.

Works.—The works of Tertullian, on the chronology of which a great deal has been written, and which for the most part do not admit of being dated with perfect certainty, fall into three classes—the apologetic, defending Christianity against paganism and Judaism; the polemical dogmatic, refuting heresies and heretics; and the ascetic or practical, dealing with points of morality and church discipline. In point of time also three periods can be readily distinguished (*see* below).

I. *Works dating from before 202–203.*—To this class belong the *Apologeticus* (197) and the two books *Ad nationes, De spectaculis, De idololatria, De cultu feminarum Libri II., De testimonio animae* (written soon after the *Apologeticus*), *Ad martyres* (perhaps the earliest of all), *De baptismo haereticorum* (now lost), *De baptismo, De poenitentia, De oratione* (the last three written for catechumens), *De patientia, Ad uxorem Libri II., De praescriptione haereticorum,* and *Adv. Marcionem* (in its first form).

II. *Works written between 202–203 and 207–208.*—*De virginibus velandis, De corona militis, De fuga in persecutione, De exhortatione castitatis, De scorpiace* (a booklet against the Gnostics, whom he compares to scorpions; it is written in praise of martyrdom), *Adversus Hermogenem, De censu animae adv. Hermogenem* (lost), *Adv. Valentinianos, Adv. Apelleiacos* (lost), *De paradiso* (lost), *De fato* (lost), *De anima* (the first book on Christian psychology), *De carne Christi, De resurrectione carnis,* and *De spe fidelium* (lost), were all written after Tertullian had recognized the prophetic claims of the Montanists, but before he had left the church.

III. *Works later than 207–208.*—To this period belong the five books *Adv. Marcionem,* his main anti-Gnostic work (in the third form—the first of the five was written in 207–208), *Ad Scapulam* (an admonition to the persecuting proconsul of Africa, written soon after 212), *De pallio* (a defence of his wearing the pallium instead of the toga), *Adv. Praxean* (his principal work against the Monarchians), and *Adv. Judaeos,* chaps. ix.–xiv. of which are a completion by another and less skilful hand. The latest extant works of Tertullian (all after 217) are his controversial writings against the laxity of the Catholics, full of the bitterest attacks, especially upon Calixtus, the bishop of Rome; these are *De monogamia, De jejunio, De pudicitia,* and *De ecstasi Libri VII.* (lost). It is quite possible that Tertullian was the author of the *Acta perpetuae et felicitatis,* but he did not write the *Libellus adv. omnes haereses* often appended to *De praescriptione;* or the poems *Adv. Marcionem, De Sodoma, De Jona, De Genesi, De judicio Domini;* or the fragment *De execrandis gentium diis;* or the *De Trinitate* and *De cibis Judaicis* of Novatian.

Editions.—For the MSS. *see* E. Preuschen in A. Harnack, *Geschichte der altchristl. Literatur,* i. 675–7. Of printed collections the chief are the *editio princeps* by Beatus Rhenanus (Basel, 1521), Migne, *Patr. Lat.* i.–ii. (Paris, 1844); Fr. Oehler (3 vols., Leipzig, 1851–4); A. Reifferscheid and G. Wissowa in the *Corpus scriptorum eccl. Lat.* (Pars i., Vienna, 1890), Oehler's text of the *Apologeticus* with trans. into English by A. Souter and notes by J. E. B. Mayor (1917). Editions of the separate books are almost innumerable.

Translations.—German by K. A. H. Kellner (2 vols. Cologne, 1882) and selections in *Bibliothek der Kirchenväter* (1869, 1872); English by S. Thelwall and others in *Ante-Nicene Fathers,* iii. and iv., and (apologetic and practical writings) by C. Dodgson in *Library of the Fathers,* x. (Oxford, 1842); and translations by A. Souter of the treatises on prayer and baptism (1919).

Literature.—Fr. Oehler's third volume contains a collection of early dissertations. *See* also A. Hauck, *Tertullian's Leben und Schriften* (Erlangen, 1877); J. M. Fuller in *Dict. Chr. Biog.,* iv. 818–864; E. Nolldechen, *Tertullian* (Gotha, 1890); P. Monceaux, *Histoire littéraire de l'Afrique chrétienne,* vol. i. (Paris, 1901); T. R. Glover, *The Conflict of Religions in the Early Roman Empire,* chap. x. (London, 1909); and the various Histories of Dogma and Church Histories.

For a complete bibliography *see* G. Krüger, *Hist. of Early Christian Literature* (Eng. tr. New York and London, 1897); Herzog-Hauck, *Realencyk. für prot. Theologie*, xix.; and O. Bardenhewer, *Patrology* (Eng. tr. Freiburg im Breisgau and St. Louis, 1908).

TERUEL, a province of north-eastern Spain, formed in 1833 from part of the ancient kingdom of Aragon; bounded on the north by Saragossa, east by Tarragona, south-east and south by Castellon de la Plana and Valencia, south-west by Cuenca, and west by Guadalajara. Pop. (1920) 252,096; area 5,720 sq.m. In the centre of the province rise the Sierras of Gudar and San Just; in the south-west and west are the lofty Albarracin range, the Montes Universales, and the isolated ridges of Palomera and Cucalon. Outliers of the Castellon and Tarragona highlands extend along the eastern border. The northern districts belong to the Ebro basin. In the west there are a few peaks, such as the Cerro de San Felipe and Muela de San Juan, which exceed 5,000 ft. in altitude and are covered with snow for many months; but the highest point is Javalambre (6,568 ft.) in the south. The sierras give rise to several large rivers, the principal being the Tagus (*q.v.*); the Guadalaviar, which rises in the Montes Universales and enters the Mediterranean at Valencia; and the Jiloca, which flows north from the lake of Cella to join the Jalón at Calatayud. The chief products are corn, wine, oil, cheese, fruits, timber, flax, hemp, silk, wool and saffron, together with cattle, sheep and swine. The only railway is the line from Murviedro, on the Gulf of Valencia, to Calatayud. Teruel (*q.v.*) and Alcañiz (8,648) are the only towns.

TERUEL, the capital of the Spanish province of Teruel; on the left bank of the river Guadalaviar, at its confluence with the Alfambra, and on the Murviedro-Calatayud railway. Pop. (1920) 12,010. The older part of Teruel is a walled city with narrow streets and crumbling mediaeval houses, but modern suburbs have been built outside the walls. In the cloisters of San Pedro lie the remains of the celebrated "lovers of Teruel," Juan de Marcilla and Isabella de Segura (13th century). Their story is the subject of works by Tirso de Molina, Artieda, Montalban, Hartzenbusch and others. The cathedral dates from the 16th century. The great aqueduct was erected in 1555–60 by Pierre Bedel, a French architect. The see was created in 1577.

TERZA RIMA, or "third rhyme," a form of verse developed by the Italian poets of the 13th century. Its origin has been attributed by some to the three-lined ritournel, which was an early Italian form of popular poetry, and by others to the *Provençals serventese incatenato,* an arrangement of triple rhymes, which unquestionably appears to have a relation with terza rima; Dante gave to terza rima its artistic character. What this character is may best be seen by an examination of the lines with which the *Inferno* opens:

Nel mezzo del cammin di nostra vita
Mi ritrovai per una selva oscura,
Ché la diritta via era smarrita.
Ah quanto a dir qual 'era è cosa dura
Questa selva selvaggia ed aspra e forte,
Che nel pensier rinnova la paura!

It is impossible, however, to break off here, since there is no rhyme to *forte,* which has to be supplied twice in the succeeding terzina, where, however, a fresh rhyme, *trovai,* is introduced, linking the whole to a still further terzina, and so on, indefinitely in the sequence *aba, bcb, cdc, ded* . . . Boccaccio wrote terza rima in close following of Dante, but it has not been a form very frequently adopted by Italian poets. The difficulty of sustaining dignity and force in these complicated chains of verse has usually deterred writers in other languages from adventuring on terza rima. In the age of Elizabeth, Samuel Daniel employed it in his "Epistle to the Countess of Bedford," but he found no followers. Shelley tried it in two poems (*Prince Athanase* and *The Triumph of Life*), Byron in one (*The Prophecy of Dante*), but probably the most successfully sustained poem in terza rima in the English language is Mrs. Browning's *Casa Guidi Windows* (1851).

TESCHEN, a town and district of Poland and Czechoslovakia. Teschen (Czech *Têšin,* Polish, *Cieszyn*), lies in the south-east corner of Silesia, and was a duchy disputed between the kings of Poland and Bohemia from the 9th century onward. In the 17th century it came under Habsburg rule. It is 852·6 sq.m. in extent. It is rich both in coke and gas coal, and is an important strategic centre of roads and railways, especially of the Bohumin (Oderberg) line. Its population in 1921 was 144,671, of whom 76·5% were Poles, 20% Germans, 3% Jews and ·3% Czechs. Both Czechs and Poles desired to succeed Austria in the possession of Teschen; in May–June 1918, their representatives decided to settle the matter in friendly agreement. When, however, Poland elected deputies from Teschen for her constituent parliament, Czech troops advanced and occupied Oderberg in Jan. 1919. The Great Powers intervened and decided (Sept. 27, 1919) to hold a plebiscite under the auspices of the principal Allies, not only for the duchy of Teschen but also for the adjacent Suvan areas of Spiš (Zips) and Orava. This commission did not arrive until Jan. 1920, when they were confronted with riots, strikes and other difficulties. They appealed to the Conference of Ambassadors at Paris, which, on July 28, 1920, abandoned the plebiscite plan and induced both Czechs and Poles to agree to a partition. The Spiš-Orava areas offered few difficulties. In the duchy itself the Czechs obtained the Karvinna (Karwin) mining area and the Oderberg-Jablunkov railway, the Poles the town of Teschen, except its western suburb, and an agricultural area. The economic unity of the duchy was preserved by an arrangement which afterwards served as a model for the partition of Upper Silesia.

See H. W. V. Temperley, *History of the Peace Conference of Paris,* vol. iv. (chap. vi., pt. 1 [1921] by R. Fitzgibbon Young).

TESLA, NIKOLA (1857–), American inventor, was born at Smiljan, Austrian Croatia. He graduated from the *realschule,* Karlstadt, in 1873, and studied at the polytechnic school, Graz, Croatia, and the University of Prague, intending to specialize in physics and mathematics, but became interested in electricity. He was first employed in the Austrian Government telegraph engineering department, later being engaged in electrical engineering in Budapest and Paris. He went to the United States in 1884. For a time he was with the Edison Co. at Orange, N.J., but relinquished his position in order to devote himself to research, for which purpose he established the Tesla laboratory in New York city. He was the first to conceive an effective method of utilizing the alternating current and in 1888 patented the induction motor, by means of which electrical energy might be converted into mechanical energy more effectively and economically than by the direct current. He invented the principle of the rotary magnetic field embodied in the apparatus used in the transmission of power from Niagara falls. He also invented new forms of dynamos, transformers, induction coils, condensers, arc and incandescent lamps and other electrical apparatus.

TEST ACTS. The principle that none but persons professing the established religion were eligible for public employment was adopted by the legislatures of both England and Scotland soon after the Reformation. In England the acts of Supremacy and Uniformity and the severe penalties pronounced against recusants, whether Roman Catholic or Nonconformist, were affirmations of this principle. The act of 7 Jac.I. c.2 provided that all such as were naturalized or restored in blood should receive the sacrament of the Lord's Supper, and under Charles II. the actual receiving of the communion of the Church of England was made a condition precedent to the holding of public offices. The earliest imposition of this test was by the Corporation act of 1661 (13 Car. II. st. 2, c.1), enacting that, besides taking the oath of allegiance and supremacy and subscribing a declaration against the Solemn League and Covenant, all members of corporations were within one year after election to receive the sacrament of the Lord's Supper according to the rites of the Church of England. This act was followed by the Test act of 1672 (25 Car. II. c.2), the immediate consequence of the king's declaration of indulgence, dispensing with laws inflicting disabilities on Nonconformists. This act enforced upon all persons filling any office, civil or military, the obligation of taking the oaths of supremacy and allegiance and subscribing a declaration against transubstantiation, and also of receiving the sacrament within three months after admittance to office. The act did not extend to peers; but in 1678 (30 Car. II. st. 2) enacted that all peers and members of the House of Commons should make a declaration against transubstantiation, invocation of saints, and the sacrifice of the mass—an exception being made in favour of the Duke of York. The provisions of the Test act were violated by both Charles II. and James II. on the ground of the dispensing power claimed by the Stuart kings. In the case of *Godden* v. *Hales* (11 State Trials, 1,166), an action for penalties under the Test act brought against an officer in the army, the judges decided in favour of the dispensing power—a power finally abolished by the Bill of Rights. After a considerable number of amendments and partial repeals of these acts, and of acts of indemnity to protect persons from penalties incurred under the Test act, the necessity of receiving the sacrament as a qualification for office was abolished by 9 Geo. IV. c. 17, and all acts requiring the taking of oaths and declarations against transubstantiation, etc., were repealed by the Roman Catholic Relief act of 1829 (10 Geo. IV. c.7). This general repeal was followed by the special repeal of the Corporation act by the Promissory Oaths act 1871, of the Test act by the Statute Law Revision act 1863, and of the act of 1678 by an act of 1866 (29 & 30 Vict. c.19). In 1871 the University Tests act abolished subscriptions to the articles of the Church of England, all declarations and oaths respecting religious belief, and all compulsory attendance at public worship in the universities of Oxford, Cambridge, and Durham. There is an exception restricting to persons in holy orders of the Church of England degrees in divinity and positions such as the divinity and Hebrew professorships.

In Scotland a religious test was imposed immediately after the Reformation. By 1567, c.9 no one was to be appointed to a public office or to be a notary who did not profess the Reformed religion. The Scottish Test act (1681, c.6) was rescinded by 1690, c.7. By 1700, c.3, renunciation of popery was to be made by persons employed in education. By 1707, c.6, all professors, principals, regents, masters, or others bearing office in any university, college, or school in Scotland were bound to profess and subscribe to the Confession of Faith; and all persons were to be free of any oath or test contrary to or inconsistent with the Protestant religion and Presbyterian Church government. The necessity for subscription to the Confession of Faith was removed for persons other than principals and professors of theology by 16 and 17 Vict. c.89. The act provided that in place of subscription every person appointed to a university office was to subscribe a declaration according to the form in the act, promising not to teach any opinions opposed to the divine authority of Scripture or to the Confession of Faith, and to do nothing to the prejudice of the Church of Scotland or its doctrines and privileges. All tests were finally abolished by an act of 1889 (52 & 53 Vict. c.55). The reception of the communion was never a part of the test in Scotland as in England and Ireland.

In Ireland an oath of allegiance was required by the Irish act of Supremacy (2 Eliz. c.1). The English act of 3 Will. & M. c.2 substituted other oaths and enforced in addition from peers, members of the House of Commons, bishops, barristers, attorneys, and others a declaration against transubstantiation, invocation of the Virgin Mary and the saints, and the sacrifice of the mass. By the Irish act of 2 Anne, c.6, every person admitted to any office, civil or military, was to take and subscribe the oaths of allegiance, supremacy, and abjuration, to subscribe the declaration against transubstantiation, etc., and to receive the Lord's Supper according to the usage of the Church of Ireland. English legislation on the subject of oaths and declarations was adopted in Ireland by Yelverton's act, 21 & 22 Geo. III. c.48, § 3 (Ir.). These provisions were all repealed by the Promissory Oaths act 1871. The Roman Catholic Relief act of 1793 (33 Geo. III. c.21. Ir.) excepted Trinity College, Dublin, from its provisions, and tests existed in Dublin university—except for professors and lecturers in divinity—until finally abolished by the University of Dublin Tests act 1873.

In the United States by art. 6 of the constitution, "no religious test shall ever be required as a qualification to any office or public trust under the United States." A similar provision is generally included in the state constitutions.

TESTAMENTS OF THE TWELVE PATRIARCHS. The Testaments of the Twelve Patriarchs are an important constituent of the apocryphal scriptures connected with the Old Testament, comprising the dying commands of the twelve sons of Jacob.

They were written in Hebrew in the later years of John Hyrcanus—in all probability after his final victory over the Syrian power and before his breach with the Pharisees—in other words, between 109 and 106. Their author was a Pharisee who combined loyalty to the best traditions of his party with the most unbounded admiration of Hyrcanus. The Maccabean dynasty had now reached the zenith of its prosperity, and in its reigning representative, who alone in the history of Judaism possessed the triple offices of prophet, priest and king, the Pharisaic party had come to recognize the actual Messiah. When we contrast the expectations of the original writer and the actual events that followed, it would seem that the chief value of his work would consist in the light that it throws on this obscure and temporary revolution in the Messianic expectations of Judaism towards the close of the 2nd century. But this is not so. The main, the overwhelming value of the book lies not in this province, but in its ethical teaching, which has achieved a real immortality by influencing the thought and diction of the writers of the New Testament, and even those of our Lord. This ethical teaching, which is indefinitely higher and purer than that of the Old Testament, is yet its true spiritual child, and helps to bridge the chasm that divides the ethics of the Old and New Testaments.

Date.—The indications in the book itself make it quite clear that it was written (1) in Hebrew, and (2) between 109–107 B.C. There are, however, numerous additions. A large body of these additions can be classed under one head as written with a well-defined object and at a definite period. This period was about 70–40 B.C., and the object of the additions was the overthrow of the Maccabean high-priesthood, which in the 1st century B.C. had become guilty of every lewdness. Test. Lev. x., xiv.–xvi.; Test. Jud. xvii. 2–xviii. 1 (?), xxi. 6–xxiii., xxiv. 4–6; Test. Zeb. ix.; Test. Dan. v. 6–7, vii., 3 (?); Test. Naph. iv.; Test. Gad. viii. 2; Test. Ash. vii. 4–7. These additions are identical in object and closely related in character and diction with the Psalms of Solomon. Other additions are of various dates and cannot be more than mentioned here; *i.e.*, Test. Reub. ii. 3–iii. 2; Test. Lev. xvii. 1–9; Test. Zeb. vi. 4–6, vii.–viii. 3; Test. Jos. x. 5–xviii.

Christian Additions to the Text.—These additions are to be found in most of the Testaments and were made at different periods. The existence of these Christian elements in the text misled nearly every scholar for the past 400 years into believing that the book itself was a Christian apocryph. To Grabe, Schnapp and Conybeare belongs the credit of showing that the Christian elements were interpolations—to Conybeare especially of the three, since, whereas the two others showed the high probability of their contention on internal evidence, Conybeare proved by means of the Armenian version that when it was made many of the interpolations had not yet found their way into the text. For a full treatment of these passages *see* Charles's *Testaments of the Twelve Patriarchs* (1908), Introd. §20.

Influence on the New Testament.—St. Paul twice quoted from the Greek text of the Testaments: Rom. i. 32 and 1 Thess. ii. 16. But these give the very faintest idea of the degree of his indebtedness in thought and phraseology in several of his Epistles, especially that to the Romans. Of still greater interest are the passages in the Gospels which show the influence of the Testaments, and these belong mainly to the sayings and discourses of our Lord. We may mention two of the most notable of these. Thus Matt. xviii. 15, 35, which deal with the great question of forgiveness, are clearly dependent on our text.

Matt. xviii. 15.	T. Gad. vi. 3.
’Εὰν δὲ ἁμαρτήσῃ ὁ ἀδελφός σου κατά σου, ὕπαγε ἔλεγξον αὐτὸν μεταξὺ σοῦ καὶ αὐτοῦ μόνου.	*’Εὰν τις ἁμαρτήσει εἰς σὲ εἰπὲ αὐτῷ ἐν εἰρήνῃ . . . . καὶ ἐὰν . . . . μετανοήσῃ, ἄφες αὐτῷ*
35. *’Εὰν μὴ ἀφῆτε ἕκαστος τῷ ἀδελφῷ αὐτοῦ ἀπὸ τῶν καρδιῶν ὑμῶν.*	vi. 6 *ἡσύχασον· μὴ ἐλέγξῃς.* v. 7 *῎Αφες αὐτῷ ἀπὸ καρδίας*

Next, the duty of loving God and our neighbour is already found in Test. Dan. v. 3, which is the oldest literary authority which en-joins these two great commands. The form is infinitely finer in Matt. xxii. 37–39, but the matter is already in the Test. Dan. *See* Introd. §26 to R. H. Charles's *Testaments of the Twelve Patriarchs*.

Besides Charles (as above), are his *Apoc. and Pseudepig.* vol. ii. and the S.P.C.K. *Translations of Early Documents* (1917). (R. H. CH.)

TESTAMENTUM DOMINI ("TESTAMENT OF OUR LORD"), one of that series of writings, claiming to embody the fundamental rules of the early church, which culminates in the "Apostolic Constitutions" (*q.v.*). Extracts from the book which bears this title, contained in an 8th-century MS. at Paris, were published by Lagarde in 1856; and a Latin fragment, edited by Dr. Montague James, appeared in 1893 (*Texts and Studies,* i. 154). The whole book was first published in Syriac in 1899, with a Latin translation by Mgr. Rahmani, the Uniat Syrian Patriarch of Antioch. His text is that of a 17th-century MS. at Mosul, translated from the original Greek by James of Edessa, in A.D. 687; but he makes use of other material, including an Arabic version made from a Coptic copy written in A.D. 927. The Mosul MS. contains the whole Bible in the Peshitto version, followed by the collection of ecclesiastical law, in eight books, which was used by the Nestorians and Jacobites. Of this the *Testament* forms the first two books; and according to the title (which, apparently by an error, is made to apply to the whole eight books) it contains the "testament, or words which Our Lord spake to His holy Apostles when He rose from the dead."

The Testament has several distinctive characteristics. First and foremost is its ascription to the Lord Himself, which scholars can hardly be mistaken in regarding as an attempt to claim a yet higher sanction than was claimed by the various compilations styled "apostolic." This fact alone would lead us to infer the pre-existence of certain of the latter. Again, the whole tone of the *Testamentum* is one of highly strung asceticism, and the regulations are such as point by their severity to a small and strictly organized body. They are "the wise," "the perfect," "sons of light"; but this somewhat Gnostic phraseology is not accompanied with any signs of Gnostic doctrine, and the work as a whole is orthodox in tone. They are set in the midst of "wolves," despised and slighted by the careless and worldly: there is frequent mention of "the persecuted," and of the duty of "bearing the cross." There appears to be no *locus poenitentiae* for serious sins excepting in the case of catechumens, and there is a notable "perfectionist" tone in many of the prayers. *Charismata,* and above all exorcisms, occupy a very important place: there is a vivid realization of the ministry of angels, and the angelic hierarchy is very complete. Great stress is laid upon virginity (although there is not a sign of monasticism), upon fasting (especially for the bishop), upon the regular attendance of the whole clerical body and the "more perfect" of the laity at the hours of prayer.

Amongst the festivals mentioned are the Epiphany, Easter and Pentecost. With regard to the prayers, they are based upon forms common to this and other Church orders, but have many lengthy interpolations of an inflated and rhapsodic kind. The bishop appears to rank far above the presbyters (more conspicuously so, for example, than in the Canons of Hippolytus), and the presbyters are still divided into two classes, those who are more learned and those who are of mature age. The deacons have functions in the Eucharist and about the altar which point to an early date; they have also much administrative work of an important kind, and especial provisions are made for the care of the sick and the dead, and the burial of those who perish by shipwreck. One of the deacons is to be chosen as "chief deacon" (*protodiaconus,* i. 19 *cf.* i. 34), and is charged with the care of pilgrims. There are no doorkeepers or singers, who begin to appear *circ.* A.D. 340. The honour given to confessors is very conspicuous, and points back to an early date. But remarkable above all is the position given to women. We have "widows having precedence" or presbyteresses, three in number, deaconesses, virgins, and widows who are in receipt of the alms of the Church; and the first-named occupy a place of very great dignity, which is almost unequalled elsewhere, and which was formally condemned by the Council of Laodicea in Phrygia.

What conclusion is to be drawn, then, as to the age and character of the *Testament?* Mgr. Rahmani's view, that it is a work of the 2nd century, is universally discredited; nor has Funk's contention found acceptance, that it and the Canons of Hippolytus are alike derived ultimately from the eighth book of the *Apostolic Constitutions.* Some scholars think that the Apocalypse at the beginning is pre-Nicene (A.D. 250–325), and that it originates from Asia Minor, probably from Montanistic circles. But the unity of thought and atmosphere is such as to show that the work is one whole (subject no doubt to a certain amount of redaction and interpolation), and that the apocalyptic part was composed as an introduction to the rest. As to the central portion (i. 19–ii. 24) it is a Church Order of the same kind as the Canons of Hippolytus (*c.* 220) and the Egyptian (*c.* 310) and Ethiopic (*c.* 335) Church Orders, standing nearer to the two latter than to the former.

Such redaction was indeed inevitable in the case of a work which has had a living history as part of a codex of Church law. It may be discerned in the interpolations in the prayers; possibly in the reference to the chief deacon, for elsewhere no single deacon is distinguished *by name* until the close of the 4th century; in the reference to the Epiphany, which is first heard of elsewhere at the beginning of the 4th century.

AUTHORITIES.—I. E. Rahmani, *Testamentum Domini nostri Jesu Christi* (1899); Bishop J. Wordsworth in *Church Quarterly Review* (April 1900); and *Revue internationale de théologie* (Bern, July 1900); R. B. Rackham in *Indian Church Quarterly Review* (January and April 1901); F. X. Funk, *Das Testament des Herrn und die verwandten Schriften* (1901); James Cooper and A. J. Maclean, *The Testament of Our Lord,* an English translation, with introduction and notes (1902). *Cf.* also A. J. Maclean, *Recent Discoveries illustrating Early Christian Life and Worship* (1904). (W. E. Co.)

TESTER, a canopy (*q.v.*) over a bed or altar.

TESTING MACHINERY: *see* MATERIALS, STRENGTH OF.

TEST PIT. A test pit may be used for many purposes, but in its generally accepted meaning the term refers to a heavily lined pit sunk in the floor of an industrial factory building, and employed in making strength and balancing tests on the revolving parts of such machines as large electric generators, motors, and steam and hydraulic turbines.

The necessity for such pits arises from the fact that machines are usually tested at speeds considerably in excess of those at which they will normally run, and consequently there is the risk of disruption, with the likelihood of great damage to property and loss of life if proper protection is not provided. While it is not intended that such tests shall be carried to the point of destruction, a certain factor of safety must be present in the machines, and this can only be demonstrated by actual over-speed tests.

Test pits are therefore sunk beneath the shop floor level, and are heavily lined with reinforced concrete and steel. All up-to-date manufacturers of large revolving machines are equipped to make such tests with safety to their employees and equipment. There are cases on record of very serious accidents resulting from the disruption of rapidly revolving machines improperly protected, and the modern tendency is toward more heavily armoured pits located in isolated sections of the manufacturing plants.

The largest test pit in the world is that designed and built by the General Electric Company in 1927, at their principal plant which is situated at Schenectady, N.Y. This pit is located in a special building with other testing equipment, a quarter of a mile from the nearest factory building. It is 30ft. deep and 45ft. in inside diameter, and is capable of enclosing the rotating member of the largest electrical machine likely to be built for many years. The walls are of double concrete construction with a layer of soft sand in between, and with a total thickness of 14ft. The floor is a concrete slab faced with steel, and is supported by wooden piles driven 60ft. into the ground. The entire construction is reinforced with one-inch steel bars cast in the concrete, giving even greater rigidity than is necessary in the case of large dams and bridges.

The top of the pit is closed by a removable lid made of steel plates and girders, and is held in place by eight steel wedges each a yard long. For testing purposes the rotating machine is lowered into the pit by a travelling crane, and is supported in a huge roller bearing at the bottom, capable of carrying a load of 500 tons. The shaft of the machine is held in the vertical position by a small upper bearing, and is connected by a coupling to an electric motor installed upon the top of the lid. Motors of as high as 3,000 h.p. are used to revolve the largest rotors at test speeds.

The pit may be used for any tests where bomb-proof protection is required. Its principal use, however, is in performing "double speed" tests on large hydro-electric generator rotors. The object of such tests is to establish the fact that rotors will not fly apart even under the maximum "runaway" conditions which might exist during an emergency in service. Huge centrifugal forces and enormous rim velocities are developed in these tests, the rim speed of the largest machine (1928) being of the order of 20,000ft. per min. (about 227m. per hour).

During the test runs no one is allowed to remain in the pit building. The observers retire to a control house 100 yards away and there manipulate the speed of the electric motor driving the machine under test, by means of a switchboard connected with the pit through underground cables. Indicating meters record the speed and degree of vibration, and telephonic communication with a microphone in the pit transmits to the observers the sounds made by the machine as it revolves. By these means it is expected that sufficient warning of a breakdown will be given, so that the test can be stopped before the machine or pit is damaged. (D. O. W.)

TESTUDO, "tortoise," the name of two military devices used by the Romans in attacking a fortified place. (1) A wooden frame covered with clay or hides as a protection against fire. Under its protection the battering ram (*aries*) was advanced to the foot of the city wall and operated in safety. (2) A device of locking together the legionaries' shields above their heads, to form a sort of shell, under which they advanced to the attack. A good representation of this is to be seen on the column of Marcus Aurelius.

TETANUS or **LOCKJAW,** a disease caused by the toxin of *Bacillus tetani* (*see* BACTERIA AND DISEASE), an anaerobic bacillus found in soil contaminated by horse dung and therefore in the dust of streets and of gardens and other cultivated land. The bacilli or their spores gain access to the body through a breach of the surface, perhaps trivial, and remain localized. The toxin they elaborate travels by the sheaths of local nerves upwards affecting the nerves themselves in its course towards the spinal cord. Ultimately nerve cells are affected. The necessary conditions for multiplication of the bacilli locally are afforded by the dirt and other micro-organisms gaining access to the wound with the tetanus bacilli. Tetanus may affect persons at any age, even the newly born infant, but is commonest in male adults; in hot countries it is more common, largely because the natives go barefoot. Horses are very liable to the disease.

In man the first symptom is stiffness in the back of the neck or the muscles of the jaw and face. There is difficulty in opening the mouth and the corners of the mouth are drawn downwards and backwards and fixed in that position (*risus sardonicus*). The jaw is so firmly set that it is impossible to pass anything between the teeth. Soon difficulty in swallowing comes on because the muscles of the throat are involved and the abdominal muscles are rigidly fixed. The muscles of the limbs are attacked by agonizing cramps, and, last of all, the muscles of the chest are involved. Though all the muscles are in a continuous state of contraction, thereby differing from strychnine poisoning which tetanus otherwise resembles, the spasmodic contractions come on in addition, and occasionally are so severe that the patient is doubled up forwards, backwards or sideways and perhaps some of the muscles tear across. These spasms may be induced by very slight causes, a sudden small noise, a breath of wind, shaking of the bed.

The sooner the symptoms come on after the injury the worse is the prognosis of tetanus. In the absence of antitoxin treatment when they arise within a week of the injury the prospect of recovery is extremely remote; if within ten days the prospects are bad; if they do not come on until three weeks or so after the injury there is hope. As shown below the prognosis is much improved by prophylactic antitoxin treatment. In the developed disease antitoxic serum is of doubtful value even though injected intrathecally by lumbar puncture. The only available treatment is absolute quiet in a darkened room, morphia to relieve pain, and such amount of liquid food as will sustain life.

Preventive Treatment.—On the appearance of tetanus in the British army during the early days of the World War immediate steps were taken to cope with it. The disease could be prevented if a dose of anti-tetanus serum were given as soon as a wound was sustained because some days elapse before the bacilli, which remain in the wound, are able to secrete sufficient poison to precipitate an attack. From that time every wound, no matter how slight, was followed as soon as possible by a dose of anti-tetanic serum. Out of 1,242,000 wounded men who were sent home to England, 1,458 cases of tetanus arose, giving a ratio of rather more than 1 per 1,000. In Sept. 1914 the ratio of tetanus cases to wounds was 9 per 1,000. In Oct. 1918 the ratio was 0·5.

In Nov. 1914 preventive inoculation, introduced about the middle of Oct. 1914, had begun to exercise its beneficial effects. The following figures giving the number of cases of tetanus per 1,000 wounded men make this clear:

	Cases of tetanus		Cases of tetanus
Sept. 1914 . .	9·0	Feb. 1915 . .	1·1
Oct 1914 . .	7·3	March 1915 . .	0·4
Nov 1914 . .	2·3	April 1915 . .	2·3
Dec. 1914 . .	1·4	May 1915 . .	0·8
Jan. 1915 . .	0·0	June 1915 . .	0·2

The same experience was met with in the French and German armies. As soon as preventive inoculation with anti-tetanic serum became a universal practice, the incidence of tetanus dropped sharply and remained small. In June 1917 it was ordered that each wounded man should receive not one inoculation as formerly but four, at intervals of a week, because the minimizing effect of the serum passes away rather quickly.

The medical department of the United States army required that a prophylactic dose of 1,000 units of tetanus antitoxin be given to all wounded, whatever the nature or severity of the wound, as soon as possible after the infliction of the wound. In such cases, at least one subsequent dose of 1,000 units was to be given after an interval of seven days. Tetanus antitoxin was also to be administered as a routine measure in the following conditions: (1) Upon the recognition of "trench foot," with or without skin abrasions. (2) In case of frost bite. (3) During operations performed under conditions of unsatisfactory asepsis. (4) During secondary operations necessary in the course of treatment of wounds received seven or more days previously. (5) Following the manipulations incident to the reduction of compound fractures or dislocations, after the removal of adherent drains, or any other procedure resulting in the disturbance of the healing process in a wound seven or more days old. As a resultant of these means, the incidence of tetanus in the United States army during the World War was decidedly low; so low, indeed, that only 36 cases were reported as being associated with 176,132 battle injuries. There were but 23 primary admissions to hospital because of tetanus.

The effect is not always to prevent absolutely. But even in those cases in which tetanus does supervene in spite of the inoculations, the incubation period is lengthened and the death rate is lowered; other things being equal, a long incubation period tends to result in a milder attack than a short incubation period, thus any circumstance prolonging the incubation period will also tend to lower the death rate. Only 26·9% of the inoculated are attacked during the first fortnight, whereas 68·9% of the uninoculated are attacked. Among the protected 40·0% have an incubation period of more than 35 days; among the unprotected only 6·5%. The average incubation among inoculated is 45·5 days, among uninoculated 10·9 days. Indeed, in each year of the war the incubation period tended to rise. Further, the inoculations tended to limit the degree of tetanus, converting what would be generalized cases into local or one-limb cases. The following table illustrates this:

Tetanus type	Percentages				
	1914	1915	1916	1917	1918
General . .	98·9	98·6	87·0	76·6	83·5
Local . .	1·1	1·4	13·0	23·4	16·5

Local tetanus tends to occur in the wounded or injured limb and to be confined to that limb. It is much less severe and far less fatal than the generalized type. Naturally the death rate reflected these successes. Among the unprotected and unrecorded the death rate was 53·5%. Among the protected it was 23·0%. The "unrecorded" here undoubtedly include cases which had received a dose. The method employed during the war fully justified the hopes which were entertained concerning it.

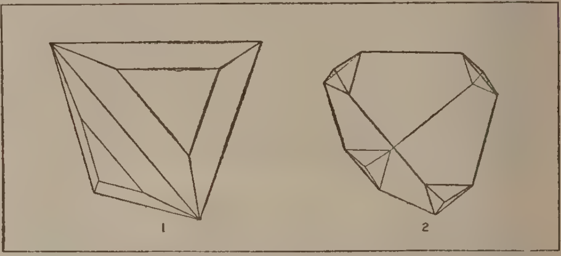
Bibliography.—Maj.-Gen. Sir David Bruce, K.C.B., F.R.S., *The Prevention of Tetanus During the Great War by the Use of Antitetanic Serum* (Research Defence Society, form D2, July 1920).

TETRADYMITE, a mineral consisting of bismuth telluride and sulphide, Bi_2Te_2S, also known as "telluric bismuth." Sometimes sulphur is absent and the formula is then Bi_2Te_3; traces of selenium are usually present. Crystals are rhombohedral, but are rarely distinctly developed; they are twinned together in groups of four; hence the name of the mineral, from the Greek, *τετραδῦμος*, fourfold. There is a perfect cleavage parallel to the basal plane; and the mineral usually occurs in foliated masses of irregular outline. The colour is steel-grey, and the lustre metallic and brilliant. The mineral is very soft (H.=1·5) and marks paper; the specific gravity is 7·2 to 7·6. It often occurs in quartz associated with native gold. (L. J. S.)

TETRAGRAMMATON, the Hebrew four-lettered name of God, commonly known as Jehovah through a misapplication of the vowels belonging to *Adonai* (Lord) to the letters J.H.V.H. Possibly the causative (*hiph'il*) imperfect reading, i.e., *Yahwèh* (He who causes to be or to fall) is the correct form. As early as the time of the Chronicler *Adonai* was substituted for the divine name: evidence for this change is supplied also by the LXX. Origen (Ps. ii.) mentions that the best Bible codices kept the Hebrew name of God in the archaic characters. The recently discovered fragments of Aquila's translation observe this rule and use 𐤉𐤄𐤅𐤄 (*see* examples in H. B. Swete's *Introd. to O.T. in Greek*, p. 38, 1902; *see* also F. C. Burkitt, p. xii. of *Legacy of Israel*, 1927) which was easily mistaken for Greek uncials IIIIII and so this absurd form arose; it is still perpetuated on the Masonic tracing boards where IIIIII figures on the cloud between the pillars Jachin and Boaz. The real pronunciation was forgotten by the Jews since it was suppressed, out of a desire to avoid misuse. The High Priest used it in the Holy of Holies and it survived for some time in the Synagogal Priestly Benediction: here the chant kept up by the choir or by the priests is said to be a survival of the musical screen to shut out the sound of the ineffable name. He who pronounced the name as spelt was guilty of blasphemy. Nevertheless the practical Kabbalists claimed to know the name and to work miracles thereby: such a thaumaturgist was called a *Ba'al Shem* and the last instance known in English was Dr. Falk (d. 1782) of whom extraordinary stories of magic are related. (*See* pp. 245 *sqq.* of J. Picciotto's *Sketches*, 1875; *Jew. Enc.*; C. Duschinsky's *Rabbinate*, 1921.)

Bibliography.—*See* "Tetragrammaton" in *Jew. Enc.* and other articles therein cited: S. R. Driver in *Studia Biblica* I. (1885); pp. 17–40 of A. Marmorstein's *Old Rabb. doctr. of God* (1927).

TETRAHEDRITE, a mineral consisting typically of copper sulphantimonite, Cu_3SbS_3, but often of complex composition. The copper is usually isomorphously replaced by variable amounts of silver, iron, zinc, mercury, lead or cobalt, and the antimony by arsenic or bismuth. Numerous special names have been applied to varieties differing in chemical composition; the arsenic compound, Cu_3AsS_3, is known as tennantite (after Smithson Tennant). The old German name *Fahlerz* includes both tetrahedrite and tennantite. Tetrahedrite is an important ore of copper, the formula Cu_3SbS_3 corresponding with 57·5% of this metal; it is also largely worked as an ore of silver, of which it sometimes contains as much as 30%. Well-developed crystals are of frequent occurrence; they belong to the tetrahedral class of the cubic system, and their tetrahedral form is a very characteristic feature of the mineral, which for this reason was named tetrahedrite. Fig. 1 shows a combination of a tetrahedron and a triakis-tetrahedron {211}, and fig. 2 a tetrahedron with the rhombic dodecahedron. The colour is steel-grey to iron-black, and the lustre metallic and brilliant. The streak is usually black; sometimes, however, it is dark cherry-red, and very thin splinters of the mineral then transmit a small amount of blood-red light. The hardness is 4·5, and the specific gravity varies with the composition from 4·4 to 5·1. There is no cleavage, and the fracture is conchoidal.



TETRAHEDRAL CRYSTALS OF TETRAHEDRITE

Tetrahedrite occurs in metalliferous veins, usually in the zone of secondary enrichment. Fine groups of crystals, coated on their surface with brassy or brilliantly tarnished chalcopyrite, were formerly found at Herodsfoot mine, near Liskeard in Cornwall. Tennantite occurred as small crystals of cubic or dodecahedral habit in many Cornish copper mines, especially in the neighbourhood of Redruth: it is also found as small, brilliant crystals very rich in faces in the white crystalline dolomite of the Binnenthal in the Valais, Switzerland, and under the name binnite was long considered as a distinct species. (L. J. S.)

TETRAHEDRON: *see* Solids, Geometric.

TETRAPOD, an animal with four legs; the term is used in zoology to denote collectively the Amphibia, reptiles, birds (*qq.v.*) and mammals (*see* Mammalia). The evolution of the tetrapods from their fish ancestors is considered in the article Amphibia.

TETRARCH, a governor of a quarter of a province: Thessaly was divided into tetrarchies by Philip of Macedon and so was Galatia before the Roman Conquest in 169 B.C. Feudal lords in Palestine were called Tetrarchs and were inferior to Ethnarchs. Tetrarch came to be used generally for a petty prince. Herod the Great was Tetrarch before becoming king. At his request Augustus appointed Pheroras tetrarch of Perea. Other Tetrarchs were Herod's two sons who at his death (4 B.C.) divided his kingdom, Herod Antipas being Tetrarch of Galilee and Philip Tetrarch of Iturea and Trachonitis: the eldest son, Archelaus, was not tetrarch but Ethnarch of Judea, Samaria and Idumea. Herod Agrippa reunited the tetrarchies (A.D. 41–44).

See *Jew. Enc. s.v.:* H. Graetz, *History of the Jews* (Philadelphia, 1898) (refs. in index).

TETRASTOÖN, in architecture, a court with a portico or colonnade on all four sides; a peristyle (*q.v.*).

TETRASTYLE, in architecture, a portico with four columns in front, or a building whose main feature is such a portico.

TETRASTYLON, the term given by Vitruvius to a type of atrium (*q.v.*) or cavaedium (*q.v.*) in which four columns at the angles of the impluvium (*q.v.*) or central basin supported the roof.

TETSCHEN: *see* Děčin.

TETZEL, JOHANN (*c.* 1460–1519), preacher and salesman of papal indulgences, the son of Hans Tetzel, a goldsmith of Leipzig, was born there about 1460. He matriculated at the university in 1482, graduated B.A. in 1487, and in 1489 entered the Dominican convent at Leipzig. He found his vocation as a preacher of indulgences, combining the gifts of a revivalist orator with the shrewdness of an auctioneer. He began in 1502 in the service of the Cardinal-legate Raymond Peraudi; and in the next few years he visited Freiberg (where he extracted 2,000 gulden in two days), Dresden, Pirna, Leipzig, Zwickau and Görlitz. Later on he was at Nuremberg, Ulm and Innsbruck. He was elected prior of the Dominicans in Glogau in 1505.

Fresh scope was given to his activity in 1517 by archbishop Albrecht of Mainz, who had agreed with Pope Leo X. to pay his first-fruits in cash, on condition that he were allowed to recoup himself by the sale of indulgences. Half the proceeds in his province were to go to him, half to Leo X. for building the basilica of St. Peter's at Rome. Tetzel was appointed general sub-commissioner for indulgences, and was accompanied by a clerk of the Fuggers from whom Albrecht had borrowed the money to pay his first-fruits. Tetzel's efforts irretrievably damaged the complicated and abstruse Catholic doctrine on the subject of indulgences. "As soon as the coin clinks in the chest," he cried, "the soul is freed from purgatory." In June he was at Magdeburg, Halle and Naumburg; the elector of Saxony excluded him from his dominions, but Albrecht's brother, the elector Joachim of Brandenburg, encouraged him at Berlin in the hope of sharing the spoils, and by the connivance of Duke George of Saxony he was permitted to pursue his operations within a few miles of the electoral territory at Wittenberg. Luther was thus roused to publish his momentous ninety-five theses on the subject of indulgences on Oct. 31, 1517.

Through the influence of Conrad Wimpina, rector of Frankfurt, Tetzel was created D.D. of that university, and with Wimpina's assistance he drew up, in Jan. 1518, 106 theses in answer to Luther's. But the storm overwhelmed him: sober Catholics felt that his vulgar extravagances had prejudiced Catholic doctrine, and Miltitz, who was sent from Rome to deal with the situation, administered to him a severe castigation. He hid himself in the Dominican convent at Leipzig in fear of popular violence, and died there on July 4, 1519.

See H. Barge, *Andreas Bodenstein von Carlstadt* (2 vols., 1905); J. Janssen's *Hist. of the German People*, and *An meine Kritiker;* M. Creighton's *Hist. of the Papacy*, vol. vi.; and H. C. Lea's *Hist. of Auricular Confession and Indulgences* (3 vols., 1896).

TEUCHIRA, an ancient city of Cyrenaica on the coast 40 m. N.E. of Berenice (mod. *Bengasi*). It was also called Arsinoe in honour of the mother of Berenice. Considerable remains of its ancient walls are preserved; they probably date from the 4th century B.C., but were restored in the time of Justinian, at the expense of the buildings of the ancient city which were laid out on a rectangular plan and of which various remains are left—a palace, another public building with terraces, and two Byzantine churches. The citadel was strongly defended by deep quarries in which numerous tombs have been excavated.

See *Ministero delle Colonie: Notiziario Archaeologico* (1915) 102–110; and authorities for CYRENAICA.

TEUTOBURGER WALD, a mountain range of Germany, stretching north-west to south-east, from west of Osnabräck to south-east of Paderborn for a distance of 70 m. with a width of 2 to 6 m. It consists of a well-marked main chain, with subsidiary ridges in its central part. Its height increases gradually south-eastward culminating in the Völmerstod (1,536 ft.). The greater part of the range is densely wooded.

TEUTOBURGER WALD, BATTLE OF (9 A.D.). At the opening of the Christian era the country between the Rhine and the Vistula was covered by dense forests, and occupied by numerous Germanic tribes. As Julius Caesar had conquered Gaul, so in his turn did Augustus Caesar determine to conquer this region. To it he sent Drusus and Tiberius, both able generals, and by 15 B.C. the Roman frontier was pushed out to the Danube. Between 12 and 9 B.C. Drusus advanced as far as Aliso (probably near Paderborn) on the Lippe, built there a strong fortress, and moved on to the Elbe. Drusus dying at the early age of 30, Tiberius succeeded him in command, and having completed the subjugation of the tribes, in 6 A.D. he was replaced by Quintilius Varus, a man of luxurious habits and disturbed by no cares. He at once began to uproot the old German customs, and by so doing consolidated the tribes against him.

Varus had under his command some 50,000 men. He had administered his province for about a year, when a contingent of Cheruscan (one of the Germanic tribes) troops under the leadership of Arminius returned to their country. Arminius was then in his twenty-fifth year, and had been educated in Rome. He bore the Romans no ill-will until his return, when his indignation was roused by the behaviour of Varus towards his countrymen. Seeing that he was powerless to strike at the Romans covered by their entrenchments, by flattery he gained over Varus, and then in order to draw him away from the Rhenish fortresses persuaded him to move his headquarters to the Weser. This he succeeded in doing.

In the summer of 9 A.D., Varus set out with the XVII., XVIII. and XIX. legions, some cavalry and auxiliaries, in all some 27,000 men to repress a local rising arranged by Arminius. He was warned of the danger, and was urged to secure Arminius and the other Cheruscan chiefs who with their men formed the rear-guard of his column. Refusing to listen to these warnings, from near Minden he entered the forests, followed by an immense train, and headed for Aliso. When the head of the column had become entangled in the brushwood near the hill of Teut, now called Grotenburg, Arminius quitted the rear and followed by his comrades, by means of fire and horn signals roused the tribesmen from the Ems to the Main. As the Romans reached the slopes of the Teutoburg, the German hordes broke in on them from all sides. So trusting and blind was Varus that at first he thought it but rough horseplay. Soon, however, he was disillusioned, and was only able to beat back the incessant assaults by moving towards an open plateau. Here he entrenched.

During Sept. 9, he burnt the *impedimenta* to lighten the column. On the 10th it was again attacked. Though Varus showed great personal bravery he gave no orders, and his troops lost confidence in him. With difficulty they reached the entrance of the Dörn pass but a few miles from Aliso. Here Arminius had determined on his decisive attack. Blocking the further exit he fell upon the flanks of the disheartened column, which broke and was slaughtered. Varus fell upon his own sword as his father had done at Philippi.

The loss of the three Roman legions was more than a staggering blow to Augustus, for it marked a great turning point in European history. It showed that Rome was not invincible. It sent the frontier of the Empire back from the Weser to the Rhine, and so prevented the latinization of what to-day constitutes a large part of modern Germany. It denied to the barbarians of the North a high culture, and it encouraged them to sweep South with a low culture and barbarize western Europe. Tactically this battle is of small account, a Marius or a Caesar would have soon finished with Arminius, but its repercussions, not only on the history of war but on that of civilization, cannot be exaggerated, for they are felt to-day in the age-long quarrel between France and Germany—the Latin and the Teutonic outlooks.

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TEUTONI or **TEUTONES,** a tribe of northern Europe who became known to the Romans in the year 103 B.C. when they reinforced the Cimbri (q.v.) after their repulse from Spain by the Celtiberi. In 102 the Teutoni and Ambrones were totally defeated by Marius at Aquae Sextiae (*see* MARIUS). The name of the Teutoni is Celtic in form, and possibly they were really a Celtic tribe, a branch of the Helvetii. But a people of this name was mentioned by the traveller Pytheas as inhabiting the coasts of the northern ocean. Strabo and Velleius classify them as Germani.

TEUTONIC (GERMANIC) LANGUAGES, a comprehensive term for a number of languages, namely English, Frisian, Dutch, Flemish, German (both High and Low) Swedish, Danish, Icelandic, the Norwegian dialects, and the now extinct Gothic, formerly spoken over a large part of Europe. The written records of the various languages date from different periods. Gothic is known to us almost entirely from Ulfilas' translation of the Bible, which dates from the 4th century. English written literature starts with the beginning of the 7th century, though earlier matter may be preserved in certain poems. The earliest known German and Dutch documents date from the 8th and 9th centuries respectively, while Frisian is practically unknown before the 13th century. Scandinavian written literature seems to have begun in the 12th century, but many poems are probably from two to three centuries older. In the North there is a large number of inscriptions of great value for linguistic purposes. They show all stages of development of language from that found in literary times back to a more archaic type even than the Gothic.

The Teutonic languages form a distinct and well-defined group of the Indo-European family (*q.v.*), and belong, together with Celtic, Italic and Greek, to the western or Centum division.

The chief characteristic of the Teutonic languages as a whole lies in their treatment of the Indo-European explosive sounds. This characteristic, generally known as Grimm's Law, is due to sound-changes peculiar to Teutonic, though somewhat similar changes may be traced both in Armenian and Celtic. The following abbreviations are used: A.S.=Anglo-Saxon; O.H.G.=Old High German; O.N.=Old Norse; I.-E.=Indo-European.

The voiced aspirates *bh,dh,gh* (Lat. *f,f,h;* Gr. φ, θ, χ) became voiced spirants, *b,d,ʒ*. After nasals these spirants became explosives (*b,d,g*); and in the first two cases the same change took place initially. The I.-E. voiceless explosives, *p,t,k*, were preserved only after *s* (*t* also in the I.-E. groups *pt* and *kt*). In all other cases they became voiceless spirants, *f*, þ, χ, (*h*). These new sounds remained (i.) initially; (ii.) in combination with other voiceless sounds; (iii.) immediately after the (original) accent. In all other cases they became voiced spirants ("Verner's Law"), identical with those arising from I.-E. *bh,dh,gh*.

The I.-E. voiced (unaspirated) explosives, *b,d,g*, became voiceless, *p,t,k*.

ʒw arising from I.-E. *ghw* or *kw* (*see* above) was reduced (except after nasals) before *u* (perhaps also before I.-E. *o*) to ʒ, and in all other cases to *w*.

The I.-E. cons. group arising from combination of dental sound +*t* became *ss*, as in Celtic and Latin. The I.-E. *s* was preserved (i.) initially, (ii.) in combination with voiceless sounds, (iii.) immediately after the (original) accent. In all other cases it became voiced (*z*). This voiced spirant subsequently became *r* in all Teutonic languages except Gothic, where, however, the distinction between voiced and voiceless spirants is not well preserved.

Most of the other consonantal changes are in the nature of assimilation. Thus, *bn,dn,zn* before the accent became *pp,tt,kk* (probably through the intermediate stage *bb,dd,gg*); *ln* became *ll; nw* became *nn; đl* became *ll*. In some combinations consonants are lost or new consonants developed.

The following changes are found in all Teutonic languages, but took place apparently later than those enumerated above:—

n was lost before χ (*h*), with resultant lengthening of the vowel. Final explosives and nasals were lost.

The chief peculiarities of the vowel-system of the earliest known form of Teutonic are:—

It had one vowel (*a*) corresponding to the two vowels *a, o,* found in the other I.-E. languages.

It had also one vowel (*ō*) corresponding to the two vowels *ā, ō,* found in the other I.-E. languages.

The other I.-E. vowels, *ē̆, ī̆, ū̆,* were preserved in the earliest Teutonic. Soon after the beginning of our era, however, *e* began to change to *i* before a nasal followed by a consonant. The diphthong *ei* became *ī*.

The reduced nasal sounds generally written *n̥, m̥,* arising from *en, ne, em, me,* etc., in unaccented syllables, became *un, um* (rarely *nu, mu*). Similarly the reduced liquid sounds *r̥, l̥,* became *ur, ul* (rarely *ru, lu*).

Accent.—In the I.-E. languages the position of the accent was originally free—*i.e.,* any syllable in the word could bear the chief accent—variation occurring very frequently, *e.g.,* between different cases of the same noun. This freedom of position must have been retained in Teutonic at the time when voiceless spirants (*f*, þχ, *s*) became voiced (see above). Eventually, the first syllable of every word came to bear the chief accent, except in certain compound words, especially verbs compounded with prepositions, which were probably long regarded as more or less independent words. This system of accentuation was intimately connected with the principle of alliteration, the essential characteristic of early Teutonic poetry and the dominant factor in family nomenclature.

The description of the phonetic characteristics given above applies in general to the Teutonic group of languages as a whole, and would probably be true for the time about the beginning of the Christian era. Dialectical differences no doubt already existed, but cannot be traced with certainty. The language of the earliest Runic inscriptions does not differ very markedly from the type. The principal changes are:—

e became *i*, (i.) in the unaccented syllable of dissyllabic and in the least accented syllables of polysyllabic words; (ii.) in accented syllables when the following syllable contained *i, j,* or *u*.

i became *e* when the following syllable contained *a, ē̆, ō*.

u became *o* when the following syllable contained *a, ē̆, ō*.

ē became *ā* always.

final *a, e,* were lost.

Final long vowels were (in general) shortened (*ī>i, ō>u*).

Final nasals and explosives were lost.

The chief sound-changes in the northern and western languages seem to have taken place in the 6th and 7th centuries. Some were common to all the languages in question, some to English and Scandinavian, some to English and German, others occurred in only one of these languages or a portion of it.

I. Among the chief changes common to English, Scandinavian and German we may reckon (1) the loss of final *a* (in Scand. also before final consonants); (2) the loss of unaccented *i, u* after long syllables; (3) the change *z>r* before vowels or *g*.

II. Among the most important of the changes common to English and Scandinavian must be classed (1) the affection (*umlaut*) of vowels by the vowels (generally *i, u*) of following syllables. In early German the only case of this kind was the affection of *a* by a following *i* and even this seems to have taken place much later. In the same category we must reckon (2) the early loss of *h* between sonants; (3) the loss of *n* before *s*.

III. Among the chief changes common to English and German were: (1) The loss of final *z*. In short monosyllables, however, *z* became *r* in High German, as in Scandinavian; (2) The change *z>r* before *d* (whereas assimilation took place in Scand.); (3) The change *đ>d* in all positions (in Scand. only initially and after *l*); (4) The lengthening of all consonants (except *r*) before *j* (in Scand. only gutturals).

The Frisian dialects agree with English in the phenomena enumerated above and in changes peculiar to these languages, such as (1) the change *ā>ō* before nasals; (2) the change *ā>a̅e̅* (later *ē*) in other positions; (3) the labialization of *a* before nasals; (4) the change *a>ae* (*e* in Fris.) in close syllables (also in open syllables before front vowels); (5) the diphthongization of vowels before *h*; (6) the loss of *n* before þ ; (7) the palatalization of gutturals before front vowels. The differences between the two languages in early times were few: (1) *a, e, i,* are diphthongized before *r* followed by a consonant in English, but not in Frisian; (2) the diphthong *ai* became *ā* in English everywhere, but in Frisian only in open syllables (*ē* in close syllables); (3) the diphthong *au* (*aeu,* then) became *ēa* in English, but *ā* in Frisian; (4) *i* was labialized in Frisian, but not in English, before (original) *w* in the following syllable. Frisian texts of the 13th and 14th centuries show many characteristic changes which must have rendered the language almost, if not wholly, unintelligible to an Englishman of the same period; but it is hardly probable that these changes were for the most part of any great antiquity.

Declension.—The I.-E. languages seem originally to have had three numbers and eight cases. In Teutonic there is scarcely any trace of the dual in nouns. All the early Teutonic languages preserved the Nominative, Accusative, Genitive and Dative. The Vocative was kept in Gothic and the Instrumental to a considerable extent in early German, while the earliest Anglo-Saxon preserved many traces of the locative.

The case endings are best preserved in the earliest Northern inscriptions and in Gothic. Whatever changes have taken place have usually tended towards simplification; thus there are but few traces of stem-variation (*ablaut*) between different cases of the same noun.

Adjectives.—The treatment of adjectives was more peculiar. In addition to the old type of declension which conformed to that of the demonstrative pronoun, almost every adjective was inflected also after the model of *n*-stems. This type of inflection occurs chiefly in conjunction with the demonstrative pronoun (definite article).

The comparative of adjectives is formed partly by a suffix *-izan-*, and partly by a suffix *-ōzan-* which is peculiar to Teutonic. Similarly the superlative is formed partly by a suffix *-ista-*, and partly by a new formation *-ōsta-*.

Most of the I.-E. demonstrative pronouns are found in Teutonic, and the peculiarities of their inflection are in general well preserved. The place of the relative pronoun is supplied by the demonstrative or by indeclinable forms. The inflection of the personal and reflexive pronouns is for the most part peculiar to Teutonic.

Conjugation.—The Teutonic verb-system is simpler than that of most of the I.-E. languages. The old Middle Voice is preserved only in Gothic, where it is used as a passive. In the other Teutonic languages only one or two isolated forms remain. In place of the Conjunctive and Optative, there is but one mood which is generally called Conjunctive, though its forms are mostly of Optative origin. There are only two tenses, Present and Preterite, the latter of which is derived partly from the I.-E. Perfect, partly from Aorist or Imperfect formations. A few old Perfects, which have no Presents, retain their original meaning and are generally known as Preterite-presents. In place of the Future the Teutonic languages use either perfective verbs (generally compounded with a preposition) or a periphrasis consisting of the Infinitive with an auxiliary verb.

The conjugation of the Pres. Indic. Act. corresponds in general to that of most of the I.-E. languages. Gothic had also forms for the 1, 2 dual, *bairos, bairats,* which have not been satisfactorily explained. In the other languages there is scarcely any trace of the dual. The conjugation of verbs corresponding to the Greek verbs in μι is preserved best in Old High German. A number of archaic forms are preserved in the "verb substantive." The forms of the Conjunctive (Optative) and Imperative correspond in general to those of the other I.-E. languages.

The Preterite formations are of two types, usually termed "strong" and "weak." The latter belong to verbs whose past participle has a stem *-da-* (I.-E. *-tó-*; see below), the former to the remaining verbs. The singular of the strong Preterite is derived from the I.-E. Perfect, while the plural, which in most verbs has a different stem, may come either from the Perfect or from Aorist formations. In the plural the endings were originally accented; hence many verbs show differences not only in the stem vowel but also in the consonants (by Verner's Law, *see* above) between the two numbers. Except in Gothic and Scandinavian the 2 sing. has generally a form (originally Aorist) similar to the plur. The stem of the Conjunctive also agrees with that of the plural.

The "weak" Preterite seems originally to have arisen out of a periphrastic formation of which the second part consisted of Imperfect or Aorist forms of the verb. The short reduplication-syllable, however, is lost in the sing., while the long syllable of the plur. (and dual) is preserved only in Gothic.

The stem of the weak Preterite almost always conforms to that of the past participle. The inflection of the Conjunctive agrees with that of the strong Preterite.

The Infinitive is formed from the present stem with an ending *-an*, and probably was originally a case-form of a verbal noun. In the western languages we find also the Dative of a stem *-anja-* used after a preposition.

The Present Participle has a stem *-and-* (I.-E. *-ont-*) identical with the ending of the 3 plur. Indic., as in the other I.-E. languages; but the Participles in actual use were declined as *-an-* or *-ja-* stems. The unextended stem survives only in substantives. The stem of the Past Participle (Passive) is formed by the suffixes *-to-* and *-no-*, as in the other I.-E. languages. The former occurs as a living formation only in connection with the verbs whose Present stem ends in *-ja-*, *-ō-*, *-ē-*. The Past Participle in use with other classes of verbs has a stem *-ena-* or *-ana-*, the former in English and Scandinavian, the latter in Gothic and German. Remains of old Participles in *-to-*, *-no-* formed otherwise than those in living use may be found in adjectives.

Thus the Teutonic group of languages has many characteristic features which distinguish it from other languages of the same stock, while the morphological differences among the Teutonic languages themselves are comparatively slight and due mainly to the operation of syncretism and other simplifying processes, which have been carried still further, so that the Danish verb has lost all inflection of person and number, while distinction of gender has wholly disappeared in English. In the earlier stages of the Teutonic languages differences of phonology are more marked than those of morphology, and afford surer criteria for determining the relations of these languages to one another. Gothic began at an early date to show marked divergences from the other languages. The Scandinavian languages also certainly underwent a considerable number of peculiar changes before the beginning of their literatures. From the 6th century to the 9th the Scandinavian peoples were practically cut off from communication with other Teutonic nations by the Slavonic occupation of Mecklenburg and eastern Holstein. By the middle of the 7th century the English and Frisian languages were about midway between Scandinavian and German, though they had already developed well-marked characteristics of their own. They doubtless represent the old language of the maritime districts, at one time spoken along the whole of the coast between the present frontiers of Belgium and Denmark. The special characteristics of German in all probability developed in the interior and those of Scandinavian round the Baltic and the Cattegat. From the 8th century onwards the High German (southern) dialects of German differed greatly from those spoken further north owing to the operation of the changes generally known as the "second sound-shifting." The northern dialects, however (Old Saxon and Low Frankish), were essentially German, though both were affected by Frisian influence.

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TEUTONIC ORDER, THE, or Teutonic Knights of St. Mary's Hospital at Jerusalem (*Der deutsche Orden, Deutsche Ritter*) was one of the three great military and religious orders which sprang from the CRUSADES (*q.v.*). Later in birth than the Templars and Hospitallers, the Teutonic Order traces its first beginnings from the third Crusade. But it is amidst the privations and plague which attended the siege of Acre, during the third Crusade, that the first certain beginnings of the Order appear. In the winter of 1190–91 certain pious merchants from Bremen and Lübeck (towns with which the Order was still to be connected in the days of its later history) laid the foundations of a hospital in a vessel which they had drawn ashore. Within a few years the foundation apparently became attached to the German Church of St. Mary the Virgin at Jerusalem; and in March 1198 (there being present in the Holy Land a number of Germans, the relics of Henry VI.'s projected crusade), the great men of the army and the kingdom raised the brethren of the German Hospital of St. Mary to the rank of an order of knights. The original members were thus ennobled; and henceforth it was the rule that only Germans of noble birth could join the Order.

Like the other two great military orders, the Teutonic Order began with charity, developed into a military club and ended as something of a chartered company, exercising rights of sovereignty on the troubled confines of Christendom. Even in its last phase, the Order did not forget its original purpose: it maintained several great hospitals in its new home on the south-east shore of the Baltic, in addition to an *hôtel des invalides* at Marienburg for its sick or aged brethren. But long before that period the Order had begun to find that its true work lay on the eastern frontiers of Germany. In 1228 Christian, bishop of Prussia, who had received from the Polish duke of Masovia a part of Kulmerland as a fief, had founded the knightly Order of Dobrzin, and was attempting to subdue the heathens of Prussia. Unsuccessful in his attempt, he invited the Teutonic Order to come to the rescue, and bestowed on the Order Kulm and some of the frontier towns in his territory, with such lands as it should conquer.

Thus the Order took its place as the founder of one of the marks on the eastern frontier of Germany, and began to play its part in the *Drang nach Osten*, which is perhaps the vitally important thing in the history of Germany from the 12th to the 14th century. Since the days of Adolf of Holstein and Henry the Lion, a movement of German colonization, in which farmers from the Low Countries, merchants from Lübeck and monks of the Cistercian Order all played their parts, had been spreading German influence from the Oder to the Vistula, from the Vistula to the Dwina—to Prague, to Gnesen and even to Novgorod. Of this movement the Teutonic Order became, along with the Hanse, the chosen representative.

In 1229 the Order began the conquest of Prussia, founding fortresses at each step to rivet its conquests (for instance, at Thorn, named after Toron in Palestine), much as the Anglo-Normans had done in their conquest of Wales; and in 1234 the Order established its independence of all authorities except the Papacy, by surrendering its territories to the Holy See and receiving them back again as a fief. The pope gave to those who joined in the work of the Order the privileges of Crusaders; and the knights, supported by numerous donations and large accessions to their ranks, rapidly increased their territories. Already by the beginning of the 14th century these conquests had fundamentally changed the character of the Order. It lost any connection with the East: after the fall of Acre in 1291, the grand master (whose seat had been at Acre, while the German master [*Deutschmeister*] had controlled the Order in Germany) moved first to Venice, and then, in 1308, to Marienburg on the Vistula.

Again, with the accession of large territories, the Order became a governing aristocracy; the original care for the sick, and even the later crusading zeal of the period of conquest, gave way, when conquests were gained and administration was needed, to the problem, half military, half political, of governing a frontier state. The statutes of the Order were altered to suit the new conditions, and a whole system of administration arose. At Marienburg the grand master maintained a magnificent court; round him were the five great dignitaries of the Order, the Grand Commander, the Marshal, the Hospitaller, the Treasurer (*Tressler*) and the Keeper of the Wardrobe (*Trapier*) to see to the clothing of the Order. There was a *Landmeister* for Livonia, and another (the *Deutschmeister*) for the German province, with his seat at Mergentheim in Swabia. Over each of the twenty districts of the Order was set a commander (*Komtur*), with the brethren of his house at his side as advisers.

The concord of the Order at this time with the towns and the Hanse was one of the great causes of its prosperity until the close of the 14th century; and the rupture of that concord in the 15th century was largely responsible for its fall. This political and material strength enabled the Order to weather the storm by which the Templars were destroyed at the beginning of the 14th century. For a time, indeed, the Order lay under papal sentence of excommunication; but the transference of his seat to Marienburg at this time (1308) gave the grand master a basis from which he was able to make easy terms with the pope. Nor was the Order, during the 14th century, at all unfaithful to its original calling. Particularly under the grand master Winrich of Kniprode (1351–1382) it was the school of northern chivalry, engaged in unceasing struggle to defend Christianity against the heathen Lithuanian.

At the height of its glory irretrievable ruin descended upon the Order. The defeat which the Polish king Ladislaus inflicted upon the knights at Tannenberg in 1410 was crushing. It brought Ladislaus little immediate gain; but it stimulated the elements of unrest in Prussia to fresh activity. The discontented clergy, especially in Livonia; the towns, such as Danzig; the native aristocracy, organized in a league (the *Eidechsenbund*, or League of the Lizard), all sought to use their opportunity. It was in vain that the heroic grand master, Henry of Plauen (1410–1413) sought to stem the tide of disaster; he was deposed by the chapter of the Order for his pains. The success of the Hussite raids in Germany gave fresh confidence to the Slavs of Poland. The Order was at variance within itself; some of the houses of the brethren refused to obey the marshal, and the grand master quarrelled with the German master. Above all, there arose in 1440 the Prussian League (*Preussischer Bund*), in which the nobles and towns joined together, nominally for common protection of their rights, but really against the Order. The League naturally sympathized with Poland, not only because Poland was the enemy of the knights, but also because under Poland it hoped to enjoy the practical liberty which Polish anarchy already seemed to offer. The ultimate result was that in 1454 an embassy of the League offered Prussia to the Polish king, and that, after many years of war, the Peace of Thorn (1466) gave to Poland West Prussia, with Marienburg, Thorn, Danzig and other towns, in full possession, and, while leaving East Prussia to the Order, made the Order the vassals of Poland for the territory which it retained. Henceforth the grand master was to sit in the Polish diet on the left of the king, and half of the knights were to be Polish.

Henceforth the Teutonic Order lived in Germany and in Livonia. The master of the latter province had beaten off an attack of the Russians in 1502, and secured a fifty years' peace. But in 1561 another master followed the example of Albert, and received Courland as an hereditary fief from Poland. Henceforth the Order was confined to Germany alone. Nevertheless, it clung to its rights with the conservatism of an ecclesiastical corporation, still maintained its claims to East Prussia and pressed them tenaciously even against the electors of Brandenburg themselves, when they inherited the land on the failure of Albert's descendants in 1618. The French Revolution finally deprived the Order of all its estates, and for a while of its existence. In 1801 the bailiwicks to the west of the Rhine were absorbed by France; in 1809 the Order was entirely suppressed, and its lands went to the secular principalities in which they lay. But in 1840 the Order was resuscitated in Austria as a semi-religious knighthood, closely connected with the Habsburgs. But its real heirs were the Hohenzollerns of Prussia. When Frederick the Great gained West Prussia by the first partition of Poland (1772), he was uniting together once more the dominions of the Order, sundered for 300 years.

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TEUTONIC PEOPLES, a comprehensive term for those populations of Europe which speak one or other of the various Teutonic languages, viz., the English-speaking inhabitants of the British Isles, the German-speaking inhabitants of Germany, Austria-Hungary and Switzerland, the Flemish-speaking inhabitants of Belgium, the Scandinavian-speaking inhabitants of Sweden and Norway, practically all the inhabitants of Holland and Denmark, small German and Flemish-speaking communities in

Italy and France, the somewhat larger German and Swedish populations in Russia, and the populations in America, Africa, Australasia, etc., which have emigrated from the same countries. In the British Isles, there is (in addition to the Celtic-speaking elements) a considerable population which claims Celtic nationality though it uses English.

The term "Teutonic," like the other terms ("Germanic," "Gothic," etc.) which are or have been used in the same sense, is of scholastic and not of popular origin, because their common origin has been forgotten. In Tacitus's time, however, a consciousness of their relationship to one another was fully retained. He cites native poems which declared that the Inguaeones, Hermiones and Istaeuones—the three main branches of the Germani (*see* below)—were sprung from three sons of a certain Mannus (perhaps "Man"), himself the son of the god Tuisto, the son of Earth; and a Frankish document at least four centuries later mentions three brothers named Erminus, Inguo and Istio, from whom many nations were descended. In English documents also eponymous national ancestors are grouped in genealogical trees.

In regard to physical features they present at the present time many varieties both of stature and of pigmentation, though on the whole they are probably the tallest and fairest of European peoples. These characteristics must in early days have been as pronounced. Moreover, the tallness and dolichocephaly which now specially mark the more northern peoples of the group appear very prominently in cemeteries of the migration period in Switzerland and other neighbouring countries. On the whole, however, the skeletons found in German and Scandinavian tombs dating even from the earliest period do not show any very remarkable differences from those of the present day. But the most striking characteristics of these peoples occur also to a considerable extent among their eastern and western neighbours, where they can hardly be ascribed altogether to Teutonic admixture.

The neolithic population of Scandinavia was composed of three elements: Food-gatherers (descendants of the epipalaeolithic inhabitants), Megalithic Builders and the People of the Separate Graves. Study of these cultures and their distribution shows that the folk of the Separate Graves were a distinct and bellicose people. Whether their original home lay in Jutland or whether they were continental invaders is disputed; but by the beginning of the bronze age, the Separate Graves' People had succeeded both in dominating and absorbing the other two elements. (*See* ARCHAEOLOGY: *Eastern Europe* and SCANDINAVIAN CIVILIZATION.) As no Teutonic inscriptions are extant from before the 3rd or 4th centuries, it cannot be stated with certainty what types of objects are characteristic of Teutonic civilization in the bronze and earliest iron ages. Yet during the bronze age, a fairly well-defined group of antiquities can be traced covering the basin of the Elbe, Mecklenburg, Holstein, Jutland, southern Sweden and the islands of the Belt, and archaeologists conjecture that these antiquities represent the early civilization of the Teutonic peoples. The civilization was, of course, not wholly of native growth. Strong foreign influence, first from the East Mediterranean and later from Italy, can be distinguished, nor is the influence of Central Europe (the Aunjetitz and the Danubian-Sudetic Tumulus cultures) to be underestimated. But the types introduced from the south have generally undergone considerable modification. The degree of wealth and artistic skill of which many of even the earliest antiquities give evidence is probably due to the importance of the amber trade. Both in eastern and in western Germany the objects found are of somewhat different types pointing to a lower standard of civilization. What peoples inhabited these regions can only be conjectured, but there is a certain amount of evidence from place-names—not altogether satisfactory—that the Celtic peoples at one time extended eastwards throughout the basin of the Weser. With the beginning of the iron age (perhaps *c.* 500–400 B.C.) Celtic influence becomes apparent everywhere. By this time, however, the great Celtic movement towards the south-east had probably begun, so that the Teutonic peoples were now cut off from direct communication with the centres of southern civilization.

HISTORY

The first recognition that the inhabitants of Germany, Holland, etc., were a people distinct from their Celtic neighbours dates from about the middle of the 1st century B.C., when Caesar's conquest of Gaul renders a knowledge of northern Europe more generally accessible. Certain notices relating to individual Teutonic tribes come down from still earlier times. Thus the Cimbri and their allies, who invaded Illyricum, Gaul and Italy in the last years of the preceding century, were for the most part of Teutonic nationality. The Bastarnae also, who in the 3rd century B.C. invaded and settled in the regions between the Carpathians and the Black Sea, are said by ancient writers to have been Teutonic, though they had largely intermarried with the native inhabitants. Again, individual travellers from the time of Pytheas onwards had visited Teutonic countries in the north. The early records, however, do not clearly distinguish the Teutonic peoples from the Celts. From the time of Caesar onwards the former were known to the Romans as "Germani," a name probably of Gaulish origin, first applied to certain Belgic tribes in the basin of the Meuse, who may have come from beyond the Rhine.

At the beginning of our era the Teutonic peoples stretched from the Rhine to the Vistula. Before Caesar's arrival in Gaul they had advanced beyond the Rhine, but in this direction were checked by his campaigns, and, though both banks of the river were occupied by Teutonic tribes throughout the greater part of its course, most of these remained in subjection to the Romans. The eastern-most Teutonic tribe was probably that of the Goths, in the basin of the Vistula, while the farthest south were the Marcomanni and Quadi, in Bohemia and Moravia, districts which had been conquered from the Boii, a Celtic people, shortly before the beginning of our era. Towards the south and west the Teutonic peoples had been pressing the Celts for some considerable time, since the Helvetii formerly extended as far as the Main, while another important Celtic tribe, the Volcae Tectosages, had occupied a still more remote position, which it is impossible now to identify. At this time the Teutonic peoples occupied at least a considerable part of the Scandinavian peninsula.

On what the grouping into Inguaeones, Hermiones and Istaeuones was based, is not certain. Kossinna (*see* bibliography) distinguishes three cultural subdivisions in the civilization of the West Germans in the first century A.D. which more or less correspond to these three groups of peoples. It is probable, however, that these three names have also a religious significance. The name of the Hermiones, who are defined as "central" or "interior" peoples, is probably connected with that of the Irminsul, the sacred pillar of the Old Saxons. The Inguaeones are defined as being "next to the ocean"; but the name can be traced only in Denmark and Sweden, where we find the eponymous hero Ing and the god Yngvi (Frey) respectively. It is likely that the name belonged only to the peoples of the southern Baltic. There were probably many tribes which did not regard themselves as belonging to any of these groups. Tacitus records a variant form of the genealogy (*see* above), according to which Mannus had a larger number of sons, who were regarded as the ancestors of the Suebi, Vandilii, Marsi and others. (*See* SUEBI, VANDALS.)

For a few years at the beginning of the Christian era the part of Germany which lies west of the Elbe was under Roman government; but after the defeat of Varus (A.D. 9) the Rhine and the Danube formed in general the frontiers of the empire. Roman influence was felt both by way of trade and by the employment of German soldiers in the auxiliary forces. In the age of national migrations—from the 4th to the 6th century—the territories of the Teutonic peoples were vastly extended, partly by conquest and partly by arrangement with the Romans. In the east, the Goths ravaged Dacia, Moesia and the coast regions as early as the 3rd century. In the following century the Vandals settled in Pannonia (western Hungary), while the Goths occupied Dacia, which had now been given up by the Romans, and subsequently seized territories to the south of the lower Danube.

The 5th century was the time of the greatest national movements. In 406–7 the Vandals and other tribes invaded Gaul from the east and subsequently took possession of Spain and north-western Africa. Immediately afterwards the Visigoths invaded Italy and captured Rome; then turning westwards they occupied southern Gaul and Spain. The southern Suebic peoples, the Alamanni and Bavarians, extended their frontiers to the Alps probably about the same time. Not much later a large part of northern Gaul was taken by the Franks, and before the middle of the century the eastern part was occupied by the Burgundians. Several of these movements were due to pressure from the Huns, an eastern people who had conquered many Teutonic tribes and established the centre of their power in Hungary. Their empire broke up after the death of their king Attila in 453. In the latter part of the century the eastern part of Britain was conquered by the Angli, Italy was invaded by the Ostrogoths and northern Gaul subjugated by the Franks. By this time most of southern and western Europe was under Teutonic government.

This great expansion was due to the increasing weakness of the Romans, to pressure of population in Germany, and, specially, to the military strength of the Teutonic nations now far more formidable than in the time of the early empire. They were better armed and their power was more concentrated. Thus a dozen different tribes in and around the lower part of the basin of the Rhine in the 1st century, by the end of the 5th century had become subject to one king. This concentration of power provided the kings with greater wealth and with larger permanent bodies of armed men. The motive force towards extension of territories was supplied by military ambition; the growth of a warlike spirit in the North was constantly driving young warriors to seek their fortunes in the service of continental princes.

The first half of the 6th century saw the subjugation of the Burgundian and Visigothic portions of Gaul by the Franks and the recovery of Africa by the Romans, which was soon followed by the overthrow of the Ostrogothic kingdom; but some years later Italy was again invaded by the Langobardi (Lombards), the last of the great Teutonic migrations. By this time the old Teutonic lands in eastern Germany, including even the basin of the Elbe had been occupied by Slavonic peoples. Before the end of the century Bohemia and Lower Austria, the basins of the Drave and the Save, had become Slavonic.

The succeeding centuries witness a return to the ethnographical conditions which prevailed before the migration period. The Franks and the Langobardi remained in Gaul and Italy, were gradually denationalized and absorbed in the native populations. In Spain Teutonic nationality came to an end with the overthrow of the Visigothic kingdom by the Moors, if not before. Yet throughout the west and south-west the Teutonic frontier remained from fifty to two hundred miles in advance of its position in Roman times. In south-eastern Europe the Teutonic elements were swallowed up by the native and Slavonic populations, a small remnant lingering in the Crimea until probably the 17th century. The political consolidation of the various continental Teutonic peoples (apart from the Danes) in the 8th century led to the gradual recovery of eastern Germany, Lower Austria and the greater part of Styria and Carinthia, though Bohemia, Moravia and the basins of the Vistula and the Warthe have remained mainly Slavonic. In the British Isles the Teutonic element, in spite of temporary checks, eventually became dominant everywhere. Lastly, from the beginning of the 9th century bodies of Scandinavian warriors began to found kingdoms and principalities in all parts of Europe. The settlers, however, did not preserve their nationality, and in almost all cases they were soon absorbed by the populations (Teutonic, Celtic, Latin or Slavonic) which they had conquered. Their settlements in Greenland and America came to an end, but Iceland, which was formerly uninhabited, remained a Scandinavian colony.

Form of Government.—Tacitus speaks of tribes which had kings and tribes which had not, the latter apparently being under a number of *principes,* and represents the power of Teutonic kings in general, with reference no doubt primarily to the western tribes, as being of the slightest, while among the Goths, an eastern people, they had somewhat more authority, and for the Swedes he gives a picture of absolutism. In harmony with these statements many Northern and probably all the Anglo-Saxon kingly families traced their origin to the gods. The Swedes, indeed, and some of the eastern peoples seem to have regarded their kings themselves as at least semi-divine. As the west was most open to foreign influence during the Roman period, the form of government which prevailed here was less primitive, especially as kingship had by this time died out among the Gauls. In later times a number of "kings," generally belonging to one family, are frequently found within the same tribe; and the early *principes* were probably persons of similar position.

The *concilium* or tribal assembly figures largely in Tacitus's account of the Germani as the final authority on all matters of first-rate importance. Here the *principes* were chosen, serious charges brought against members of the tribe and youths admitted to the rights of warriors. The duties of opening the proceedings and maintaining order belonged to the priests, so that probably the gathering itself was primarily of a religious character and met, as among the Swedes in later times, in the immediate neighbourhood of the tribal sanctuary. Such religious gatherings were no doubt common to all Teutonic peoples in early times, but it is not certain that among the eastern and northern tribes they were invested with all the powers ascribed to them by Tacitus. After his time tribal assemblies are seldom mentioned, and though we hear occasionally, both in England and elsewhere, of a concourse of people being present when a king holds court on high days or religious festivals, there is no evidence that such concourses took part in the discussion of state affairs. Indeed, considering the greatly increased size of the kingdoms in later times, it is improbable that they were drawn from any except the immediately adjacent districts. When we hear of deliberations now they are those of the king's council or court, a body consisting partly of members of the royal family and partly of warriors old and young in the personal service of the king. Such bodies of course had always existed (*see* below) and exercised at all times a powerful influence upon the kings, frequently even forcing them into war against their own wishes.

Probably no institution of the Teutonic peoples exercised a greater influence on their history than the *comitatus.* Caesar records that it was customary at tribal assemblies for one or other of the chiefs to propose an expedition. He had generally no difficulty in gathering a following, and those who embraced his service were held bound to accompany him to the end, any who drew back being regarded as traitors. Moreover, kings and other distinguished persons kept standing bodies of young warriors, an honour to them in time of peace, as Tacitus says, as well as a protection in war. Chiefs of known prowess and liberality attracted large retinues, and their influence within the tribe, and even beyond, increased proportionately. The followers (called by Tacitus *comites,* in England "thegns," among the Franks *antrustiones,* etc.) were expected to remain faithful to their lord even to death; indeed the relationship between the two seems to have reckoned as equivalent to that of father and son.

According to Tacitus it was regarded as a disgrace for a *comes* to survive his lord, and in later times they frequently shared his exile. At the battle of Strassburg in 357, when the Alamannic king Chonodomarius was taken prisoner by the Romans, his two hundred *comites* gave themselves up voluntarily to share his captivity. In return for their services the chief was expected to reward his followers with treasure, arms and horses. If he were a king the reward might take the form of a grant of land, or of jurisdiction over a section of the population subject to him—in early times a village, in later, perhaps, a considerable district. Further, since the grantees as a rule naturally sent their sons into the service of their own lords, such grants tended to become hereditary, and in them we have the origin of the baronage of the middle ages. The origin of the earls or counts, on the other hand, is to be found in the governors of large districts (Tacitus's *principes*), who seem at first generally to have been members of the royal family, though later drawn from the highest barons.

Social Organization.—In the time of Tacitus there were three social classes, viz. nobles, freemen and freedmen, which are met with in later times, though occasionally one of them disappears, *e.g.* the nobility among the Franks and the freedmen (as a distinct class) in the Anglo-Saxon kingdoms, except Kent. Each of these classes was, to a large extent at least, hereditary and had separate rights and privileges of its own. Among the chief of these must be reckoned the wergeld or "man-price." When homicide took place vengeance was regarded as a sacred duty incumbent on the relatives, and sometimes at least the lord also, of the slain man; but, as in the case of any other injury, compensation could be made by a fixed payment. From the evidence of later custom it is probable that the normal payment for a freeman was a hundred head of cattle. The sums paid for members of the other classes were more variable; for the freedman, however, they were always lower, and for the noble higher, sometimes apparently three or four times as high. Similar gradations occur in the compensations paid for various injuries and insults, in fines and, among some tribes, in the value attached to a man's oath. There is uncertainty in regard to both the exact position and numbers of the nobles and freedmen of Tacitus's age.

Groups of family and kindred occupy a prominent position in the accounts of Teutonic society given by Caesar and Tacitus. It was regarded as a universal duty to afford protection to one's kinsmen, to assist them in the redress of wrongs and to exact vengeance or compensation in case of death. Hence to have a numerous kindred was a guarantee of security and influence. The large amounts fixed for the wergelds of nobles and even of freemen were paid no doubt, as in later times, not only by the slayer himself, but by every member of his kindred in proportion to the nearness or remoteness of his relationship; and in like manner they were distributed among the kindred of the slain. The kindred appear also in the tenure of land, and according to Tacitus the tribal armies were drawn up by kindreds. As to the nature of these organizations the evidence is not altogether consistent. Agnatic succession prevailed among the princely families of the Cherusci, and the general account given in the *Germania* implies that this type of organization was normal. On the other hand there are distinct traces of matriliny in Tacitus's works in Northern traditions and in the Salic law.

Marriage.—All the usual forms of marriage were known. Marriage by purchase appears most prominently in Kent and among the Old Saxons, Langobardi and Burgundians. In other nations, *e.g.* the Franks, we find the payment of a very small sum, which is often regarded as symbolic and as a relic of real purchase. Yet this explanation is open to question owing to the very early date at which the regulation appears, and to the fact that in the case of widows the sum specified had to be paid to relatives of the widow herself on the female side, and by preference to those of a younger generation. Again, Tacitus states that the presents of arms and oxen given by the bridegroom at marriage were made to the bride herself and not to her guardian, and such appears to have been the case in the North also from early times. It is not certain, therefore, that marriage by purchase was a universal and primitive Teutonic custom. Of the actual ceremonies practised at marriage little is known. It was preceded, however, by a formal betrothal and accompanied by a feast.

There is no doubt that the marriages of heathen times were often of a kind which could not be permitted after the adoption of Christianity. Among these may be mentioned marriages with brothers' widows and stepmothers, the latter especially in England. Polygamy was known, but limited, both in early and late times, to persons of exceptionally high position, while of polyandry there is hardly any trace. Indeed, the sanctity attached to marriage seems to have struck the Romans as remarkable.

State of Civilization.—It is disputed whether the Teutonic peoples were really settled agricultural communities at the time when they first came into contact with the Romans, shortly before the beginning of our era. That agriculture of some kind was practised is clear from Caesar's account, and Strabo's statement to the contrary must be attributed to ignorance or exaggeration. But Caesar himself regarded the Germani as essentially pastoral peoples and their agriculture as secondary, while Tacitus shows that in his time it was of a primitive character. The husbandry was co-operative, as in later times, and apparently the ploughlands were changed from year to year without any recognition of a two-course or three-course system. Caesar, moreover, says that the clans or kindreds to whom the lands were allotted changed their abodes also from year to year—a statement which gives a certain amount of colour to Strabo's description of the Germani as quasi-nomadic. Yet this representation of early Teutonic life was by no means universally true. Evidence, both archaeological and linguistic proves that the cultivation of cereals in Teutonic lands goes back to a very remote period, while the antiquity even of the ox-plough is attested by the rock-carvings at Tegneby in Bohuslän (Sweden), which date from early in the bronze age. Further, that the tribes were not normally of a migratory character, as Strabo seems to imply, is shown by the existence of sanctuaries of immemorial age and by frontier ramparts like those of the Angrivarii against the Cherusci.

It would seem that Julius Caesar encountered the Germani under somewhat abnormal conditions. Several of the tribes with which he came into collision had been expelled from their own territories by other tribes, and we are expressly told that Ariovistus's troops had not entered a house for fourteen years. Indeed Caesar himself regarded the prevalence of the military spirit as the chief hindrance to the development of agriculture. From this time onwards it was from the west mainly that Roman civilization made its way into Germany; but in earlier ages there are more abundant traces of civilization in the basin of the Elbe than in the districts farther to the west.

All ancient writers emphasize the essentially warlike character of the Germani. Yet Tacitus represents their military equipment as being of a somewhat primitive type. Swords, helmets and coats of mail, he says, were seldom to be seen; in general they were armed only with huge shields, unwieldy spears and darts. Here again he appears to be thinking of the western tribes; for elsewhere he states that some of the eastern peoples were armed with short swords and round shields—which probably were of comparatively small size, like those used in later times. This latter type of equipment prevailed also in the North, as may be seen, *e.g.* from the figures of warriors on the inscribed golden horn found at Gallehus (Jutland) in 1734. The favourite method of attack was by a wedge formation (known later in the North as *svínfylking*), the point being formed by a chosen band of young warriors. Certain tribes, such as the Tencteri, were famous for their horsemen, but the Germani in general preferred to fight on foot. Sometimes also we hear of specially trained forces in which the two arms were combined. Naval warfare is seldom mentioned. The art of sailing seems to have been unknown, and it is probable that down to the 3rd century the only seafaring peoples were those of the Baltic and the Cattegat.

Roman influence brought about a considerable advance in civilization during the early centuries of our era. The cultivation of vegetables and fruit trees seems to have been practically unknown before this period, and almost all their names testify to the source from which they were derived. The mill was introduced in place of the quern hitherto in universal use. Great improvements took place likewise in armour and weapons; the equipment of the warriors whose relics have been found in the Schleswig bog-deposits, dating from the 4th and 5th centuries, appears to have been vastly superior to that which Tacitus represents as normal among the Germani of his day. Yet the types, both in armour and dress, remained essentially Teutonic—or rather Celtic-Teutonic.

Writing.—As to the antiquity of the art of writing among the Teutonic peoples, Tacitus says that certain marks were inscribed on the divining chips, but it is not known whether these were really letters or not. The national type of writing, generally known as Runic, must have been fully developed by the 4th century, when some of its letters were borrowed by Ulfilas (Wulfila) for his new alphabet. (*See* RUNES.) Indeed, by this time it was probably known to most of the Teutonic peoples, for several of the inscriptions found in Jutland and the islands of the Belt can hardly be of later date. The Roman alphabet first came into use among the western and northern Teutonic peoples after their adoption of Christianity.

Funeral Customs.—Icelandic writers of the 12th and 13th centuries distinguished between an earlier "age of burning" and a later "age of barrows," and the investigations of modern archaeologists in general confirm the distinction, though they have revealed also the burial-places of times antecedent to the age of burning. Throughout the stone age inhumation appears to have been universal, many of the neolithic tombs being chambers of considerable size and constructed with massive blocks of stone. Cremation makes its appearance first in the middle bronze age and, at a later period, in the late bronze age practically displaces the older rite. Although the earliest of the ensuing epoch graves in Gotland contain inhumed remains, cremation is practically the universal rite in the early iron age.

The latter practice is the one recognized by Tacitus. In the national migration period, however, it fell into disuse among most of the continental Teutonic peoples, even before their conversion, though practised by the Heruli in the 5th century and by the Old Saxons probably till much later. It came into Britain with the Anglo-Saxon invaders and continued in use in certain districts perhaps until nearly the close of the 6th century. In Scandinavian lands the change noted by Icelandic writers may be dated about the 5th and 6th centuries, though inhumation was certainly known before that time. After the 6th century cremation seems not to have been common, if we may trust the sagas, but isolated instances occur as late as the 10th century. Cremation and the use of the barrow are not mutually exclusive, for cremated remains, generally in urns, are often found in barrows.

On the other hand inhumation below the surface of the ground, without perceptible trace of a barrow, seems to have been the most usual practice during the national migration period, both in England and on the continent. A special form of funeral rite peculiar to the North was that of cremation on a ship. Generally the ship was drawn up on land; but occasionally legendary sagas tell of the burning ship being sent out to sea. Large ships containing human remains have been found in barrows of the viking age. Arms and ornaments are frequently met with, sometimes also horses and human remains which may be those of slaves.

Religion.—The conversion of the Teutonic peoples to Christianity covered some seven centuries. The Goths accepted the new religion about the middle of the 4th century, and the Vandals followed their example very quickly. In the course of the 5th century it spread to several other nations, including the Gepidae, Burgundians, Rugii and Langobardi. In all these cases the Arian form of Christianity was the one first adopted. The Franks were converted to the Catholic form at the end of the 5th century. The extension of Frankish supremacy over the neighbouring Teutonic peoples brought about the adoption of Christianity by them also, partly under compulsion, the last to be converted being the Old Saxons, in the latter half of the 8th century. The conversion of England began in 597 and was complete in less than a century. In the north, after several attempts during the 9th century which met with only temporary success, Christianity was established in Denmark under Harold Bluetooth, about 940–960, and in Norway and Sweden before the end of the century, while in Iceland it obtained public recognition in the year 1000. Many districts in Norway, however, remained heathen until the reign of St. Olaf (1014–1028), and in Sweden for half a century later.

Our knowledge of the beliefs and forms of worship which prevailed before the adoption of Christianity, is due chiefly to Icelandic literary men of the 12th and 13th centuries, who gave accounts of many legends which had come down to them by oral tradition, besides committing to writing a number of ancient poems. Icelandic history is unique in this respect. In the literatures of other Teutonic countries we have only occasional references to the religious rites of heathen times, and these are generally in no way comparable to the detailed accounts given in Icelandic writings. Hence it is often difficult to decide whether a given rite or legend which is mentioned only in Icelandic literature was really peculiar to that country alone or to the North generally, or was once common to all Teutonic peoples.

A number of gods were certainly known both in England and among many, if not all, the Teutonic peoples of the continent, as well as in the North. Among these were Odin (Woden), Thor (Thunor) and Týr (Ti); so also Frigg (Frig), the wife of Odin. The evidence that Balder, the son of Odin, was once known in Germany, is doubtful. Heimdallr, the watchman of the gods and Ullr, the stepson of Thor, as well as Hoenir, Bragi and most of the other less prominent gods, were also probably peculiar to the North, though Ullr at least was known in Denmark. Some of these deities may originally have been local. Indeed, such may have been the case with Frey, the chief god of the North after Thor and Odin. Tradition uniformly points to Uppsala as the original home of his cult. But both he and his sister Freyia were probably specialized forms of a divinity which had once been more widely known. Their father, Niörðr, the god of wealth, a somewhat less important figure, corresponds in name to the goddess Nerthus (Hertha), worshipped by a number of tribes, including the Angli, round the coasts of the southern Baltic.

Tacitus describes her as "Mother Earth," and his account of her cult bears a remarkable resemblance to the ceremonies associated in later times with Frey. This family of deities were collectively known as Vanir, and are said to have once been hostile to the Aesir, to whom Odin belonged. Their worship was generally connected with peace and plenty, just as that of Odin was chiefly bound up with war. Gefion was another goddess who may represent a later form of Nerthus. In her case tradition points distinctly to a connection with Denmark (Sjaelland). On the other hand, the portraiture of Skaði, the wife of Niörðr, seems to point to a Finnish or Lappish origin.

Some of the deities known to us from German and English sources seem also to have been of a local or tribal character. Such doubtless was Fosite, to whom Heligoland was sacred. Saxnot (Seaxneat), from whom the kings of Essex claimed descent, was probably a god of the Saxons. Holda, who is known only from the folklore of later times, appears to have been a German counterpart of Nerthus. Ing, connected with Denmark in Anglo-Saxon tradition, was in all probability the eponymous ancestor of the Inguaeones. (*See* above.) His name connects him, too, with the god Frey, who was also called Yngvifreyr and Ingunarfreyr, and he must at one time have been closely associated with Nerthus. The relationship of Ing to the Inguaeones is paralleled by that of Irmin to the Hermiones. (*See* above.) He may be the deity whom Tacitus called "Hercules."

Some of these eponymous ancestors may be regarded as heroes rather than gods, and classed with such persons, as Skiöldr, the eponymous ancestor of the Danish royal family, who is not generally included in the Northern pantheon. But the line of division between the human and the divine is not very definite. The royal family of Norway claimed descent from Frey, and many royal families, both English and Northern, from Woden (Odin). Indeed, several legendary kings are described as sons of the latter. Sometimes, again, the relationship is of a conjugal character. Skiöldr, though hardly a god himself, is the husband of the goddess Gefion. So we find Freyia's priest described as her husband and Frey's priestess as his wife, and there is no reason for regarding such cases as exceptional.

It is seldom easy to distinguish between gods and heroes, but much more difficult to draw a line between the former and other classes of supernatural beings, such as the "giants" (O.N. *iötnar*, A.S. *eotenas*). Here again we have intermarriage. Skaði, the wife of Niörðr, and Gerðr, the wife of Frey, were the daughters of the giants Thiazi and Gymir respectively, though Skaði is always reckoned as a goddess. Loki was of giant birth; but he is always reckoned among the gods, and we find him constantly in their company, in spite of his malevolent disposition. In general the giants were regarded as hostile to both gods and men. Often they are represented as living a primitive life in caves and desolate places, and their character is usually ferocious. But there are exceptions even among the male giants, such as Aegir, whom we find on friendly terms with the gods. We may note that some of the leading families of Norway claimed descent from giants, especially from

Thrymr, the chief opponent of Thor. In such cases there may be some connection between the giants and the semi-civilized (Finnish or Lappish) communities of the mountainous districts. This connection is more clear in the case of Thórgerðr Hölgabrúðr, who is known chiefly from the extreme veneration paid to her by Haakon, earl of Lade (+995). According to one story she was the daughter of Hölgi, the eponymous king of Halogaland (northern Norway); according to another she was the wife of Hölgi and daughter of Gusi, king of the Fins.

Another class of supernatural beings was that of the dwarfs. They were distinguished chiefly for their cunning and for skill in working metals. More important than these from a religious point of view were the elves (O.N. *álfar*, A.S. *ylfe*), who certainly received worship, at all events in the North. They are almost always spoken of collectively and generally represented as beneficent. In some respects, *e.g.*, in the fact that they are often said to inhabit barrows, they seem to be connected with the souls of the dead. In other cases, however, they are hardly to be distinguished from spirits (the Icel. *landvaettir*, etc.) which may be regarded as *genii locorum*.

There were yet other classes of supernatural beings. The *fylgiur* and *hamingiur* of Northern belief, are of two kinds, though the names seem not always to be clearly distinguished. Sometimes the *fylgia* is represented as a kind of attendant spirit, belonging to each individual person. It may be seen, generally in animal form, in visions or by persons of second sight, but to see one's own *fylgia* is a sign of impending death. In other cases the *fylgiur* (or perhaps more correctly the *hamingiur*) apparently belong to the whole family. These appear as maidens.

Human beings, especially kings and other distinguished persons, were not infrequently honoured with worship after death. In Sweden during the 9th century we have trustworthy record of the formal deification of a dead king and of the erection of a temple in his honour. In general the dead were believed to retain their faculties to a certain extent in or near the place where they were buried, and stories are told of the resistance offered by them to tomb-robbers. They were credited with the power of helping their friends (and likewise of injuring other people) very much in the same way as they had done in life. Hence the possession of the remains of a chief who had been both popular and prosperous was regarded as highly desirable.

The blessings which kings were expected to bestow upon their subjects, in life as well as after death, were partly of a supernatural character. Chief among them was that of securing the fertility of the crops. The prevalence of famine among the Swedes was attributed to the king's remissness in performing sacrificial functions; and on more than one occasion kings are said to have been put to death for this reason. Under similar circumstances Burgundian kings were deposed. In connection with this attribution of superhuman powers, we may mention also the widespread belief that certain persons had the faculty of "changing shape," and especially of assuming the forms of animals. (*See* LYCANTHROPY.)

We hear occasionally of sacred animals. Tacitus tells of horses consecrated to the service of the gods, and of omens drawn from them, and we meet again with such horses in Norway nearly a thousand years later. In the same country we find the legend of a king who worshiped a cow. Northern mythology speaks also of theriomorphic demons, the chief of which were Midgarðsormr, the "world-serpent," and Fenrisulfr, a monster wolf, the enemies of Thor and Odin respectively. These beings are doubtless due in part to poetic imagination, working on a substratum of primitive religious belief. Tacitus states that the ancient Germans had no images of the gods. But he does speak of certain sacred symbols which he defines elsewhere as figures of wild beasts. One of the chief objects of veneration among the Cimbri is said to have been a brazen bull.

The Quadi are said to have considered their swords divine. Worship was paid, especially in the North, to rocks and stone cairns, while springs and pools also were frequently regarded as sacred in all Teutonic lands. But, on the whole, the most prominent characteristic of Teutonic religion, in early and later times, is the sanctity attached to certain trees and groves, though in such cases there is often a doubt as to whether the tree itself was worshipped or whether it was regarded as the abode of a god or spirit. The sanctuaries mentioned by Tacitus seem always to have been groves, and in later times we have references to such places in all Teutonic lands. One of the most famous was that in or beside which stood the great temple of Uppsala. Here also must be mentioned the Swedish Vårdträd or "guardian tree," which down to our own time is supposed to grant protection and prosperity to the household to which it belongs. One of the most striking conceptions of Northern mythology is that of the "world-tree," Yggdrasil's Ash, which sheltered all living beings. The description given of it recalls in many respects that of a particularly holy tree which stood beside the temple at Uppsala. For the idea we may compare the Irminsul, a great wooden pillar which appears to have been the chief object of worship among the Old Saxons, and which is described as *universalis columna quasi sustinens omnia.*

The Northern sanctuaries of later times were generally buildings constructed of wood or other materials. A space apparently partitioned off contained figures of Thor or Frey and perhaps other gods, together with an altar on which burned a perpetual fire. In the main body of the temple were held the sacrificial feasts. The presiding priest seems always to have been the chief to whom the temple belonged, for there is no evidence for the existence of a special priestly class in the North. In England, however, the priests were never allowed to bear arms. There is record also of priests among the Burgundians and Goths, while in Tacitus's time they held a very prominent position in German society. Among all Teutonic peoples from the time of the Cimbri onwards we frequently hear also of holy women whose duties were concerned chiefly with divination. Sometimes, indeed, as in the case of Veleda, a prophetess of the Bructeri, during Vespasian's reign, they were regarded practically as deities.

Of religious ceremonies the most important was sacrifice. The victims were of various kinds. Those offered to Odin (Woden) were generally, if not always, men, from the time of Tacitus onwards. Human sacrifices to Thor and the other gods are not often mentioned. The animals consumed at the sacrificial banquets were chiefly horses, but included oxen and boars. At human sacrifices, however, dogs and hawks were often offered with the men. At all sacrifices it seems to have been customary to practise divination; in connection with human sacrifice we have record of this rite from the time of the Cimbri. One custom which was regarded as a sacrifice was the dedication of an enemy's army to the gods, especially Odin. This custom, which prevailed from the earliest times, involved the total destruction of the defeated army, together with everything belonging to them. In general the chief sacrificial festivals seem to have taken place at fixed times in the year, one in early or mid-autumn, another at mid-winter and a third during the spring. Sacrifices on an exceptionally large scale were held at Uppsala and Leire every nine years, at the former place about the time of the spring equinox, at the latter in the early part of January.

Beside the belief that the dead retained a conscious existence in or near the place where they were buried, and that they were able to confer blessings upon their friends, we find that the souls of the dead passed to the realm of Hel, who in Northern mythology is represented as the daughter of Loki. Again, those who had fallen in battle were supposed to go to Valhalla, where they became warriors in Odin's service. This last belief seems to have been connected at one time with the practice of cremation. In conclusion it must be mentioned that even the life of the gods was not to be for ever. A day was to come when Odin and Thor would fall in conflict with the wolf and the world-serpent, when the abode of the gods would be destroyed by fire and the earth sink into the sea. But the destruction was not to be final; in the future the gods of a younger generation would govern a better world. How far these beliefs were common to the Teutonic peoples as a whole cannot be determined with certainty. Some think them peculiar to the mythology of Norway and Iceland, and largely due to Christian influence. But very similar ideas in some respects were current among the ancient Gauls.

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(H. M. C.; J. M. DE N.)

TEVIOTDALE, valley of the Teviot, Roxburghshire, Scotland. In a limited sense the word describes the stretch above Hawick (9 m.) and, in a wider sense, the whole vale, extending in a north-easterly direction from Teviothead nearly to the confines of the parish of Roxburgh (23 m.). Branxholm tower, the peel of Goldielands, and Harden castle (on Harden burn, a tributary of Northwick water) are spots familiar through the writings of Sir Walter Scott and many Border ballads. Five m. to the east of Hawick stands the hill of Ruberslaw (1,392 ft.). Among the crags on its summit is the rock, still called "Peden's chair," from which Alexander Peden preached to conventicles of Covenanters. Below Hawick are Minto, Hassendean—the Hazeldean of Sir Walter Scott's song, "Jock o' Hazeldean"—and Ancrum.

TEWFIK, AHMED PASHA (1845–), Turkish statesman, was born in Constantinople on Feb. 11, 1845, the son of Ismail Hakki Pasha. In 1866 he went to the ministry of foreign affairs, where he spent six years. After acting as first secretary to the Turkish legation in Athens, he was sent to St. Petersburg (Leningrad), where in 1877 he received Prince Gorchakov's note declaring war. The following year he became Turkish minister in Athens, in 1885 he went to Berlin as ambassador, and remained there for 10 years. From 1895 to 1909 he was minister of foreign affairs. After the Young Turk revolution he became grand vizier, and in 1909 was sent to London as ambassador, where he remained till 1914. In 1919 he was reappointed grand vizier, afterwards becoming president of the Senate, and in 1921 he attended the London Conference arranged by the Supreme Council of the Allies. He retired in 1922. During his long career of more than 60 years, Tewfik Pasha played an important part in Turkish affairs. His conciliatory spirit won him universal admiration and the agreements which he concluded with the Balkan States did much to improve relations between these States and Turkey.

TEWFIK PASHA (1852–1892), khedive of Egypt, son of the Khedive Ismail, was born on Nov. 15, 1852. With the alteration of the succession law in 1866 Tewfik became heir apparent. In 1878 he was appointed president of the council after the dismissal of Nubar Pasha. He held this office only for a few months; he then returned to his estate, but was soon recalled to public life. On June 26, 1879, Ismail, at the instance of Great Britain and France, was deposed by the sultan, who sent orders at the same time that Tewfik should be proclaimed khedive. The new khedive was little pleased at the honour thrust upon him at a moment when Egypt was in a chaotic state. Disorder prevailed until November 1879, when the dual control was re-established by the governments of Great Britain and France. For over two years Baring (afterwards Lord Cromer), Auckland Colvin, and de Blignières practically governed the country, endeavouring to institute reforms while possessing no means of coercion. During all this time the disaffection in the Egyptian army was increasing. Tewfik has been blamed for his failure to take a firm line with the rebels, but his attitude was governed by his relations with Great Britain and France, and he was unable to control events. For the anti-foreign movement which culminated in the revolt of Arabi *see* ARABI PASHA and EGYPT.

Before the bombardment of Alexandria began it was suggested to Tewfik that he should leave the city and embark either upon a man-of-war belonging to one of the neutral powers, or in his own yacht, or in a mail steamer which was then in the port. His answer was, "I am still khedive, and I remain with my people in the hour of their danger." At his palace of Ramleh, 3 m. from the town, he was beyond reach of the shells, but his life was nevertheless imperilled. When the rebel soldiers attacked the palace he escaped to another palace after going through the burning streets of Alexandria. Here he was obliged to agree that a guard of British bluejackets protect him from further risk.

In 1884 Baring went back to Egypt as diplomatic agent and consul-general of Great Britain. His first task was to demand that Tewfik should abandon the Sudan. Tewfik gave his consent with natural reluctance, but, having consented, he did everything he could to ensure the success of the policy which Baring had been sent to carry out. He behaved with equal propriety during the negotiations between Drummond Wolff and the Turkish envoy, Mukhtar Pasha, in 1886. The sultan was his suzerain; in Great Britain he recognized his protector: to the representative of each he endeavoured to show friendliness and esteem. As time went on his confidence in Baring increased, until at last he deferred to the British agent in almost everything. He took a great interest in irrigation, education and justice.

In private life Tewfik was courteous and amiable. He had no desire to keep up the unapproachable state of an oriental ruler. Indeed, in many ways his manners and habits were less oriental than European. He married in 1873 his kinswoman, Amina Hanem, with whom he lived very happily. She was his only wife and Tewfik was a strong advocate of monogamy. He died on Jan. 7, 1892, at the Heluan palace near Cairo, and was succeeded by his eldest son, Abbas II. (*q.v.*).

A warm tribute to Tewfik's many admirable qualities was paid by Baring (Lord Cromer) in his report on the administration of Egypt for 1891 (see *Egypt*, No. 3, 1892, pp. 1 and 2).

TEWKESBURY, a town in Gloucestershire, England, 15½ m. N.E. of Gloucester by the L.M.S.R., on the Warwickshire Avon, close to its junction with the Severn. Pop. (1921) 4,704. The Severn is crossed by an iron bridge of 170 ft. span. Of the Benedictine abbey, one of the richest foundations in England, refounded and enlarged in the 12th century on the site of an ancient hermitage and Saxon monastery, there only remain the gate and a few other fragments. The abbey church, consecrated in 1125, is a magnificent specimen of early Norman. One of the most remarkable features of the building is the unique western front, the central part of which is occupied by one vast arch extending from the ground to the roof. Originally it was filled in with Norman windows, but a Perpendicular window now occupies the space. The whole building underwent restoration in the Decorated period, and of this style it is one of the finest existing examples. The Norman columns in the choir still exist; but above them rises a grand superstructure of Decorated work. The elegant clerestory windows are of the 14th century, with stained glass of the same date. There are two organs, one dating from the early 17th century. There are a grammar school (1625) and a number of charities and almshouses. Tewkesbury is chiefly dependent on agricultural trade and milling.

Roman remains prove that the earliest settlement near Tewkesbury was a military encampment against the British. It was the site of a Saxon castle and monastery, and its position led to the growth of a town, which was a borough with a market in 1087. It was subsequently granted to Earl Robert of Gloucester. Charters were granted in 1107, 1337, 1574 (when the borough was incorporated), 1604, 1605, 1609, 1685, 1698 and 1835. Several ancient fairs were granted, but one fair only is now held, on October 10. It is a pleasure fair and a fair for hiring servants.

Cloth-making lasted from the 11th century until the 18th; gloving in the 17th was followed by worsted-combing in the 18th; cotton-thread lace-making, introduced in 1825, collapsed about 1862, and the manufacture of mustard ceased at the end of the 18th century. Stocking-frame knitting was the chief trade in 1830, but has been replaced by the boot and shoe trade. (X.)

Battle of Tewkesbury.—This battle, fought on May 3, 1471, closed the long conflict in England of the Wars of the Roses. The Yorkist victory at Barnet (*q.v.*), less than three weeks before, marked the ruin of the Lancastrian cause; Tewkesbury was a last desperate venture. Contrary winds had delayed the passage from France of Queen Margaret, wife of the imprisoned King Henry VI., and with a small body of Lancastrian supporters she landed in the West of England on the day of the disaster at Barnet. With her was her young son, Edward prince of Wales. The duke of Somerset and other survivors of the defeated army a few days later joined her standard. Margaret wished to return to France, but was persuaded that the Lancastrian strength in the West was unbroken. Adherents were recruited from Devon and Somerset as Margaret struck inland towards the Welsh border, hoping to join forces with Jasper Tudor. Edward IV., at Windsor, gathered an army and moved westwards to intercept the invaders, who after forced marches found the city of Gloucester hostile and its gates closed against them. They struggled on to Tewkesbury, utterly exhausted. King Edward arrived the same evening.

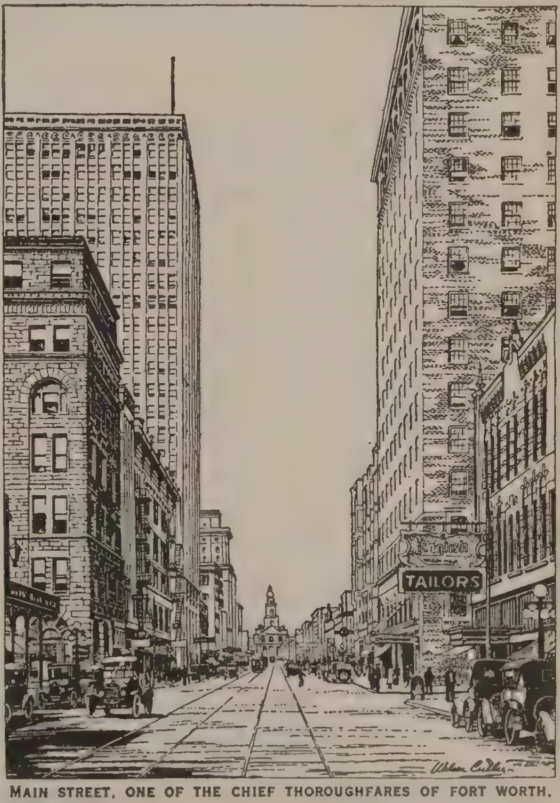
Somerset, commanding the Queen's forces, accepted battle next morning. The position chosen was a strong one, on the gentle slope where the broad Severn flows through the valley. It was much cut up by dykes and hedges, and declivities, through which small watercourses passed, protected both flanks. The town and river were at the rear. As at Barnet, each opposing army was drawn up in three divisions, Edward commanding the Yorkist centre and Richard duke of Gloucester and Lord Hastings the two wings. Little impression was made by Edward's attack, till Somerset, whose ranks were being depleted by the fire of the Yorkist artillery and archers, led the Lancastrian right in an impetuous charge on the King's line. It was not supported. Lord Wenlock and the earl of Devon, with the Lancastrian centre and left divisions, kept their ground. The charge failed, and Somerset was driven back with heavy loss. He suspected treachery, and in the subsequent rout was said to have cleft the skull of Lord Wenlock with his battle-axe for not taking part in the charge.

Pursuing their advantage in the confusion, the Yorkists broke into the Lancastrian main position, forcing their enemy back to the town and Severn banks, where great slaughter ensued. A riverside field to this day bears the name of "Bloody Meadow." Edward prince of Wales was slain when crying for mercy; the earl of Devon and other nobles perished. Somerset himself, with Langstrother the treasurer and many fugitives gained sanctuary in Tewkesbury Abbey, from which they were forcibly taken and after summary trial were executed. Next day Queen Margaret, who had fled to a neighbouring convent, was made prisoner. On the night of Edward IV.'s return from the victory, King Henry VI. was murdered in the Tower of London. The death of Edward prince of Wales on the battlefield left the English throne with no direct heir in the Lancastrian line. (W. G. B.)

TEXARKANA (tĕk-sahr-kăn′a), an urban community formed of two cities, on each side of the Texas and Arkansas boundary line, U.S.A., 165 m. E. by N. of Dallas; on Federal highways 67 and 71, and served by the Kansas City Southern, the Missouri Pacific, the St. Louis South Western, and the Texas and Pacific railways. Pop. (1920) 19,737 (70% native white and 28% negroes) estimated locally at over 32,000 in 1928. The Texas city, Bowie county, had a population of 11,480 in 1920; Arkansas city, county seat of Miller county, had 8,257. Of necessity the cities have separate municipal governments, but commercially, industrially, and socially they are a unit. The assessed valuation of Greater Texarkana was $19,739,732 for 1927. The first permanent settlement was made in 1874. Texarkana, Texas, was incorporated in 1875; Texarkana, Arkansas, in 1881.

TEXAS, popularly known as the "Lone Star State," is a south-central State of the United States of America. It extends from 93° 31′ to 106° 38′ W. long. and from 25° 51′ to 36° 30′ N. latitude. A western projection is bounded north by New Mexico, but the main portion is bounded north by Oklahoma, from which it is separated in part by the Red river. On the east the northern projection is bounded by Oklahoma, but the main portion is bounded by Arkansas and Louisiana, the Sabine river separating it in part from Louisiana. On the south-east the State is bounded by the Gulf of Mexico, the coast line being about 400 m., or, counting all irregularities and inlets, 973 m. long. On the south-west Texas is bordered by Mexico from which it is separated by the Rio Grande river. On the west, by New Mexico.

Physical Features.—Physiographically, there are four provinces. In the south-east are the West Gulf plains, a part of the Coastal plain province of the United States. Thence westward to the 100th meridian are the prairies, the south-westward extension of the Prairie plain province of the United States. The Great Plains (really a plateau) comprise the western half of the State, except a mountainous area in the west which belongs to the Basin Range province. The mountains of the Basin Range region, known in Texas as the Trans-Pecos province, rise in El Capitan, a peak of the Guadalupe mountains in Culberson county, to 9,020 ft., (the greatest elevation in the State), and the Great Plains have a maximum elevation in northern Texas exceeding 4,000 ft., but from these heights the surface descends to sea-level and the mean elevation of the State is about 1,700 feet. The Gulf plains are bordered along the Gulf of Mexico by a series of long narrow



MAIN STREET, ONE OF THE CHIEF THOROUGHFARES OF FORT WORTH, TEXAS islands and peninsulas, or sand-bars. Padre, the longest of these islands, extends northward from the mouth of the Rio Grande more than 100 miles. Back of the island sand-bars are the quiet waters of lagoons, and at the mouths of rivers are several bays indenting the mainland; these bays were formed by only a slight subsidence of the land and the rivers are fast filling them with deposits of silt. For 20 m. or more inland in the north and for 50 m. inland in the south the Gulf plains are low and flat, seldom rising as much as 100 ft. above the sea, but farther west the surface is more broken and rises to a maximum of 700 feet.

Along a line drawn approximately south-south-west from the south-east corner of Oklahoma, the north-west part of the Gulf plains merges with the Prairie plains. The north-east portion of the Texas Prairie plains is only gently rolling, but the south portion is quite rugged, and the west half rises in a succession of scarps or steps to an elevation of 2,500 ft. at the beginning of the Great Plains province of the State. South of the parallel of the southern boundary of New Mexico the Great Plains province is known as the Edwards plateau; between the Edwards plateau and the valley of the Canadian river, as the Llano Estacado, or Staked plains; and north of the Canadian valley as the North plains. The eastern and southern parts of the Edwards plateau and the eastern margin of the Llano Estacado have been made by headward erosion of streams, but the central portion of the Edwards plateau and nearly all the Llano Estacado have a notably even surface rising slowly to the north-west. In the south-eastern corner of the Trans-Pecos province is a smaller plain known as the Stockton plateau, but the remaining portion of this province is traversed from north-west to south-east by isolated mountains of the Basin Range or block mountain type.

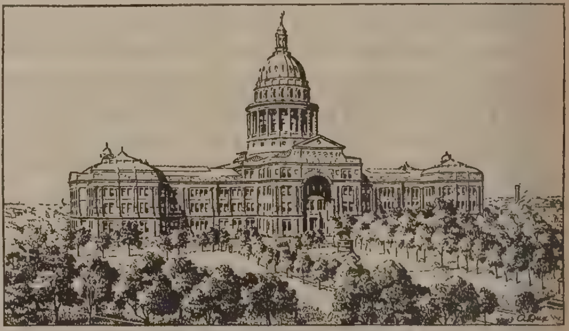
The northern portion of the Panhandle is drained by the Canadian river eastward into Arkansas and thence to the Mississippi. The south portion of the northern Panhandle and a strip along the north border of the State, east of the Panhandle, is drained by the Red river south-eastward into the Mississippi. The rest of the State is drained south-east directly into the Gulf of Mexico. The Rio Grande and its principal tributary, the Pecos, drain narrow basins in the south-west; these two rivers and the Canadian river rise in the Rocky Mountains in Colorado and New Mexico, but all the other rivers by which the State is drained rise within its borders. The Red, Brazos, Colorado, Guadalupe and the Nueces rise on the east or south-east border of the Great Plains; the Sabine and the Trinity on the Prairie plains; and numerous small streams on the Coastal plain. In the Great Plains region and in the Trans-Pecos province the rivers have cut deep canyons, and the character of the longer rivers in their upper courses varies from mere rivulets late in summer to swift and powerful streams during spring freshets. Most of the large Texas rivers have deposited great quantities of silt along their lower courses on the Coastal plain, where the current is often sluggish and the banks are periodically overflowed.

Soils.—The Coastal plain has for the most part a light sandy soil, but there is a fertile alluvium in the river bottoms and good clay soil on some of the uplands. The eastern part of the Prairie plains is a belt known as the Black Prairie which has a rich black soil derived from Upper Cretaceous limestone; immediately west of this is another belt with a thinner soil derived from Lower Cretaceous rocks; a southern part of the same plains has a soil derived from granite; a large area in the north-west has a reddish clay soil derived from Permian rocks and a variety of soils—good black soils and inferior sandy and clay soils—derived from Carboniferous rocks. A very thin soil covers the Edwards plateau, but on the Llano Estacado are brownish and reddish loams derived from the sediments of a Neocene lake.

Flora and Fauna.—The arboreal flora of Louisiana and Arkansas extends into north-eastern Texas, conformable with the Coastal plain, where, immediately south of the Colorado river, the great pine belt of the Atlantic and Gulf coasts terminates. The flora of the Great Plains region, consisting principally of nutritious grasses, enters the north-west portion of the State and extends south to the Edwards plateau and east into the Prairie plains region. The peculiar plants of the Rocky Mountain plateaux penetrate into the Trans-Pecos region, while north Mexican flora crosses the Rio Grande in the south-west. The central region is a transition ground where these floras find representation generally in deteriorated and dwarfed species. The long-leaf pine is the dominant forest tree on the uplands of the Coastal plain, north of the Colorado river, for 100 m. or more from the coast; further inland and especially in the north-eastern corner of the State it is succeeded by the short-leaf pine. Between the rising swells of long-leaf pine lands are thickets of hawthorn, holly, privet, plane trees and magnolias. Loblolly pine, cypress, oaks, hickory, ash, pecan, maple, beech and a few other deciduous trees are interspersed among both the long-leaf and short-leaf pines, and the proportion of deciduous trees increases to the westward. In the broad river valleys of the eastern part of the Prairie plains region are forests and isolated groves consisting principally of pecan, cypress, cottonwood and several species of oak. A low growth of mesquite and other shrubs and vines is found on upland areas in the eastern half of the Prairie plains. The western half of these plains has only a few trees along the water courses, and some scraggy oak, juniper, mesquite and cedar in the more hilly sections. In the canyons of the Edwards plateau grow the pecan, live oak, sycamore, elm, walnut and cypress; on the hilly dissected borders of the same plateau are cedars, dwarf and scrubby oak, and higher up are occasional patches of stunted oak.

Only a few of the large wild animals remain, but animal life is still varied, for it includes and is a meeting ground for species common to northern, eastern and western United States and many species of Mexico. White-tailed Sonora and grey mule-deer, and a few antelopes are found in the south-western counties. Louisiana bears still inhabit the inaccessible cane-brakes near the coast, and in the western mountains black and cinnamon bears are occasionally found. Coyotes, jack rabbits and prairie dogs are common on the plains. The Texas game birds consist chiefly of plover, snipe, teal, mallard and wild geese. Alligators are found in the low coast region and are especially numerous in the Nueces river. The horned-toad is the most common Texas lizard, except in the western counties where rock lizards are numerous. Among venomous snakes the coral snake is common along the coast, the copperhead along the wooded banks of creeks and rivers, the cottonmouth in all parts of the State, except the most arid, the "side wiper" or massasauga and ground rattlesnake in all sections.

Climate.—In the region of Galveston, along the northern section of the coast, where southerly and south-easterly winds from the Gulf prevail throughout the year, the climate is warm, moist and equable, but the moisture decreases westward and south-westward, and the equability, partly because of northerly winds during the winter months, decreases in all directions inland. The mean annual temperature decreases to the north-westward with an increase of both altitude and latitude, ranging from 73° F in the lower Rio Grande valley to 55° F in the northern portion of the Panhandle. Along the coast the average number of days during a year in which the temperature falls below the freezing-point is only three or four, but in the Panhandle this average is from 100 to 115. The average annual rainfall decreases quite regularly westward and south-westward from 46 in. at Galveston

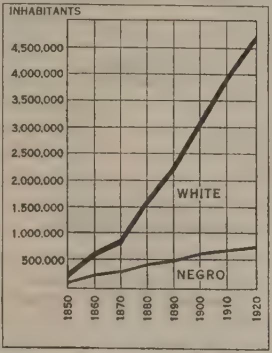


BY COURTESY OF THE AUSTIN CHAMBER OF COMMERCE

THE STATE CAPITOL AT AUSTIN, TEXAS

to 9 in. at El Paso. In middle, eastern and north-eastern Texas the spring months are the wettest and winter months are the driest. In western and south-western Texas the summer months are the wettest and spring months the driest. In these sections irrigation or dry-land farming is necessary for the best results in agriculture. The average annual snowfall for the State is about 5 in. ranging from 19 in. in the northern portion of the Panhandle, to scarcely any along the coast and lower Rio Grande.

Population.—In June, 1928, the population of Texas, according to the estimate of the Federal Census Bureau, was 5,487,000. This was 823,773 more than in 1920 when the actual count was 4,663,228. The estimated increase was based upon the rate of growth between 1910 and 1920, which was 19·7%. In 1910 the population was 3,896,542; in 1900 it was 3,048,710. In 1920 Texas ranked fifth among the States in total population, but in density it ranked only 35th, with 17·8 inhabitants per square mile. This is about one-half the average density for the United States as a whole. There were 18 counties with a density of over 55 inhabitants per square mile. These are found chiefly in a strip from Fort Worth and Dallas north-east to the Red river and south-west through Waco, Austin and San Antonio, with a branch strip south-east from Waco to Houston and Galveston. Except for the branch strip most of the counties are in the black soil belt. Nearly one-half the 254 counties have a population averaging less than ten inhabitants per square mile, the most thinly settled areas being the Edwards plateau and Trans-Pecos region.



GRAPH OF GROWTH OF TEXAS POPULATION, SHOWING PERCENTAGE OF NEGRO ELEMENT

The population is predominantly native-born white of Anglo-Saxon extraction. The larger portion came originally from Tennessee, Alabama, Georgia, Mississippi and other States of the older South, with, however, especially in recent years, an appreciable addition from the Middle Western States. Despite the large preponderance of native whites, Texas has received more emigrants from foreign countries than any other Southern State. In 1920 there were 360,519 foreign-born in Texas, or 7·7% of the total population. In addition there were 276,670 persons born of foreign parentage and 168,714 born of mixed parentage. These three classes together, representing a classification known to the Census Bureau as "foreign white stock," comprised 17·3% of the total population of Texas and 20·8% of the white population. Of the foreign-born over one-half, and of the "foreign white stock" nearly one-half were Mexicans. There were 249,652 born in Mexico and 398,174 of "foreign Mexican stock."

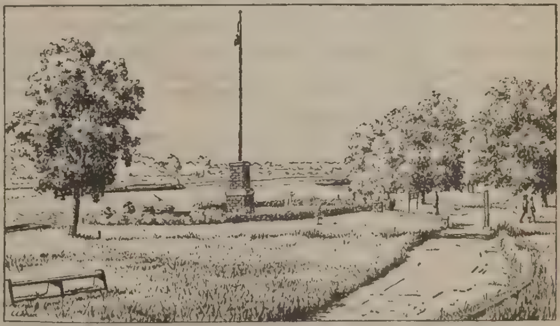
These immigrants have crossed the Rio Grande primarily in response to a demand for labour on the ranches and farms of southern and south-west Texas. The Federal immigration restrictions apply to them, but restrictions are lifted for the temporary immigration of Mexican labourers to satisfy certain seasonal demands. Besides the great length of the Mexican border prohibits an adequate guard to prevent unlawful access to the country. Most of the present Mexican population is along the Rio Grande and in south Texas, but throughout the cotton belt there is an appreciable scattering. Germans and Austrians were next in importance. There were 31,062 foreign-born Germans and 159,219 of German stock, 6,441 foreign-born Austrians and 64,074 of Austrian stock; 12,819 born in Czechoslovakia, 7,057 in Russia; 5,047 in Poland; 8,024 in Italy; 7,685 in England; 4,333 in Ireland; 4,536 in Sweden and 4,175 in Canada. Most of the German and Austrian inhabitants are found in south-central Texas where they constitute a thrifty element of the agricultural population. The negro population of Texas in 1920 was 741,695, or 15·9% of the whole. The negro has increased in number since 1900 but not in proportion to the increase in total population. The negro migration from the South to Texas is not large, the migration being rather to the Northern States. The negroes are almost all in the eastern half of the State, principally along the eastern border, the Gulf coast and in the cities. In 1920 518,321 negroes were rural dwellers and 223,373 lived in cities, the city element showing the greatest increase between 1910–20.

The total urban population in 1920 was 1,512,689, or 32·4% of the whole, as compared with 24·1% in 1910 and 17·1% in 1900. The chief cities with their 1920 population (Census Bureau 1927 estimate in parentheses) were: San Antonio, 161,379 (211,400); Dallas, 158,976 (211,600); Houston, 138,276 (no estimate made because of exceptional growth); Fort Worth 111,336 (163,600); El Paso, 77,560 (113,500); Galveston, 44,255 (49,900); Beaumont, 40,422 (54,400); Wichita Falls, 40,079 (no estimate made, exceptional growth); Waco, 38,500 (45,700); Austin, 34,876 (38,800). Other cities with a population over 10,000 in 1920 were Abilene, Amarillo, Brownsville, Cleburne, Corpus Christi, Corsicana, Del Rio, Denison, Greenville, Laredo, Marshall, Palestine, Paris, Port Arthur, Ranger, San Angelo, Sherman, Temple, Texarkana and Tyler.

Government.—The State's fourth constitution adopted in 1876 remains the basis of the government. Since its adoption there had been (1927) 58 amendments, the majority of them involving but minor points. An amendment may be proposed by a two-thirds vote of all members elected to each house of the legislature, and is adopted if approved by a majority of the voters at the next election.

The legislature is composed of a senate of 31 members, chosen by popular vote for four-year terms, one-half the body retiring every two years, and a house of representatives of 150 members (the constitutional maximum) elected biennially. Bills may originate in either house, except bills of revenue, which must originate in the house of representatives, but can be amended or rejected as other bills in the senate. Regular meetings of the legislature are biennial, opening upon the second Tuesday of January in odd-numbered years. Special sessions may be called by the governor.

The chief executive and administrative officers are a governor, lieutenant-governor, secretary of State, comptroller of public accounts, treasurer, commissioner of the general land office, attorney-general, railroad commissioners (three), commissioner of agriculture, and superintendent of public education. All are elected by the voters except the secretary of State who, contrary to the custom in most States, is appointed by the governor. All serve for two-year terms except the railroad commissioners who serve for six years. The governor's powers are rather more extensive than those of the average State executive. The actual administration of the details of government is performed by many officials, boards and commissions mostly appointed by the governor so as to be under executive control.



BY COURTESY OF HOUSTON CHAMBER OF COMMERCE

SAN JACINTO BATTLEGROUND NEAR HOUSTON, CLOSE TO THE SPOT WHERE GENERAL HOUSTON RECEIVED THE CAPTURED MEXICAN GENERAL SANTA ANNA, IN 1836, DURING THE STRUGGLE FOR TEXAN INDEPENDENCE

The State judiciary consists of a supreme court, a court of criminal appeals, 11 courts of civil appeals in 11 districts and over 100 district courts. These are State courts, all provided for by revenue from the State's general fund. The 11 civil appellate courts, the court of criminal appeals and the supreme court all consist of three justices each, elected for six-year terms. In addition the supreme court has an assisting commission of appeals consisting of two sections of three judges each, and the court of criminal appeals has an assisting commission of two members. These commissions are temporary bodies. The district courts each have one judge elected for four years. Minor criminal and civil cases are tried by a justice of the peace or in the county court.

Finance.—In 1922, according to the estimate of the Federal Census Bureau, the total wealth of Texas was $9,850,000,000. In 1928 a conservative estimate is approximately $12,000,000,000. The principal developments between 1922–28 which increased the total wealth were the great increase in the output of petroleum, increased manufacturing, an increase in power transmission lines, new reclamation and irrigation projects, and an increase in property values, especially in the cities. The income of Texas from raw products (crops, live stock products, minerals, forest products) was approximately $1,385,000,000 in 1928. To this may be added approximately $325,000,000 which represents the value added to raw products by manufacturing processes in the State. The total of $1,710,000,000 annual income takes no account of the wholesale or retail trade, professional income or other sources of wealth.

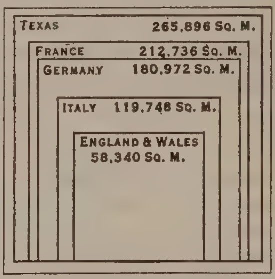
The assessed valuation of property in the State amounted to $3,898,954,064 in 1927. State receipts from taxation for the fiscal year ending Aug. 31, 1928 were $70,968,300. Of this $23,822,261 was a direct *ad valorem* tax on property. A poll tax of $1.50 from each person from the ages of 21 to 60 amounted to $1,737,616 for the year ending Aug. 21, 1928, and an occupation tax which contributed $306,677. From a gross receipts tax $8,336,278 was received. Three-fourths of this is credited to the general revenue and one-fourth to the available school fund. The inheritance tax for the same year amounted to $978,937, all of which was credited to the general revenue fund. A sixth tax is a gasolene sales tax, one-fourth of which goes to the available school fund and three-fourths to the highway fund. This amounted for the year ending Aug. 31, 1928 to $19,214,075. An auto licence fee amounted to $14,559,566 the same year, all of which was credited to the highway fund. The final tax source is the franchise taxes collected by the secretary of State and paid into the general revenue fund. These in the same year amounted to $2,012,886.

In addition the State receives annually many millions of dollars from sources other than taxes, the exact amount for the year ending Aug. 31, 1928 being $18,870,024. These are fees collected by the various departments, interest on the various permanent funds, revenue from the State prison, etc. A substantial amount also comes from the U.S. Government for highway purposes. The grand total of receipts of the State Government for the year ending Aug. 31, 1928 was $89,838,324.

Total disbursements for the same year amounted to $84,358,918. Of this amount $22,602,419 was expended from the general revenue fund, $20,551,172 from the available school fund, and $28,762,188 from the highway fund. The remaining $9,557,619 was expended from the miscellaneous smaller funds numbering about thirty-seven. The bonded debt in 1926 was but $4,002,200, a small total for so large a State, amounting to an average of but $.75 per caput. All of it is owned and held by the permanent funds of the public schools and State institutions for which it was incurred. There were on Oct. 3, 1928 636 national banks and 729 State banks. Resources and liabilities of the national banks totalled $1,189,295,000; of the State banks, $327,663,101.

Education.—The school population of Texas—7 to 18 years inclusive—was 1,399,798 for the year 1928–29. Education in the public schools is free for all children above six years of age. Between the ages of 7 and 16 attendance at some school, either public or private, is compulsory. The public school system in 1928 was organized into approximately 1,000 independent school districts and 7,200 common school districts. There were in attendance during the year 1925–26, 455,493 white pupils and 89,143 coloured pupils in the independent districts, and 374,771 white pupils and 96,553 coloured pupils in the common districts, in all an elementary school attendance of 1,016,260. In addition there were 181,127 white and 13,067 coloured high school students. The value of all public school buildings, grounds and equipment in 1928 was $179,200,598.

The most pressing problem of the school system is the proper maintenance of the common or rural schools. The situation is recognized and aided by a special rural aid appropriation from the State amounting to $1,500,000 for 1926–27 and $1,600,000 for 1927–28. The regular State appropriations for 1927–28 were $20,549,220. Local taxation for public school maintenance totalled $22,951,676. The totals for State and local support show that the State shared the educational expense almost fifty-fifty with local units, a proportion which is very high indeed compared with other States. Texas has a larger permanent endowment for its public schools than any other State, the fund totalling $76,445,248 in 1926. It was derived from the sale of public school lands and is invested chiefly in Government bonds.



AREA OF TEXAS COMPARED WITH CERTAIN COUNTRIES OF EUROPE

There are 17 State-supported institutions of higher learning. The chief is the University of Texas at Austin and its branches, the Medical school at Galveston, and the College of Mines and Metallurgy at El Paso. The Agricultural and Mechanical college is located at College Station, the North Texas Junior Agricultural college at Arlington, and the John Tarleton Agricultural college at Stephenville. The Texas Technological college is at Lubbock, and the College of Industrial Arts at Denton. Prairie View State Normal and Industrial college for negroes is at Prairie View. State Teachers' colleges are located at Alpine, Canyon, Commerce, Denton, Huntsville, Kingsville, Nacogdoches and San Marcos.

Charities and Corrections.—There are under the administration of the State board of control the following charitable and correctional institutions, their average populations in 1927 being given in parentheses: Five hospitals for the insane at Austin (2,063), Rusk (915), Terrell (1,725), Wichita Falls (544) and San Antonio (2,351); a special State hospital for epileptics at Abilene (791); State tuberculosis sanatorium at Carlsbad (362); State orphan home at Corsicana (584); home for dependent and neglected children at Waco (97); State juvenile training school at Gatesville (1,071); Girls' training school at Gainesville (159); school for the blind at Austin (238); school for the deaf at Austin (503); deaf, dumb and blind institute for coloured youths at Austin (180); Confederate woman's home at Austin (97); Texas Confederate home at Austin (353); and the Austin State school for the feeble-minded at Austin (453). The State prison is situated at Huntsville, and there are also 12 State convict farms.

Mines and Quarries.—The value of the total mineral output of Texas leaped from $29,220,000 for 1915 to $371,250,000 for 1920. A sudden depression reduced the value of the 1921 output to $212,302,000, but from then to 1928 the valuation steadily increased, amounting to $351,211,000 for 1925 and $435,000,000 for 1928. The peak valuation of 1920 was due primarily to inflated prices, particularly of petroleum, but the increases since 1921 were due primarily to increase in volume of output, that of 1926 being greater than for any previous year. The 1925 valuation represented 7·05% of the mineral output of the United States, Texas ranking fourth among the States as a producer.

In 1925 all except $89,211,000 and in 1926 all except $61,300,000 of the total valuation was contributed by the petroleum industry, Texas ranking third as an oil-producing State in both years. In 1928 the State rose to first place. The year 1928, with an output of 255,557,000 bbl., was the 18th successive year in which there had been a substantial increase in petroleum production in the State. These outputs may be compared with that as late as 1918 which was only 38,750,000 bbl., from which some idea of petroleum developments in Texas since the World War may be had. The value of the petroleum output increased from

$193,580,000 for 1923 to $308,700,000 for 1926. Next to cotton, petroleum has become the State's chief money-making product.

The petroleum-producing fields are widely scattered and differ greatly in character. It was the discovery of the Spindle Top field near Beaumont in 1901 that first brought Texas to the front in petroleum production. This field in 1902 produced 17,420,949 bbl. after which it declined so that in 1925 it produced but 428,873 barrels. In 1926, however, there came a startling leap to 13,370,000 bbl., the field again leading all Texas fields but one. Another even older field, the Corsicana, in which production started in 1896 saw a similar rejuvenation in 1923 when deeper sands were discovered, the output jumping from 245,705 bbl. in 1922 to 32,361,150 bbl. in 1923. The field in Wichita and Wilbarger counties was first in 1926 with 15,249,000 barrels. There were in all 35 producing fields.

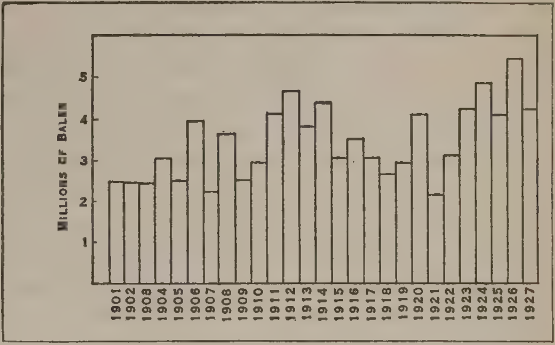
Next to petroleum the two most important mineral products were natural gas gasolene and natural gas. Production of the former increased in value from $14,460,000 in 1924 to $18,346,000 in 1927. There were 117 natural gas gasolene plants in 1925. Production of natural gas increased in value from $13,748,000 in 1924 to $19,715,000 in 1925, Texas ranking fifth among the States both years. One of the most remarkable developments of Texas in 1927 was the rapid extension of gas pipe lines into new territory. Principal gas production is from the great field north of Amarillo, from Palo Pinto, Clay and Eastland counties in North Central Texas and from Harrison county in East Texas.

There were six active cement plants in 1925 producing cement to the value of $8,729,046, giving this fourth place among the minerals. Clay products were valued at $6,298,045. Clays susceptible of commercial development have been found in nearly every county of the State and in great variety, including several grades of brick clay, pottery, tile and statuary clays. There were 53 operating clay-products plants in 1923. Clay deposits, cement materials, sand and gravel and building stone seem apparently inexhaustible and merely await better transportation facilities and increased local demand for their increased development. The increase in highway and other construction has brought about greater demand for sand and gravel, the 1925 output being valued at $3,478,517. Stone products in 1925 were valued at $2,076,560. Limestone is used extensively in the making of cement, but is also quarried for building stone and burned in kilns for the making of lime. The 1926 production of limestone was valued at $2,210,828, and the output of lime at $706,153. There is a large industry in Texas manufacturing plaster, wall board, cement, roofing and other materials from gypsum. The State ranked fourth in point of output and fifth in point of value of gypsum in 1925, the value being $3,721,954. The asphalt production in 1925 was valued at $4,900,000, 204,527 tons being native, and 220,473 being manufactured from petroleum. With the closing of the Louisiana sulphur mines in 1924 Texas in 1925 remained the only large sulphur-producing State in the Union, producing 99·9% of the nation's total. The output in 1925 was 1,409,262 tons valued approximately at $11,000,000.

The abundant supply of petroleum and natural gas for fuel has retarded the development of coal deposits. Texas has a fair supply of bituminous coal which is found in north-central and middle-western Texas and also of sub-bituminous or cannel coal found in Webb and Maverick counties in south-west Texas along the Rio Grande. In addition there is an almost inexhaustible supply of lignite, the belt extending across the State from the vicinity of Laredo on the Rio Grande to north-east Texas, covering about 60,000 sq.m. and having an estimated quantity of 30,000,000,000 tons unmined. The bituminous and sub-bituminous areas cover about 25,000 sq.m. and contain, it is estimated, 8,000,000,000 tons. Coal produced in 1926 totalled 1,091,158 tons valued at $1,751,000.

The chief metal of commercial importance in 1924–25 was silver, the output being valued at $482,895 and $383,088 respectively. Silver ores are found in Culberson, Hudspeth and Presidio counties in the Trans-Pecos province. There is a steady production of mercury, Texas producing about one-fourth of the annual production of the United States. There are extensive iron deposits easily available, but production is slight chiefly because of lack of coking coal. Manganese, zinc and tin ores are found, but are only slightly developed.

Agriculture and Live Stock.—Texas is preëminently an agricultural State. In 1927, for the eighth successive year, it led all other States in the value of crops raised. In number of live stock, according to the Federal farm census of 1925, it was exceeded by none, and in value of live stock it was exceeded only by Iowa. Of its total population 2,114,532 or 40·6% lived on farms in 1925. Of its total land area, estimated at 167,934,720 ac., 109,674,000 ac. were owned as farm lands in 1925, and 29,309,000 ac. of this was classified as crop land. By 1927 crop land had increased to approximately 32,000,000 acres. Of the 75,068,000 ac. classified as pasture, 13,617,000 ac. was ploughable, 11,230,000 ac. was woodland and the remainder chiefly treeless hills and plains used for grazing purposes. The number of farms increased from 436,033 in 1920 to 465,646 in 1925, and their average size decreased from 261·5 to 235·5 acres.



Cotton crop each year, 1901–1927
The figures are running bales, counting round as half bales

The period 1920-25 was a difficult one for agriculture, however, because of the sharp depression of prices which occurred in 1921 and continued for several years thereafter. The total value of all farm property, which between 1910-20 had increased from $2,218,645,000 to $4,447,420,000, fell to $3,471,867,000 by 1925. Between 1920–25 farm land decreased $620,520,000 in value, farm buildings decreased $34,851,000, farm implements and machinery decreased $12,422,000 and farm live stock decreased $308,328,000. The decrease in value of land per acre was from an average of $28.46 to $23.94. The decrease in live stock values was considerably over half, the total valuation of live stock in 1925 being but $284,698,000.

The years 1926–28 witnessed a rapid revival of prosperity in the live stock industry, but low yields and, to a lesser extent, low prices for some products, prevented a corresponding increase in crop values. The following table shows the comparative number and value of live stock in 1925 and 1928:—

	Number 1925	Number 1928	Value 1925	Value 1928
Cattle .	6,275,000	5,607,000	137,422,500	224,840,700
Swine. .	1,250,000	1,375,000	12,500,000	16,500,000
Sheep. .	3,500,000	4,593,000	26,250,000	39,040,000
Horses .	857,000	748,000	46,278,000	33,660,000
Mules .	1,042,000	1,000,000	86,486,000	70,000,000

Texas led all States in 1928 in the number of cattle, sheep and mules. There were also in 1927, 2,400,000 goats in Texas, valued at $11,500,000. Texas had more than one-half the total number in the United States.

Texas is ideally adapted to live stock raising. There are large areas which produce luxuriant pasture grasses, and the soil readily produces feed-stuffs such as corn, Kafirs, oats, hay, etc. The mild winters and light snows make it unnecessary to provide expensive sheltering, or store great quantities of winter feed. Beef cattle are raised primarily in the western and southern areas of the State, while dairying is developing rapidly in north-central Texas where a denser population provides good local markets. There were 936,000 milch cows in 1928. Butter made in creameries increased from 4,982,000 lb. in 1918 to 14,594,000 lb. in 1926. The total value of dairy products for 1925 amounted to $35,442,000. Large-scale ranching, so prevalent formerly on the Great Plains area of north-western Texas, is fast disappearing in that region, giving way largely to crop growing. Below the cap rock throughout the great expanse of middle west and north-central Texas there remains a large ranching industry, with the large ranch holding its own, particularly in the rougher country. The chief "big ranch" country, however, may be said to begin with Kennedy county on the coast below Corpus Christi and spread toward Laredo and San Antonio, continuing on across the broad expanse of the Edwards plateau, including the middle and upper sections of the Rio Grande valley and the Trans-Pecos province.

The sheep and goat industry is much more highly localized, being confined largely to the Edwards plateau and the hilly regions of west-central Texas. Wool production in 1927 was 32,675,000 lb., valued at $10,357,975. The weight per fleece averaged 8·5 lb. as against 7·7 lb. for the entire United States. The Angora goat with its production of fine mohair has been bred up from the common black goat introduced into Texas by the early Mexicans by importing Angora rams. The value of mohair produced in 1926 amounted to $4,550,000.

Swine decreased from 3,205,000 in 1910 to 2,400,000 in 1920 and 1,250,000 in 1925, despite the fact that they are favourably advocated by agricultural specialists for Texas farmers. Their raising is largely an avocation of the cotton growers in the eastern part of the State. Higher prices for cotton and successive shortages in the corn crop are the main reasons for their decrease. On the other hand when cotton prices were poor in 1926–27 swine showed their first increase in numbers for many years. Poultry-raising showed an encouraging increase between 1920–25. Eggs produced and chickens raised in 1924 were valued at $33,000,000. In addition the total value of turkeys marketed and consumed locally was estimated at about $14,000,000.

The annual value of all crops in Texas ranged, for the period 1919–27, from $424,776,000 for 1921 to $1,071,527,000 for 1919. In 1926 the total value was $631,584,000; in 1927, $729,754,000. Of the 1927 total value, $464,053,000 was contributed by the cotton crop alone, Texas leading all States and raising slightly more than one-third of the cotton crop of the United States. For many years there was a feeling that the cotton-raising area would be halted at the foot of the cap rock which marks the beginning of the high plains of Texas, but the phenomenal development of cotton-raising above the cap rock between 1920–27 has demonstrated that there is yet much land that can be turned to that use. Of a total farm acreage of about 31,000,000 ac. in 1926, 18,363,000 ac. were devoted to cotton. This was the largest acreage up to that date, and the resulting crop of 5,628,000 bales was the largest ever produced in the State. Prices were very low, however, and the return of $395,653,000 from the crop was lower than in any year since 1921. As a result only 16,270,000 ac. were planted to cotton in 1927, yielding but 4,280,000, but valued, because of higher prices, $68,500,000 above that of 1926. Of the agricultural population it is estimated that at least 1,750,000 derive their livelihood largely from cotton-growing.

The value of other crops in 1927 follows: corn $64,118,000; winter wheat, $39,355,000; grain sorghums, $39,242,000; oats, $31,793,000; tame hay, $14,880,000; sweet-potatoes, $8,128,000; rice, $6,756,000; barley, $4,081,000; white potatoes, $3,885,000; wild hay, $2,770,000; sorghum-syrup, $2,584,000; sugar-cane syrup, $2,224,000. Wheat and rice are grown for the market and all other grains are primarily for home consumption. Corn is grown throughout the crop-growing areas of the State. Rice is confined to the lower courses of the rivers on the coastal plain. The other grains are principally in the northern and western sections. There has been a notable increase in the acreage devoted to barley from 25,000 in 1919 to 195,000 in 1927, but it is confined almost entirely to the northern Panhandle. This is also the chief wheat belt. In the extreme southern portion of Texas there is a rapidly developing production of sub-tropical fruits and vegetables. There is little canning, as yet, most of the vegetables being shipped for table stock, the early spring permitting them to be marketed at high prices. Texas is not a leading fruit-growing State, but approximately $5,000,000 annually is derived from orchard crops. Citrus fruits, especially oranges and grapefruit are grown along the Gulf coast and in the lower Rio Grande valley, the output being 360,000 boxes in 1926 as compared with 71,000 in 1923.

Forest Products.—In 1925 Texas ranked eighth among the States in lumber production. Between 1922–27 production varied between 1,500,000,000 and 1,600,000,000 bd.ft. annually and the annual value of output was between $50,000,000 and $55,000,000. In addition to the regular lumber cut an additional 400,000,000 ft. was annually taken for railway ties, telephone and telegraph poles, fence posts, etc. The commercial lumber output comes almost entirely from the heavier forested areas in the eastern 25 or 30 counties. About 90%—1,351,248,000 bd.ft. in 1925—is yellow pine. The only other soft wood of importance was cypress, of which the 1925 cut was 15,079,000 board feet. About 200,000,000 bd.ft. of hardwood lumber is cut annually, the chief varieties being oak (98,486,000 bd.ft. in 1925) and tupelo (16,422,000 bd.ft. in 1925). There is some turpentine and rosin production from the long-leaf pine section in the south-east. The rate of cut in Texas, 1922–27, was very heavy compared with the total timber resources of the State. Surveys estimated about 17,000,000,000 bd.ft. of pine and about 7,500,000,000 bd.ft. of hardwood still standing in 1927. The area of virgin pine was but 1,100,000 ac. compared with an original area of 14,000,000 acres. There are no national forests in the State, and State action toward conservation was slow in commencing, the first purchase of tracts for reforestation taking place in 1923.

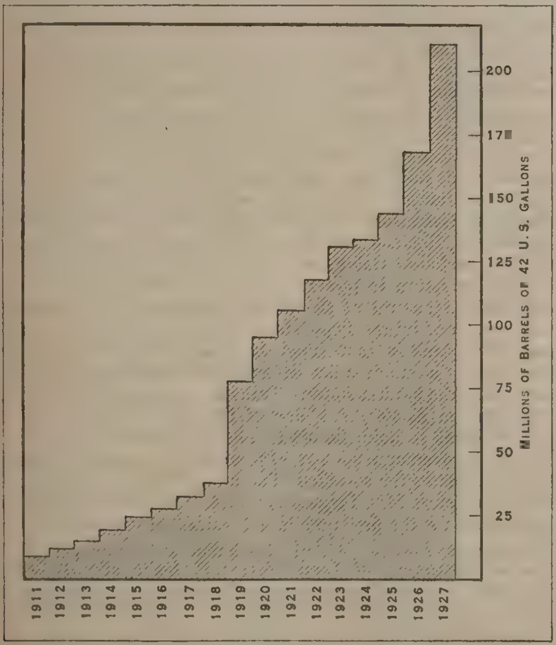
Manufactures.—The products of Texas factories increased in value from $969,556,000 in 1923 to $1,237,952,000 in 1925. The value actually added by the various manufacturing processes was $329,246,334 respectively. In 1925 there were 3,606 establishments employing an average of 106,792 wage-earners and paying $116,363,302 in wages. The industries are almost entirely those which use as raw material the mineral, agricultural and forest products of the State. The advantages of Texas for manufacturing are that an abundance of raw materials exists at hand, petroleum, natural gas and coal furnish cheap and unlimited fuel, and living costs are low. Lack of capital has been the chief deterrent. The leading industries in 1925 follow:—

Industry	Establishments	Wage-earners	Value of products
Petroleum-refining	63	10,902	$488,181,732
Cottonseed oil, cake and meal	167	3,924	86,387,983
Slaughtering and meat-packing products	27	3,805	79,208,777
Lumber and timber products of sawmills and planing mills	300	20,644	60,675,779
Flour, feed and other grain-mill products	90	1,212	54,528,293
Car and general construction and repairs of steam railway shops	109	14,692	43,612,493

Manufacturing cities of the first class were Dallas, Houston, Fort Worth and San Antonio. Those of the second class were El Paso, Texarkana, Beaumont and Galveston.

Commerce and Transportation.—Texas ranked as the chief exporting State in the Union in 1924, and in 1925 and 1926 ranked second only to New York. The value of the exports these three years was respectively $737,216,502, $758,665,052 and $648,991,954. Of the total, approximately two-thirds ($429,388,673 in 1926) consists of raw cotton. It was the low price of this commodity in 1926 that brought the total value of exports down, the actual tonnage having increased. Other products exported in large quantities, in the order of their value, were wheat, gasolene, illuminating oil, gas and fuel oil, lubricating oil, sulphur, cottonseed cake and meal, wheat flour, machinery and parts, chemicals, lumber, wood and paper and vegetable food products. Imports were much less important, amounting in 1926 to about $49,000,000, and consisted largely of manufactured articles for distribution on the south-western market. In addition to the foreign trade, to which the statistics above apply, there is a heavy coastwise trade between Texas ports and ports of the Atlantic seaboard. Total tonnage of coastwise trade varies from 15,000,000 to 20,000,000 annually and is valued at about $600,000,000. The interior harbours of the Texas coast line offer excellent advantages once the outlying bars are penetrated. It is usually necessary to dredge through the bars and often in the harbours themselves to make them deep enough for ocean vessels. Galveston is the oldest and the chief port. Its dock and terminal facilities are well built up. The total commerce of the port in 1926 was 6,203,835 tons valued at $688,433,560. The port of Houston has shown more rapid development than any other in recent years. It is situated about 60 m. from the Gulf but is served by the Houston ship canal, large enough for ocean vessels. In 1926 1,391 seagoing vessels arrived and 1,386 departed, the total commerce of the port amounting to $400,116,647. Corpus Christi is the latest addition to the deep water ports of Texas, the year 1927 witnessing the first heavy traffic since the completion of a channel through Corpus Christi bay and Aransas pass to the Gulf. It is the chief port for all of southern Texas. The other important ports are Texas City, Port Arthur, Beaumont, Orange and Freeport. There is some trade across the Mexican border, principally at Brownsville, Laredo, Eagle Pass, Presidio and El Paso.

There were 16,287 m. of main line railway track in Texas at the opening of the year 1928. From 1915 to 1924 there was almost no construction, due first to the World War and afterwards to the general depression which prevailed in all industries. From 1925 to the end of 1928 there was considerable construction amounting to over 100 m. annually, more than in any other State. A part of the construction was into new oil-fields, especially north of Amarillo, but the greater part was but a carrying on of programmes of development by the larger railways which had been interrupted by the World War. Most of the construction was in the northern Panhandle, in the region bordering New Mexico, in the Trans-Pecos province and in the lower valley of the Rio Grande.



PETROLEUM PRODUCTION, 1911–1927

There were, in 1927, approximately 180,000 m. of public roads in Texas, of which 18,728 m. were in the State highway system. At the close of 1927 9,643 m. of the State system were surfaced, about 800 m. being paved and 4,487 m. being gravelled or macadamized. Receipts to the State highway department for 1927 totalled $25,976,165, coming chiefly from licence fees, gasolene taxes and Federal aid, and disbursements totalled $20,115,964. From 1925 to 1927 motor bus transportation developed rapidly, and in 1927 buses were operating regularly over about 21,000 m. of Texas highway. There were in Sept. 1927, 247 companies operating 865 passenger vehicles. Motor vehicle registration in the State increased from 194,720 in 1917 to 1,121,233 in 1927.

HISTORY

The earliest explorations were made by the Spaniards, Cabeza de Vaca, 1528–36, and Francisco Vásquez de Coronado 1540–42. There were many other Spanish expeditions in the first three-quarters of the 17th century which entered or crossed parts of the State, and in 1682 the Spaniards founded the first permanent settlement at Isleta in the Rio Grande valley a few miles below El Paso. In 1685 the French under the Sieur de la Salle founded a colony at Matagorda bay, which, however, was soon abandoned. The French threat was sufficient to scare the Spanish into activity, and beginning in 1690 they established several ecclesiastical, military and civil settlements known respectively as missions (Franciscan), presidios and pueblos. In 1727 the territory, with vaguely defined limits, was formed into a province and named Tejas, or Texas, after the confederacy of Tejas Indians. For more than a century the conditions were favourable for colonization. The French in Louisiana proved peaceable neighbours and that province both under French (to 1763) and under Spanish rule (1763–1803) served as a protection against the English. Spain failed to take advantage of this favourable period, however, and it was lost after the United States purchased Louisiana in 1803.

Three abortive Anglo-American invasions during the first few years of the century indicated the future trend of events. The first, under Philip Nolan, in 1799–1801, was poorly supported, and was crushed without difficulty; the second, under Bernardo Gutiérrez and Augustus Magee, 1812–13, captured San Antonio and defeated several Mexican armies, but was finally overpowered; the third, under James Long, 1819–21, was less formidable. The United States claimed the eastern part of Texas, basing the claim on the Louisiana Purchase, but by the Treaty of Florida with Spain, finally ratified in 1821, these claims were given up and the eastern and northern boundaries were fixed as follows: the Sabine river, the 94th meridian (approximately), the Red river, the 100th meridian, the Arkansas river and the 42nd parallel. So far as Spain was concerned this was only a form, inasmuch as Mexico, of which Texas was a part, was just completing its long struggle for independence (1810–21). In 1821, also, Stephen F. Austin established the first permanent Anglo-American settlement at San Felipe de Austin on the Brazos river. This was followed by extensive immigration from the United States during the period of Mexican rule. It is estimated that the population, exclusive of Indians, increased from 4,000 in 1821 to 10,000 in 1827, and nearly 20,000 in 1830. In 1827 Texas was joined to Coahuila to form a State of the Mexican federation.

Difficulties arose between the Americans, especially the members of the Edwards colony around Nacogdoches, and the Spanish settlers who were there before the Americans came. There was also a Federal decree in 1830 forbidding further immigration into the colony, while lavish grants of land were made to Mexican favourites. A convention at San Felipe de Austin in 1835 organized a provisional government with Henry Smith, who desired independence, as governor and Sam Houston as major-general of the armies of Texas, and two commissioners were elected to seek aid in the United States. Hostilities had already begun, armed conflicts having taken place at Velasco, Anahuac and Gonzales over customs regulations and attempts of the Mexicans to disarm the American settlers.

A Mexican army under General Cos, which had marched into Texas to disarm the Texans, was driven out of San Antonio, but early in 1836 Santa Anna with a larger army returned to lay siege to the city. On March 6, the Alamo, in which the garrison of 183 defenders had taken refuge, fell with the slaughter of every man. On the 20th, the Mexicans captured the Texas general, Fannin, and his force of 371 men, and a week later shot them all except 20 that had escaped. Houston then assumed active command and retreated before Santa Anna until he reached the San Jacinto river, where he turned and dealt the Mexicans a crushing blow which brought the war to an end. Santa Anna himself was captured. The weakness of the Mexican Liberals and the necessity of securing aid in the States led the Austin party to abandon their opposition to independence, and on March 2, a convention had assembled at the town of Washington and adopted a declaration of independence. On the 17th a republican Constitution was adopted, and in Sept. 1836 Houston was elected the first president. In 1837 the independence of the republic was recognized by the United States, Great Britain, France and Belgium.

Standing alone the republic faced many difficulties. Mexico had by no means accepted the independence declaration and threatened continual hostilities. There were troubles with the various Indian tribes. The public debt mounted and the Texas paper dollar fell in value to about 2 cents. It was generally admitted that the United States desired to annex Texas, but the question was bound up with that of slavery over which the Union was divided. In March 1845 Congress passed a joint resolution offering Statehood to Texas, and this the Texans gladly accepted. The United States was to settle all questions of boundaries with foreign countries, while Texas was to retain all its vacant and unappropriated public lands. The formal admission occurred in Dec. 1845. Texas had claimed the Rio Grande to its source as its western boundary, although as a political division of Mexico its limits had never extended farther west than the Nueces and the Medina. The United States asserted the Rio Grande claim and prepared to defend it; at the same time the Mexican Government considered the annexation, regardless of the boundary question, a declaration of war by the United States. In the Treaty of Guadalupe Hidalgo (1848) which ended the war Mexico accepted the Rio Grande boundary. Texas also included then the eastern half of present New Mexico (that portion east of the Rio Grande) and Colorado, a corner of Wyoming (the boundary running north from the source of the Rio Grande to the 42 parallel), south-western Kansas and the arm of Oklahoma north of the Panhandle. By the Compromise of 1850 all of this territory not included in Texas to-day was ceded to the United States for $10,000,000.

Texas was a slave State from the first. Its climate and soils, especially in the section first settled, made its industries similar to those of the older Southern States, while most of its settlers were natives of the slave States east of the Mississippi. A strong Unionist influence was exerted by the considerable German element which had settled in the State from 1845–60, but neither this nor the influence of Sam Houston, then governor, could prevent a convention which met at Austin, Jan. 28, 1861, from drawing up and adopting articles of secession. Houston was deposed and the lieutenant-governor, a secessionist, held office in his place. The State, luckily, was not the scene of active military operations during the Civil War, although it is interesting to note that the last battle of the conflict was fought on its soil at Palmito, near Palo Alto, on May 13, 1865, more than a month after the surrender of Appomattox. In conformity with President Johnson's plan of reconstruction, a Constitution recognizing the abolition of slavery, renouncing the right of secession and repudiating the war debt was adopted in 1866 and a Unionist Democrat was elected governor. When in 1867, the congressional plan of reconstruction was substituted, Texas was joined to Louisiana to constitute the fifth military district, and Gen. P. H. Sheridan was placed in command. A new Constitution was adopted in 1869. In Feb. 1870, the legislature ratified the 14th and 15th Amendments to the Federal Constitution, and in March it was readmitted to the Union. But the State remained under the rule of negroes and carpet-baggers, supported by U.S. troops, until the inauguration of Governor Coke in 1874. A legislature responsive to the people had also been elected, so that the people were again in control. The Constitution of 1869 containing many obnoxious provisions was replaced by the present Constitution adopted in 1876.

After 1876 there was rapid recovery from the effects of the war and reconstruction, and the history of the State becomes chiefly a record of agricultural and industrial expansion. Cotton production, which in 1859 amounted to 431,645 bales, slumped heavily during the Civil War and it was 1870 before production again reached the 400,000 mark. In 1878 it went above 1,000,000 bales for the first time. In 1891 it first passed 2,000,000 bales and in 1894 it passed 3,000,000 bales. The early cotton production all came from the heavily wooded sections of eastern Texas, and expansion was not rapid until the settlement of the black land belt, which coincided with the extension of railways into the area in the early '70s. The second great impetus was given by the settlement of the fertile prairie lands of middle-west Texas which began in the early '90s. After the Indians were driven from southern and western Texas, the herds of wild cattle began to increase rapidly so that, after the Civil War, they crowded the ranges. A good market in the Middle West inaugurated the practice of rounding up these cattle and driving them north over cattle trails that soon became well-defined. The trail-driving era continued until the middle '80s when the extended railways began to intercept the drive. During the years of reconstruction, much violence and disorder became prevalent, and on the frontier where there was almost no protection, this condition was not checked. Organized gangs of land and cattle thieves often controlled whole neighbourhoods and worked their will. Furthermore the Indians were restless and menacing. The situation was met by the organization, in 1874, of the famous Texas Rangers, a State constabulary force, which succeeded soon in controlling the situation.

Another troublesome matter was the strife between ranchman and settler, or "nester," which found vent largely in the cutting of the barbed-wire fences which were beginning to spread over the plains. A special session of the legislature was called to deal with this problem in 1884 and drastic legislation to stop the practice was enacted. With the extension of the railways there developed also widespread abuses in their operation, especially various forms of discrimination. The demand for their control culminated in the hotly contested political battle of 1892 which the radicals won. The victory resulted in the establishment of a railway commission to fix the rates and investigate complaints. In 1899 and in 1902 there were destructive floods on the Brazos river, which led to the building of levees to protect the lands from overflows. In 1900 a great tropical hurricane swept the coast country of Texas, doing tremendous damage, especially at Galveston. The loss of life was estimated at 6,000. The result was the building of the Galveston sea wall. Out of the disaster, also, the commission form of city government was born, it proving the most trustworthy and efficient in Galveston in the heavy task of reconstruction. Other Texas cities, Houston, Fort Worth, Waco and Austin, were among the first to follow Galveston's example.

Since its return to power in 1874 the Democratic Party has continued in control of the State Government. Its supremacy was threatened by the Populists in 1894, but the adoption of the free silver plank in 1896 saved the situation for the Democrats. The primary elections which determine the Democratic candidate are usually the hardest fought. Texas in 1924 elected as governor, Mrs. Miriam A. Ferguson, one of the two first women in the United States to hold the office. She was the wife of James E. Ferguson, governor from 1915–17, who was impeached. Opposition in Texas to the so-called "Ferguson régime" mobilized sufficiently to defeat Mrs. Ferguson in 1926. In 1928 the State voted Republican for the first time in a Presidential campaign.

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TEXTILE PRINTING. The application of art and science in the production of designs on any fibrous materials without resource to embroidering or appliqueing. (*See* Calico Printing.) Its origin is unknown. Some ascribe it to the Chinese, but it is more likely that India and Egypt could claim earlier knowledge of the printing of textiles. Indian prints were highly valued by the Romans, and India is undoubtedly the source from which the application of block printing to woven fabrics spread by way of Persia, Asia Minor and the Levant to Europe. Although wood engraving was used in Europe for illustrating books as early as the 15th century, it was not until the latter half of the 17th century that textile printing was practiced to any great extent. About that time the French brought from the east coast of India, blue and white resist prints and particulars of the methods used to produce them. At the end of the 17th century Augsburg was noted for its printed linens, and in 1746 the works of C. Koechlin was founded at Mulhouse. Textile printing was established in England in 1690 by a French refugee who opened a works near Richmond, but little progress was made until 1764 when Messrs. Clayton of Bamber Bridge, near Preston, opened the first print works in Lancashire.

After this, printing progressed at a remarkably rapid rate in England. The effects were obtained by impressing carved blocks smeared with thickened colour on to cloth until 1770, when Bell conceived the idea of printing calico in much the same way that engravings are produced on paper with engraved copper plates. The difficulty experienced in this method was to make successive impressions *join up* imperceptibly, and it has always been limited to handkerchiefs and designs made up of detached objects; this was overcome by the invention of the roller printing machine by Bell in 1783. In 1800 Ebinger invented a method of peg or surface printing, which was practically a block in the form of a cylinder. This was greatly improved upon by an Englishman, Burch of Accrington, who introduced the method of coppering (often employed in hand block printing), covering the rollers with varnish to protect them from damp and supplying them with a colour furnishing blanket. This method, with improvements, is adopted in the production of cheaper cretonnes with designs resembling those of hand block printing.

A combination of relief and intaglio printing is sometimes carried out. Watt in England and Depouilly in France were pioneers in the production of relief printing machines, but the most satisfactory block machine was constructed by Perrot of Rouen to print three colours. This is used to some extent in England but still more in France, Switzerland and Italy. In all countries roller printing is the most important method, but thick fabrics, such as cretonnes, heavy velvet and plush do not present the kind of surface which is well adapted to roller printing in heavy shades, and such material is block printed by hand. For the successful application of roller printing, the engraving of the copper cylinders is a most important matter. Every part of a design which is represented in a particular colour requires a separate roller, so that every new design which is introduced involves considerable expense for roller engraving. Various devices have been proposed for overcoming this difficulty, but they do not appear to find much application.

Printed fabrics are really locally dyed, but the applications of watery liquids to the surface of cloth results in blurred and indefinite outlines. Such effects are sometimes desirable, in which case *spray dyeing* is resorted to, with perhaps the most pleasing effects in the case of real silk material. Special machines (aerograph sprays) have been devised for this purpose. If clear, well defined outlines are required, it is necessary either to size the cloth or to thicken the colour solution. The first method was probably adopted in the early days of printing in England, and natural gums were used until the end of the 18th century.

The discovery of a satisfactory substitute for natural gum is said to have originated from a fire in a starch factory in Dublin early in the 19th century, the gummy material produced by the mixture of half burnt starch and water being tried at a print works and proved satisfactory. According to other accounts the discovery is attributed to Vauquelin and Bouillon-Lagrange. In any case British gum must have been discovered before 1815. It was found that it could be conveniently used as an addition to the colour instead of applying it to the cloth.

There are three methods of printing designs on textiles, viz., *Block printing*, using the hand block, or the perrotine machine, also peg or surface printing. *Intaglio printing*, the roller or cylinder machine being the only satisfactory device. *Surface printing by lithography*, using some special machines of limited application. In addition to these is stencilling (of considerable importance, especially for the application of metals to fabric), the drop and brush method and spraying.

METHODS OF PRINTING

Hand Blocks.—These are made of box, lime, holly, sycamore, plane or pear wood, but generally one of the last three. The blocks vary in area, but are always two or three inches thick and are backed with pieces of deal or pine, the grain of each adjacent piece running in a different direction. All are secured firmly together to prevent warping. When the surface of the block has been planed and rubbed level, the outline of the design is put on by applying a tracing in lamp black and oil to the surface and rubbing. The portions to be left in are tinted with ammoniacal carmine or magenta, the block is damped and the parts which are not required are cut away, commencing with the heavier masses and proceeding to the finer ones. The latter are sometimes cut on a separate block. Coppered blocks are used for fine work and these are made by inserting strips and pegs of brass or copper into the surface of the block. Burch of Accrington devised an instrument (fig. 1) for preparing blocks which closely resembles a drilling machine used by engineers, but in place of the drills, fixed punches (heated by a small gas blow-pipe or bunsen burner) can be raised or lowered by a foot lever, while the block is moved about by the worker. The heated punches are sometimes made to revolve. Blocks are often felted or flocked so that more colour can be applied to the cloth, and this secures better penetration.

In addition to the engraved block, a stone printing table and a colour sieve are required. Over the table top a woollen printer's blanket is tightly stretched. At one end, the table is provided with a couple of iron brackets to carry the roll of cloth, and, at the other, a series of guide rollers, extending to the ceiling, are arranged for the purpose of suspending and drying the newly printed goods. The colour sieve consists of a *swimming tub,* half filled with starch paste on the surface of which floats a frame, covered at the bottom with a tightly stretched piece of mackintosh or oiled calico. On this the colour sieve proper, a frame covered with fine woollen cloth, is placed, and forms, when in position, an elastic colour trough over the bottom of which the colour is spread evenly with a brush.

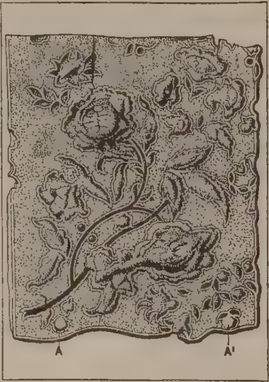


FIG. 1.—FELTED BLOCK
The pitch pins should be fixed in the holes in the lower ends

The *modus operandi* of printing is as follows: The printer commences by drawing a length of cloth, from the roll, over the table, and marks it to indicate where the first impression of the block is to be applied. He then applies his block in two different directions to the colour on the sieve and finally presses it firmly and steadily on the cloth, ensuring a good impression by striking it smartly on the back with a wooden mallet. The succeeding impressions are made in the same way, continuity being ensured by means of pins, at each corner of the block, which are arranged so that, when those at the right side or at the top of the block fall upon those at the left side or the bottom of the previous impression, two printings join up exactly and continue the pattern without a break. As each length is finished it is wound over the drying rollers, thus bringing forward a fresh length to be treated similarly. If the pattern contains several colours the cloth is usually first printed throughout with one, then dried, rewound and printed in turn with the others.

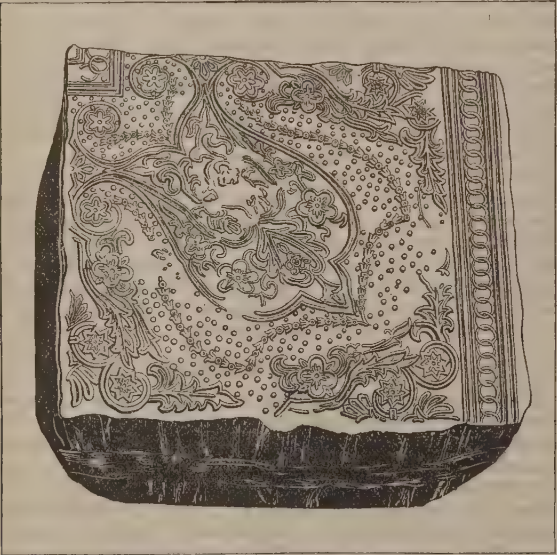


FIG. 2.—COPPERED BLOCK SHOWS THE LAYERS OF WOOD WITH THE COPPER WIRE AND PEGS PRODUCING THE DESIGN IN THE TOP PIECE

Many modifications of block-printing have been tried from time to time, but of these only two—"tobying" and "rainbowing"—are of any practical value. The object of "toby-printing" is to print the several colours of a multicolour pattern at one operation, and a block, with the whole of the pattern cut upon it, and a specially constructed colour sieve are employed. The latter consists of a thick block of wood, on one side of which a series of compartments are hollowed out, corresponding roughly in shape, size and position to the various objects cut on the block, and supplied with colour to correspond to the design.

The Perrotine.—Three blocks (3 ft. by 3 ft.-5 in.), with the pattern cast on them in relief, are brought to bear successively on the three faces of a specially constructed printing table over which the cloth passes (together with its backing of printer's blanket) after each impression. The faces of the table are arranged at right angles to each other, and the blocks work in slides similarly placed, so that their engraved faces are perfectly parallel to the tables. Each block is provided with its own colour trough, distributing brush and woollen colour pad or sieve, and is supplied automatically with colour by these appliances during the time the machine is in motion. For certain classes of work the perrotine possesses great advantages over the handblock, for not only is the rate of production greatly increased, but the joining up of the various impressions to each other is much more exact, and no sign of a break in continuity of line is noticeable in well executed work. However, the perrotine can only be used for patterns containing not more than three colours and not exceeding 5 in. in vertical repeat, whereas hand block-printing can cope with patterns of almost any scale and containing any number of colours. The two processes, therefore, cannot be compared on the same basis; the perrotine is best for work of a utilitarian character and the handblock for decorative work in which the design only repeats every 15 to 20 in. and contains colours varying in number from one to a dozen.

Machines for peg or surface printing, as it is sometimes termed, are arranged much in the same way as intaglio printing machines, except that the peg or printing roller is cut in relief and the colour is served to it by means of a short endless colour blanket or sleeve which is supplied from colour furnishing rollers. It is usually employed for rather large designs on cheap cretonnes and linoleum.

Roller Printing or Cylinder Printing.—The working of the machine is shown in fig. 3. A cast iron cylinder is mounted in adjustable bearings capable of sliding up and down slots in the sides of rigid iron framework. It is covered with several folds of lapping and a blanket of wool or rubber to give elasticity. Beneath is an engraved copper roller which is supplied with colour from a roller which revolves in a colour box below it. Two knives known as "doctors" rest against the engraved roller, one serving to remove colour from the smooth parts of the roller and known as the "cleaning doctor." It is pressed against the roller by means of levers. The other, made of brass, is the

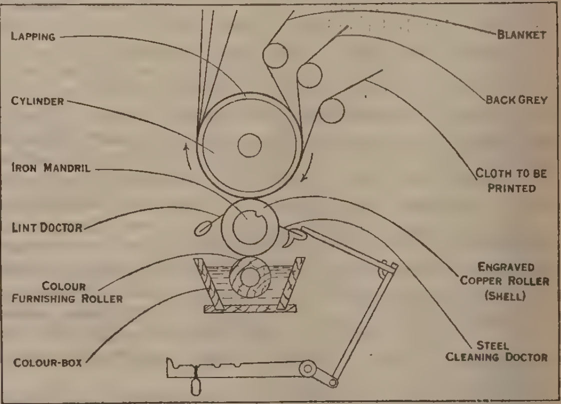
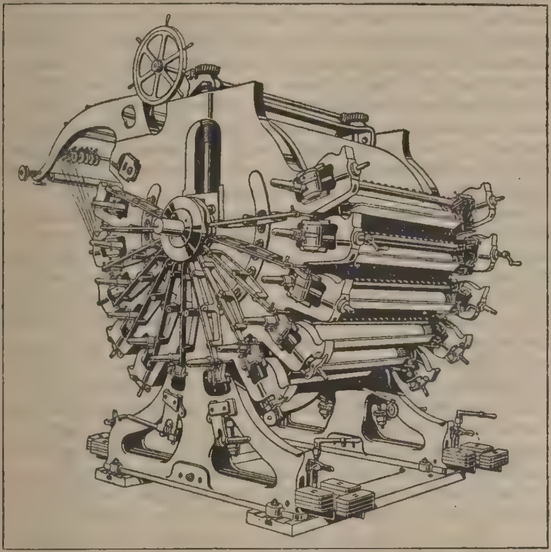


FIG. 3.—DIAGRAM SHOWING WORKING PARTS OF A ONE-COLOUR PRINTING MACHINE

"lint doctor" which removes loose filaments or lint which the roller picks up from the cloth.

In operation, the cylinder is screwed down with an even pressure into frictional contact with the roller below; the machine is then set in motion, turning in the direction indicated by the arrows; the cloth is now introduced between them and as it leaves the machine fully printed it is carried over a series of drying chambers situated above and heated by steam. The printing roller is the only part of the machine directly connected with the motor or main drive of the works through the cog-wheel on its axle—the "mandril"—all the other parts deriving their motion from it, either by friction as in the case of the cylinder or by a spur wheel as in that of the colour-furnishing roller. The mode of printing is almost self-evident; the roller revolving in the direction of the arrow takes colour from the "furnisher"; the excess is then scraped off by the "doctor" and, in continuing on its course, it comes in contact with the cloth which being pressed by the cylinder into the engraving abstracts the colour therefrom and of course receives an exact impression of the engraved pattern. The pressure may be applied either through the cylinder to the roller or from the engraved roller to the cylinder by compound levers.



BY COURTESY OF MATHER & PLATT

FIG. 4.—TWELVE COLOUR GARMENT PRINTING MACHINE

Larger machines printing from two to 16 colours are precisely similar in principle to the above, but differ somewhat in detail and are naturally more complex and difficult to operate. In a 12 colour machine (fig. 4) for example, 12 copper rollers, each carrying one portion of the design, are arranged round a central pressure cylinder, or bowl, common to all, and each roller is driven by a common driving wheel, called the "crown" wheel, actuated, in most cases, by its own steam-engine or motor. The pressure is applied to the cylinder through the rollers which work in specially constructed bearings capable of the following movements: (1) Of being screwed up bodily until the rollers are lightly pressed against the central bowl; (2) of being moved to and fro sideways so that the rollers may be laterally adjusted; and (3) of being moved up or down for the purpose of adjusting the rollers in a vertical direction. Notwithstanding the great latitude of movement thus provided each roller is furnished with a "box-wheel," which serves the double purpose of connecting or gearing it to the driving wheel, and of affording a fine adjustment. Each roller is further furnished with its own colour-box and doctors.

In recent years many improvements and additions have been made in printing machines. Chief amongst these are those embodied in the "intermittent" and the "duplex" machines. In the former any or all of the rollers may be moved out of contact with the cylinder at will, and at certain intervals. Such machines are used in the printing of shawls and "saris" for the Indian market. The goods require a wide border right across, and it is to effect this, with rollers of ordinary dimensions, that "intermittent" machines are used. The body of the "saris" will be printed, say for six yards, with eight rollers; these then drop away from the cloth and others, which have up to then been out of action, immediately fall into contact and print a border or "crossbar" say one yard wide, across the piece; they then recede from the cloth and the first eight again return and print another six yards, and so on continually.

The "duplex" or "reversible" machine derives its name from the fact that it prints both sides of the cloth. It consists of two ordinary machines so combined that when the cloth passes, fully printed on one side from the first, its plain side is exposed to the rollers of the second, which prints an exact duplicate of the first impression upon it in such a way that both printings coincide. A pin pushed through the face of the cloth ought to protrude through the corresponding part of the design printed on the back if the two patterns are in good "fit."

Lithographic printing is employed with success in the printing of silk handkerchiefs. Haley's process is described in the 1915 *Journal of the Society of Dyers and Colourists*. In 1920 an Indian named Cooper proposed to avoid engraving rollers by using designs, cut in paper (stencils) or curtain net, on the bowl and placing the cloth between this and a uniform layer of colour on a roller beneath it. The arrangement was applicable when used with lithographic (oil) inks but was not so successful with calico printers' colours (starch or gum thickening). In 1926 A. Crompton obtained a patent for a machine with rollers arranged side by side but otherwise on a similar principle to that of Cooper and claimed it to be successful in calico printing.

In stencilling colour is brushed through holes cut in stout paper or metal. The Japanese are particularly successful in hand work of this kind for they can by tying parts of the designs with raw silk thread produce almost circular patterns. In England a machine for stencilling has been patented by S. H. Sharp.

Variegated and marbled effects, patented by the Calico Printers' Association, Ltd., E. Schofield and F. Farnworth, are obtained by applying colours to the underside of a horizontally travelling fabric by means of rotating brushes which dip into a colour box beneath, and to the upper side by allowing colour to drop on to the cloth from a series of colour cans provided with taps to regulate the rate of flow. Reversible effects can be obtained. The rollers are of smooth brass and travel at a higher speed than the cloth; they pick up the surplus colour and transfer it to doctors which carry it away to a suitable vessel. It may be utilized for a very wide range of styles.

Thickening Agents.—The thickening agents in most general use in printing are starch, flour, gum arabic, gum senegal and gum tragacanth, British gum or dextrine and albumen. With the exception of albumen all these are made into pastes, or dissolved by boiling in jacketed pans between the inner and outer casings of which either steam or water may be made to circulate. Mechanical agitators, fitted in these pans, are in action during boiling and cooling, to mix the various ingredients and to prevent the formation of lumps.

Starch paste is made by mixing 15 lb. of wheat starch with cold water to form a creamy paste; a little olive oil is then added and sufficient water to bring the whole up to 10 gallons. The mixture is thickened by being boiled for about an hour and, after cooling, is ready for use. It is the most extensively used of all the thickenings, and is applicable to all but strongly alkaline or strongly acid colours. With the former it thickens up to a stiff unworkable jelly, while mineral acids or acid salts convert it into dextrine, thus diminishing its thickening power. Acetic and formic acids have no action on it even at the boil. Flour paste is made in a similar way to starch paste. At the present time it is rarely used for anything but the thickening of aluminium and iron mordants, for which it is eminently adapted.

Gum arabic and gum senegal are both very old thickenings, but their expense prevents them from being used for any but delicate tints. They are specially useful thickenings for the light ground colours of soft muslins and sateens, on account of the property they possess of dissolving completely out of the fibres of the cloth in the washing process after printing. Starch and artificial gums always leave the cloth somewhat harsh unless they are treated specially and are incapable of yielding the clear and even tints resulting from the use of natural gums. Very dark colours cannot well be obtained with gum senegal or gum arabic thickenings; they come away too much in washing, the gum apparently preventing them from combining fully with the fibres. Stock solutions of these two gums are usually made by dissolving 6 or 8 lb. of either in one gallon of water, either by boiling or by standing in the cold.

British gum or dextrine is prepared by heating starch. It varies considerably in composition, sometimes being only slightly roasted and consequently only partly converted into dextrine, and at others almost completely soluble in cold water and very dark in colour. Its thickening power decreases and its gummy nature increases as the temperature at which it is roasted is raised. The lighter coloured gums or dextrines will make a good thickening with from 2 to 3 lb. of gum to one gallon of water, but the darkest require from 6 to 10 lb. per gal. to give a substantial paste, and are very useful for strongly acid colours, and, with the exception of gum senegal, are the best thickening agents for strongly alkaline colours and discharges. Like the natural gums, neither light nor dark British gums penetrate into the fibre of the cloth so deeply as pure starch or flour, and are therefore unsuitable for very dark strong colours.

Gum tragacanth, or "Dragon" is one of the most indispensable thickening agents possessed by the textile printer. It may be mixed in any proportion with starch or flour and is equally useful for pigment colours and mordant colours. When added to starch paste it increases its penetrating power, adds to its softness without diminishing its thickness, makes it easier to wash out of the fabric and produces much more level colours than starch paste alone. Used by itself it is suitable for printing all kinds of dark grounds on goods which are required to retain their softness. A tragacanth mucilage may be made either by allowing it to stand a day or two in contact with cold water or by soaking it for 24 hours in warm water, and then boiling it up until it is smooth and homogeneous. If bottled under pressure it gives a very fine smooth mucilage (not a solution proper), much thinner than if it had been made in the cold.

Albumen is both a thickening and a fixing agent for insoluble pigments such as chrome yellow, the ochres, vermilion and ultramarine. Albumen is always dissolved in the cold, a process which takes several days when large quantities are required. The usual strength of the solution is 4 lb. per gal. of water for blood albumen, and 6 lb. per gal. for egg albumen. The latter is expensive and only used for the lightest shades. For most purposes one part of albumen solution is mixed with one part of tragacanth mucilage, this proportion of albumen being found amply sufficient for the fixation of all ordinary pigment colours. In special instances the blood albumen solution is made as strong as 50% but this is only in cases where very dark colours are required to be fast to washing. After printing, albumen-thickened colours are exposed to hot steam which coagulates the albumen and effectually fixes the colours.

Concentrated solutions of the colouring matters and other adjuncts are added to the cold thickenings, of which large quantities are kept in stock. Colours are reduced in shade by simply adding more starch or other paste. For example, a dark blue containing 4 oz. of methylene blue per gal. may readily be made into a pale shade by adding to it 30 times its bulk of starch paste or gum, as the case may be. Similarly with other colours. Before printing it is very essential to strain or sieve all colours in order to free them from lumps, fine sand, etc., which would inevitably damage the polished surface of the engraved rollers and result in bad printing, since every scratch on the surface of a roller prints a fine line in the cloth. The straining is usually done by squeezing the colour through fine cotton or silk cloths. Mechanical means are also employed for colours that are used hot or are very strongly alkaline or acid.

STYLES OF PRINTING

The designation of any particular style of printing is based on its method of production. There is a large number of these recognized technically and it frequently happens that a multi-coloured effect involves more than one style of work, but in such a case it is usual to apply the name of the predominating style to the whole. Styles may be grouped under the following headings:—Direct printing (many colours for which special methods have been devised and are frequently classed under special groups, for example para red or insoluble azo style can be applied directly in printing); dyed style; discharge style; resist printing; processes of producing differences of texture or lustre in the textile fabrics either with or without colouring.

Direct Printing.—This style is largely used and can be applied with almost all types of colouring matters, if suitable ingredients are chosen which will react, in steaming, to produce colour lakes fixed on the fibre. In this way very fast effects can be produced, for this style of printing differs entirely from dyeing with direct cotton colours which are seldom used in cotton printing. The *mordant colours,* applied with a salt of alumina (frequently the acetate or the sulphocyanide), iron, or chromium, together with thickening and acetic acid, give bright and full shades of good fastness.

For alizarine red of full brilliance it is necessary to add a little oxalate of tin and lime, together with a little acetic, tartaric or oxalic acid, to obtain the brightest shades. In most cases, too, it is preferable to treat the cloth before printing with an oil "prepare" which consists of 50 parts ricinoleic acid, 20 parts ammonia, 20 parts sodium carbonate made up together to 1,000 parts. After printing, the goods are steamed and the colour is fixed. When utilized for the fixation of mordant colours this is sometimes known as the "extract style" because it was originally used in the case of madder, logwood and quercitron bark extracts. For printing alizarine red the following printing paste (made up in parts by weight) may be applied to cloth treated with oil prepare:— 47 parts water, 13 starch, 13 alizarine (20% paste), 3 acetic acid 9° Tw. Boil, turn off the steam and add 2·5 chlor oil (made by mixing equal parts of olive oil and 7° Tw. bleaching powder solution to form an emulsion), 2·5 stannic hydrate 20% paste, 2·5 oxalate of tin. Cool, and immediately before use add cold 3·5 acetate of lime 23° Tw., 4 nitrate of alumina, 23° Tw. and 10 sulphocyanide of alumina 20° Tw. If it is desirable to print cloth which has not been previously oiled (*e.g.,* when aniline black is to be printed side by side with alizarine) a special emulsion may be made with sulphoricinoleic acid, gum tragacanth and acetic acid. There is then no danger of the black being spoiled by the alkali in the oil prepare.

Alizarine blue and green give good shades with chromium acetate as mordant:—½ lb. alizarine blue (powd.) (light shade), 1 gal. water, 3½ gal. thick paste, 1½ gal. acetate of chrome 40° Tw.

Logwood and other natural colours are specially boiled. For logwood black—15 lb. starch, 10 lb. British gum, 4½ gal. water, ¾ gal. acetic acid, 1½ gal. logwood extract, 48° Tw., ⅜ gal. quercitron extract, 48° Tw. Boil, cool and add:—½ lb. red prussiate of potash, ¼ gal. water, 2 gal. acetate of chrome, 40° Tw., 2 oz. chlorate of potash.

Indigoid Colours.—There are three methods of printing indigo blue: The glucose or Schlieper and Baum process; the hydrosulphite process; and by the utilization of already reduced compounds such as indigosol and soledon colours.

In the first method the cloth is first prepared with glucose (300 parts grape sugar to 700 water) dried and then printed with 150 indigo (20%) and 850 alkaline thickening (made by mixing 30 maize starch, 100 dark British gum and 870 caustic soda 77° Tw.). The goods are steamed as quickly as possible after printing by running for ½ min. through an ager at 100° C (moist steam). They should then appear a brownish olive colour in the printed parts, and are exposed to the air, washed in running water, treated with 1° Tw. sulphuric acid, and again washed. Light shades of indigo can be oxidized by exposing to the air. This is perhaps the cheapest way of printing indigo and the colour is in no way inferior to that produced by the second method. The hydrosulphite process overcomes the necessity of preparing the cloth, for in this process indigo is printed in admixture with hydrosulphite formaldehyde. This compound dissociates in steaming, the hydrosulphite reduces the indigo and the cloth is locally dyed. The goods are then "aged" and allowed to lie a short time, after which they are washed in cold water first, until the indigo is thoroughly re-oxidized, and then in hot water or soap. The composition of this printing colour is as follows:—200 parts hydrosulphite N.F. (or 100 of the concentrated product), 450 parts alkaline dextrine paste, 150 parts indigo 20% paste (ground up in gum), 200 parts alkaline dextrine paste. Thickening—150 parts dextrine or British gum and 850 parts caustic soda, 70° Tw.

Indigosol O is printed in admixture with gum tragacanth thickening and sodium nitrate, being afterwards developed by passing through a bath containing hot formic or oxalic acid; in some instances hot acetic acid may be used. Thus 100 parts indigosol O, 350 parts hot water and 550 parts tragacanth thickening and 30 parts sodium nitrate is printed on to cotton fabric, which is then dried in hot air. Blue is developed by treating for a few seconds at about 80° C in a bath containing 4 parts formic acid (90%), 8 parts common salt and 100 parts water. The Soledon products and other indigosols may be applied in a somewhat similar way. As these materials can be used in conjunction or juxtaposition with colouring matters of totally different groups (both as regards dyeing and chemical constitution), such as insoluble azo colours and aniline black, they are especially useful. Rowe and Bean (1927) have given valuable information with regard to the development of the indigosols and allied products with different oxidizing agents.

Other Vat Colours.—Indanthrene, duranthrene, caledon and cibanone colours as well as those of the algol and alizarine indigo series may be applied by methods analogous to those described for indigo. Some very fast effects may be obtained, but difficulty is experienced by printers, owing to the fact that if the backgreys become stained with the colours, it is almost impossible to bleach them. This is a serious matter if customers' cloth is used for backgrey. Some of these colours require much alkali for their fixation and this is liable to attack the blanket. A steaming method for the printing of these colours which gives satisfactory results is the following:—600 parts alkaline thickening (a mixture of British gum and gum senegal), 100 colouring matter, 80 stannous oxide 50% paste, and 50 glycerine. Hydrosulphite formaldehyde may be used in place of stannous oxide as the reducing agent. Duranthrene yellow and cibanone blue 3G are colours suitable for printing in this way. After the goods have been steamed and the colour fully developed it is best to wash out the alkali from the cloth as thoroughly as possible. Sulphur colours and sulphurized vat colours are best printed with hydrosulphite formaldehyde.

Aniline Black.—Various methods for the oxidation of *aniline*, but particularly the prussiate method described under DYEING, may be utilized in printing. All are difficult to print well. Some difficulty is experienced in steaming or ageing, and special ageing appliances, with suction elements to carry away acid vapours and to maintain a relatively pure atmosphere of steam, have been patented. From the same source patents, in which the amount of acid used in the formation of the black is reduced to a minimum, figure conspicuously. The following is an ungreenable black which requires no afterchroming: 7.5 parts starch, 300 gum tragacanth mucilage, 32 aniline, 44 aniline salt, 4.5 paraphenylene diamine dihydrochloride, 40 formic acid (90%) 34 boracic acid, 41 chlorate of soda, 40 copper sulphide (24%). Print this mixture on to the cloth, age, wash and soap. The ageing process is carried out in an apparatus fitted with suction elements between the layers of cloth.

Basic Colours are of importance where brightness is the most important consideration. The usual method is to add the dyestuff to the prepared thickening, then some acetic, citric or tartaric acid, and then a mixture of tannic acid and acetic acid; *e.g.*, 20 parts methylene blue, 50 acetic acid (40%) 120 water and 720 starch paste are heated together, 10 ground tartaric acid cooled, and 80 tannic acetic solution (50%) are added. After printing the cloth is steamed.

Insoluble Azo Colours may be employed in a variety of ways, the most important being: (*a*) Printing a pattern in thickened naphthol and afterwards passing through a diazo solution. (*b*) Printing a diazo solution on cloth prepared in various naphthols. In these processes procedure is much the same as in DYEING (*q.v.*), except that in (*a*) the naphthol is thickened with British gum and in (*b*) the diazo solution is thickened with gum tragacanth. Various naphthols may be used and a large variety of shades obtained by utilizing naphthol A.S. and allied products. A good black can be obtained with A.S., S.W. and fast black base L.B. The colours possess great fastness and are but little affected by hot ironing (a defect of the beta naphthol colours). The latter such as para red and alpha naphthylamine maroon are used for cheap work. (*c*) The *rapid fast colours* (stabilized diazo compounds or nitrosamines mixed with analido compounds of beta oxynaphthoic acid) can be applied directly in printing. They are rather expensive but find considerable application because they are readily developed by treating the cloth after printing with hot dilute acetic acid. It is necessary to add a little potassium chromate to the printing colour if these are printed in combination with basic or chrome colours. They are conveniently used in combination with indigosols or Soledon colours. Everest has shown (1928) that the naphthols may be applied to silk from a soap bath and in the absence of caustic alkali. The method is patented for silk printing.

Application of Pigment Colours.—Before the introduction of coal-tar colours, pigments and lakes played a more important part in textile printing and they are still largely used for certain styles of work. They form a series of colours more difficult to work than those already mentioned, but very fast to soap and light. Pigment colours, being insoluble mineral precipitates or lakes, can only be fixed on the fibre mechanically; consequently they require to be applied in conjunction with vehicles which cause them to adhere to the fabric in much the same way that paint adheres to wood. Of these vehicles, albumen is the most important and the best. It forms a smooth viscous solution with cold water, mixes readily with all the colours used in pigment printing, and possesses the property of coagulating when heated to the temperature of boiling water. When cloth printed with colours containing albumen is passed through hot steam or hot acid solutions, as in the indigo discharge style, the albumen coagulates, forming a tough insoluble colloidal deposit, which firmly fixes on the fibre any colour with which it is mixed.

The colours chiefly employed in pigment printing are: chrome yellow and orange, Guignet's green or chrome green, artificial ultramarine, lamp black for greys, the various ochres for golds and browns, zinc oxide, vermilion and its substitutes, and occasionally lakes of the natural and artificial colouring matters.

Dyed Style.—Before the introduction of the azoic colours of the naphthol A.S. series, practically the only reliable method of obtaining fast shades in printing was by printing mordants on to cotton and then dyeing in natural colours such as madder, persian berries, logwood and other dyewoods. Alizarine has entirely superseded madder but logwood and persian berries are sometimes used. Other alizarine and chrome colours may be dealt with in this way. The application of the mordant in printing involves (1) the preliminary preparation of the cloth with oil, (2) printing on the mordant usually in the form of acetate, (3) ageing, (4) fixing (dunging is said to be more efficient than substituted fixing agents because it removes thickening material as well as excess of mordant) and (5) dyeing (*see* DYEING) in alizarine. In order to obtain perfect white in the unprinted portions, cloth after washing and soaping is passed through a very dilute solution of bleaching liquor. The process has been mainly used for obtaining red, pink, lilac and black prints, by depositing varying strengths of alumina and iron and dyeing in alizarine and logwood.

The thickened mordants used in the madder style are called colours, not because they contain any colouring matter, but because they give definite shades when dyed in alizarine. For madder red the following method applies:—6T Red. 100 parts wheat starch, 50 parts flour, 900 parts red liquor 6° Tw. (from which the red acquires its designation), 20 parts olive oil and 0·5 parts magenta (to sight the mordant). The goods are then passed at full width through a fly dunging machine containing 500 gal. water, 15 parts chalk, 2½ parts phosphate of soda and 70–85 parts cow dung.

A second dunging is carried out in a vessel similar to a dye beck and the goods are worked for 20–30 min. at 50–60° C. Malt or bran added to the dunging liquor accelerate the removal of starch but this is more necessary when using one of the substitutes for dung, *i.e.*, phosphate of soda (1½–6 parts by weight), binarsenate of soda (2–5 parts), or silicate of soda 32° Tw. (20 parts), with 7·5 parts of chalk per 1,000 parts water. After fixing, the goods are washed and dyed in 5% alizarine (20% paste) with the addition of Turkey red oil 5% and 0·5% chalk. Soaping and clearing completes the process.

The following table gives the ingredients necessary for obtaining six colours by printing the mordants on one piece and afterwards dyeing in a single bath with 4·5% alizarine (20% paste) and acetate of lime, proceeding as before. Aniline black may be printed along with red and black liquors. It is usual to employ only one or two colours, in this style of printing, with perhaps two concentrations of red or black liquor for light and dark shades of red and purple.

Ingredients	Red	Pink	Chocolate	Dk. purples	Violet	Black
Aluminium acetate, 6° Tw	12 gal.	3 gal.	10½ gal.	..	..	..
Black liquor, 24° Tw.	..	..	1½ ,,	1 gal.	½ gal.	8 gal.
Water	..	8 gal.	..	11 ,,	11½ ,,	4 ,,
British gum	..	36 lb.	..	..	36 lb.	..
Acetic acid	..	1 gal.	..	..	..	..
Tin crystals	1½ lb.	¾ lb.	..	..	..	..
Cotton-seed oil	¼ gal.	..	¼ gal.	¼ gal.	..	¼ gal.
Starch	16 lb.	..	16 lb.	16 lb.	..	16 lb.

Discharge Printing.—This depends upon the action of acids, alkalis, oxidizing and reducing agents for the destruction of dyed colours. It stands to reason that colours which are very fast require drastic oxidizing or reducing agents for their decomposition, but the former are difficult to apply without danger to the printed fabric. Sometimes two reagents play a part in the process. One is printed on the dyed fabric and reacts with the second, through a solution of which the printed fabric is passed. An advantage of this method is that fine delicate patterns can be discharged on a dark ground with a crispness of definition which is difficult to attain with a blotch roller.

Iron and *alumina mordants* are discharged by printing with citric acid, so that a white pattern on a coloured ground is obtained on dyeing. *Basic colours* are destroyed with alkalis. The *chrome discharge* is produced by printing the goods with a solution of sodium or potassium bichromate thickened with British gum, passing through a mixture of oxalic acid and sulphuric acid. White and coloured discharges on indigoid colours are obtained in this way.

Chromate Discharge.—White: 8½ gal. British gum paste, 12 lb. bichromate of soda and ½ gal. turpentine (prevents frothing).

Yellow: 32 lb. chrome yellow pigment, 3 gal. 50% albumen solution, ½ gal. thick tragacanth mucilage, and ¼ gal. oil (vegetable), 12 lb. bichromate of soda neutralized with ¾ gal. caustic soda, 70° Tw., and ½ gal. water.

Print, dry, pass through a "beck" (*i.e.*, a bath) containing: 100 gal. water, 50 lb. sulphuric acid (168° Tw.), and 50 lb. oxalic acid, then wash well and dry.

A green discharge is obtained with Guinet's green, a red with vermilion and brown with burnt sienna in place of chrome yellow. These colours resist the action of the bichromate and the acid treatment which follows printing coagulates the albumen. Another method (Freyberger) consists in printing on a thickened solution of sodium nitrate and, after drying, running through sulphuric acid of 50° Tw.

With colours of the indanthrene series, indigo gives compound shades and, as these are not destroyed by bichromate, over printing this with a roller of another pattern produces three colour effects and white. With two rollers the following four colours can be obtained on a light indigo blue: blue; green, by overprinting indanthrene yellow; white, by discharging parts of the blue; and yellow, by applying the discharge on parts coloured green. Azo colours resist the action of bichromate and can be used in this style of printing by incorporating mixtures for their production with the chromate printing discharge for blue.

As compared with oxidation discharges (chromate and chlorate) the *Leucotrope hydrosulphite discharge* possesses a great advantage in that the darkest shades of indigo can be discharged to a pure white without any danger of tendering the cloth. Hydrosulphite is the reducing agent for the indigo, but the leucotrope forms either a means of removing indigo white from the fibre (Leucotrope W. forms an alkali soluble yellow compound with indigo white) or a means of producing coloured discharges (Leucotrope O. forms a yellow compound which is not removed by washing in alkali). Examples:—

Strong Discharge White: 160 parts zinc oxide (50% paste), 100 parts Leucotrope W., 240 parts hydrosulphite formaldehyde, 40 parts anthraquinone (30% and paste), 460 parts British gum thickening.

Yellow Discharge: 460 parts British gum thickening, and 200 parts hydrosulphite formaldehyde, dissolve, cool and add 100 parts Leucotrope O., 40 parts anthraquinone (30% paste) and 200 parts zinc oxide (50% paste). Glucose may be used as the reducing agent for discharging indigoid colours. This is especially useful in producing coloured discharges with insoluble azo colours. Leucotrope cannot be used with indanthrene colours as it acts as an efficient resist to their fixation.

Resist Style.—In the resist style, dyeing is prevented (1) by the application of substances which mechanically protect the fibre from contact with the dyestuff or (2) by the action of substances which act chemically either by decomposing the dyeing material or preventing its formation.

A very ancient method of ornamenting fabric is what is known as the *batik style* (*see* BATIK and TEXTILES). Imitations of this style are obtained by printing wax from engraved roller plates and stencils. Different colouring is obtained by putting on another pattern or part of a pattern in wax and redyeing. When the madder style is used for the colouring, the wax printed goods are mordanted and then dyed, the wax resist is broken, the cloth is dipped in the indigo vat, and a red, white, blue and chocolate effect is obtained, the latter by the superposition of blue on red. By tinting the cloth in chrysamine (direct cotton colour) a buff instead of white is obtained.

In machine printing resin is used in place of wax: for this purpose rollers heated with an internal electric heater have been patented by F. Ashton and the Calico Printers' Association. Resin-printed cloth fixes chromium from hydrosulphite formaldehyde mixtures instead of resisting it. Bichromate of soda and formosul are the best for this purpose. If resin-printed cloth is dyed in indigo before mordanting, the batik cracks appear in light blue on a dark ground, the shade of the ground being slightly modified by the superposed mordant colour. Other white resists are obtained by printing metallic salts, flowers of sulphur and lactic acid, or ammonium nitrate under the ordinary printing resists. The composition of the best resist for indigo printed by the glucose process is as follows: 150 parts flowers of sulphur, 50 parts lactic acid 50%, and 800 parts 30% gum Senegal solution.

Sulphur is liable to etch the roller immediately following the resist roller, and this may be avoided by the use of chemical resists (Reserve Salts W and O, Kalle and Co.), which however do not give good results if crushed by the next roller, so can only be used with advantage for single colour resists. Indigosols can be used with success in resist printing. Leucotrope (150 parts Leucotrope O. 850 British gum thickening) will prevent the fixation of any vat dye printed over it.

Resists Under Aluminium and Iron Mordants.—For the production of this important class of goods, use is made of the fact that alkaline citrates prevent the fixation of the mordants. The cloth is first printed with citrate of soda (or sometimes citric and tartaric acids for iron mordants), then dried, and again printed over the previous impression, with either a fine "all over" pattern or flat uniform ground, in iron or aluminium mordants. The fabric is then aged, dunged, washed and dyed as already described, with the result that, wherever the "reserve" of citrate or acid was printed, a white pattern is left on a figured or plain ground. The fine patterns printed over "resists" are called "covers" and the plain grounds "pads," hence the name cover and pad style in cases where, as frequently happens, a dark cover and a light pad are both printed over a white resist. The cover and pad style is, for the most part, restricted to dyed alizarine purples, under which red, black, dark purple and white can all be resisted at the same time, thus giving rise to very pleasing effects.

In the case of resists under steam, alizarine red, and pink, a reserve composed of citrate of chromium alone, or in conjunction with citrate of soda, gives the best results. The goods are first prepared in alizarine oil and then printed with the following: 10 lb. china clay, ½ gal. citrate of soda, 54° Tw., ½ gal. citrate of chromium, 42° Tw., ½ gal. water, and 2½ gal. British gum paste. After printing the above, the goods are dried, again printed either with cover or pad or both in alizarine pink, dried, steamed for 1½ hr., well washed and soaped. On leaving the steamer the parts printed with the resist are yellow, but become quite white on soaping. Like the purples, the alizarine pinks can be reserved in colours. For blue, green, yellow and violet the ordinary steam basic colours are used with additions of citric or tartaric acid; *e.g.*, 7 lb. china clay, ½ gal. water, 6½ gal. British gum paste, 2 lb. methylene blue, 1 lb. citric acid and 1 gal. acetic acid. Boil, cool and add 1½ gal. 50% tannic acid solution in acetic acid. The *resisting* of *aniline black* is effected by the use of alkalis, which, as Prud'homme discovered, prevent the formation of the colour. White and coloured resists may be applied either before the liquor is padded with the prussiate black liquor or after padding, in which case it is often termed a *discharge black*. The black is developed except where the resist (discharge) has been printed. For the true resist process it is essential that the printing mixture shall contain some insoluble plastic material, such as zinc oxide.

Variations.—Variations in the appearance and properties of portions of textile fabrics are frequently brought about by printing. A *crimped surface* on cotton fabric may be obtained either by printing caustic soda (60–70° Tw.) thickened with British gum, then washing; or by printing a very strong thickening on to the cloth and then passing the whole piece through a solution of 60° Tw. caustic soda and washing. In the first case the printed parts shrink, and so make the rest appear crimped; and in the second case, the printed parts, being protected from the action of the alkali, are caused to appear crimped by the shrinking of other parts of the material. These effects are usually applied in the form of stipes which is the best pattern for showing the effect to advantage. It is an adaptation of mercerizing.

Matt, lustring and delustring effects on fabrics composed wholely or partly of artificial silk of various kinds is carried out to a large extent. F. Scholefield produces an effect which closely resembles wool and silk by printing sodium sulphite, or other desulphurizing agent, on to a fabric composed of viscose silk containing sulphur (unbleached viscose). The latter, when spun in a suitable form, looks somewhat like wool and feels warm, but wherever it is desulphured the lustre of silk appears. Alternatively, if the sulphur yarn, of which the piece is composed, is fine and smooth it shows an opalescent lustre, while the delustred portions have a bright silk-like lustre. The lustre of acetate silk is altered by steaming alone. If protective agents in the form of organic acids are printed on to a piece of such artificial silk and it is then steamed, the lustre of the unprotected portions is reduced or lost while that of acid printed portions remains unimpaired. In nearly all cases of which these effects are typical, it is possible to combine the lustring and delustring style with one or more of the other styles of printing. In a very simple way effects of a novel character are obtained; for example, a piece of sateen, composed of cotton warp and acetate silk weft, is printed in fine check pattern with caustic soda, below mercerizing strength but still sufficiently strong to impart some modification in the dyeing property of the fibres. It is then dyed in one bath with a mixture containing a cotton blue and golden yellow for acetate silk. On one side the cloth appears almost as if it were composed of threads of metallic gold woven so as to show a transparent and shot dark and light blue background; on the reverse side the cloth appears mainly dark and light blue check, shot or intercepted with some gold threads. Warp printing is utilized to a considerable extent for the production of cretonnes, and other heavy weight fabric, for by this means it is easy to get good colour penetration like that obtained in dyeing. Holden (Nov. 1928) has obtained increased dyeing with direct colours and indigosols by printing cloth (velvet) with gelatine and then steaming.

Before cotton goods can be printed it is necessary that the cloth shall be thoroughly well bleached, and that all nap shall be removed from the surface by singeing and shearing. Especially if good whites are desired, or printing is done with fine stipple rollers (rollers engraved with dots instead of fine lines), the cloth must also be straightened on stenters and weft straighteners before it is printed, in order to show the pattern in proper position and register. Woollen goods are chlorinated before printing, for only comparatively mild steaming with moist steam is possible for this material. Silk is treated with stannous chloride or phosphate. Animal fibres take colours readily enough, after proper preparation, and not only wool, direct cotton, basic and mordant colours may be used, but also aniline black, nitroso blue and insoluble azo colours.

For complete directions for the printing of fabrics of both animal and vegetable origin, *see* E. Knecht and J. B. Fothergill, *Principles and Practice of Textile Printing* (2nd ed.). (E. Hi.)

ART AND ARCHAEOLOGY

Printing patterns on textiles, whether of flax, cotton or silk, by means of incised wooden blocks, is so closely related in its ornamental effects to other different methods of similar intention, such as by painting and by processes of dyeing and weaving, that it is almost impossible to determine from the picturesque indications afforded by ancient records and writings of pre-Christian, classical or even mediaeval times, how far, if at all, allusion is being made in them to this particular process. Hence its original invention must probably remain a matter of inference only.

Whilst the earlier history of stamping patterns by hand on to textiles in the East has still to be written, a serious attempt has been made to account for the existence of this decorative process in Europe during several centuries prior to the introduction of the "Indiennes" or printed and painted calicoes imported from the East. Specimens of printed stuffs have of recent years been obtained from disused cemeteries in Upper Egypt (Akhmîm and elsewhere) and tell us of Egypto-Roman use of such things. Some few of them are now lodged in European museums. For indications that earlier Egyptians, Greeks and Romans were likely to have been acquainted with the process, one has to rely upon less certain evidence. Of textiles painted by Egyptians there are many actual examples. Apart from these there are wall paintings, *e.g.*, those of Beni Hassan—about 2100 B.C.—in which are represented certain Asiatic people wearing costumes irregularly patterned with spots, stripes and zig-zags, which may have been more readily stamped than embroidered or woven. A rather more complicated and orderly pattern well suited to stamping occurs in a painting about 1320 B.C., of Hathor and King Meneptha I. Herodotus, referring to the garments of inhabitants of the Caucasus, says that representations of various animals were dyed into them so as to be irremovable by washing. Pliny describes "a very remarkable process employed in Egypt for the colouring of tissues. After pressing the material, which is white at first, they saturate it, not with colours, but with mordants that are calculated to absorb colour." When this was finished the cloth was "plunged into a cauldron of boiling dye" and "removed the next moment fully coloured." "It is a singular fact, too, that although the dye in the pan is of one uniform colour, the material when taken out of it is of various colours according to the nature of the mordants that have been respectively applied to it." Egypto-Roman bits of printed stuffs from Akhīm exhibit the use, some 300 years later than the time of Pliny, of boldly cut blocks for stamping figure-subjects and patterns on to textiles. Almost concurrent with their discovery was that of a fragment of printed cotton at Arles in the grave of St. Caesarius, who was bishop there about A.D. 542. Equal in archaeological value are similar fragments found in an ancient tomb at Quedlinburg. These, however, are of comparatively simple patterns. Other later specimens establish the fact that more important pattern-printing on textiles had become a developed industry in parts of Europe towards the end of the 12th and the beginning of the 13th century.

The Rhenish Monks.—According to Forrer (*Die Kunst des Zeugdrucks*, 1898) mediaeval Rhenish monasteries were the cradles of the artistic craft of ornamental stamp or block cutting. In rare monastic mss. earlier in date than the 13th century, initial letters (especially those that recurred frequently) were sometimes stamped from hand-cut blocks; and German deeds of the 14th century bear names of block cutters and textile stampers as those of witnesses. Between the 11th and 14th centuries there was apparently in Germany no such weaving of rich ornamental stuffs as that carried on in Spain and Italy, but her competitive and commercial instincts led her to adapt her art of stamping to the decoration of coarse textiles, and thus to produce rather rough imitations of patterns woven in the Saracenic, Byzantine and Italian silks and brocades. Amongst the more ancient relics of Rhenish printed textiles are some of thin silken stuff, impressed with rude and simplified versions of such patterns in gold and silver foil. Of these, and of a considerable number of later variously dyed stout linens with patterns printed in dark tones or in black, specimens have been collected from reliquaries, tombs and old churches. From these several bits of evidence Dr. Forrer propounds an opinion that the printing of patterns on textiles as carried on in several Rhenish towns preceded that of printing on paper. He proceeds to show that from after the 14th century increasing luxury and prosperity promoted a freer use of woven and embroidered stuffs, in consequence of which textile printing fell into neglect, and only three centuries later it revived.

Augsburg, famous in the 17th century for its printing on linens, etc., supplied Alsace and Switzerland with many craftsmen in this process. After the revocation of the edict of Nantes, French refugees took part in starting manufactories of both painted and printed cloths in Holland, England and Switzerland; some few of the refugees were allowed back into France to do the same in Normandy; manufactories were also set up in Paris, Marseille, Nantes and Angers; but there was still greater activity at Geneva, Neuchâtel, Zürich, St. Gall and Basle. The first textile-printing works in Great Britain are said to have been begun towards the end of the 17th century by a Frenchman on the banks of the Thames near Richmond, and soon afterwards a more considerable factory was established at Bromley Hall in Essex; many others were opened in Surrey early in the 18th century. At Mulhouse the enterprise of Koechlin, Schmatzer and Dollfus in 1746, as well as that of Oberkampf at Jouy, led to a still wider spread of the industry in Alsace. In almost every place in Europe where it was taken up and followed, it was met by local and national prohibitions or trade protective regulations and acts, which, however, were gradually overcome.

Invention of Roller Printing.—Towards the end of the 18th century a revolution in the British manufacture of printed textiles was brought about through the invention of cylinder or roller printing from metal plates. This is usually credited to Oberkampf of Jouy, but it seems to have occurred also to a Scotsman named Bell, and was successfully applied in a large way about 1785 at Monsey near Preston. From this and the calico-printing works at Manchester in 1763, and in Scotland in 1768, the present huge proportions of the industry in Great Britain have been developed.

Illustrations accompanying this brief account merely indicate a few types of patterns used in various European countries up to the beginning of the 19th century. Typical specimens of East Indian painted and printed calicoes for coverlets and other draperies are shown in the Indian division of the Victoria and Albert Museum. These are *sui generis,* and therefore differ from the bulk of Western prints on chintz, cretonne, etc., which together with a less quantity of printing on satin, silk, velvet, crêpe and the like are principally from adaptations of weaving patterns. An interesting series of over 2,500 patterns, chiefly of this character, was made by M. Corimand between 1846 and 1860, and is preserved in the National Art Library at South Kensington. For many years of the latter part of the 19th century, William Morris designed and produced attractively ingenious floral and bird patterns, admirable in contrasts of bright colours, frequently basing his arrangement of crisply defined forms in them upon that of Persian surface ornament.

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